KONKAN RAILWAY CORPORATION LIMITED

EIA & SIA Study Report
for
Construction of Twin Tunnel (2+2 Lane) with Four Lane Approach from Aanakampoyil to Meppadi in Kozhikode and Wayanad Districts






EIA Consultant

MM Gardens, P.B.No.1820,
Church Landing Road,
Kochi – 682016,
Kerala

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Abbreviations

CPCB	:	Central Pollution Control Board
CPR	:	Common Property Resource
CRZ	:	Coastal Regulation Zone
CSC	:	Construction Supervision Consultant
DIZ	:	Direct Impact Zone
DPR	:	Detailed Project Report
EAC	:	Expert Appraisal Committee
EC	:	Environmental Clearance
EIA	:	Environmental Impact Assessment
EMAP	:	Environmental Management Action Plan
EMP	:	Environmental Management Plan
FGD	:	Focus Group Discussion
GoK	:	Government of Kerala
HWC	:	Human Wildlife Conflict
IIZ	:	Indirect Impact Zone
IMD	:	India Meteorological Department
IRC	:	Indian Road Congress
IS	:	Indian Standard
KIIFB	:	Kerala Infrastructure Investment Fund Board
KPWD	:	Kerala Public Works Department
KRCL	:	Konkan Railway Corporation Limited
MDR	:	Major District Road
MoEF&CC	:	Ministry of Environment, Forests & Climate Change
NAAQ	:	National Ambient Air Quality
NATM	:	New Austrian Tunneling Method
NBWL	:	National Board for Wildlife
NGO	:	Non Government Organisation
NH	:	National Highway
NOC	:	Non Objection Certificate
PAF	:	Project Affected Family
PAP	:	Project Affected Persons
PIU	:	Project Implementation Unit
PIZ	:	Project Impact Zone
PMU	:	Project Management Unit
PRoW	:	Proposed Right of Way
PWD	:	Public Works Department
R&R	:	Resettlement and Rehabilitation
RAP	:	Resettlement Action Plan
RoW	:	Right of Way
SH	:	State Highway
SPCB	:	State Pollution Control Board
TBM	:	Tunnel Boring Machine
TCS	:	Typical Cross Section
ToR	:	Terms of Reference

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Chapter 1. Introduction

1.1. Introduction

The proposal for the construction of Aanakkampoyil–Kalladi–Meppadi Tunnel Road is an endeavor of the Government of Kerala to overall development of the State, especially of the Malabar area. The Malabar region is facing inadequate transportation infrastructural facilities. Increased level of economic activity can be kick started in this region by providing adequate infrastructure facilities.

1.1.1. Objective of the Project

The Malabar region comprises of Palakkad, Malappuram, Kozhikode, Wayanad, Kannur and Kasarakode districts. The Arabian Sea is on the western border of Kozhikode district whereas the adjoining district of Wayanad is towards its east. The NH 766 that connects Kozhikode to Kollegal in Karnataka State is the primary road link between these two districts. Topographically, after a narrow, flat coastal strip, the ground rises by around 900 m in reaching the Deccan Plateau. The 11.5 km long tow way stretch on NH 766 between Adivaram in Kozhikode district and Lakkidi in Wayanad district is the Thamarassery Churam of steep gradient with nine hairpin bends and through forestland. Each year, as the monsoon gathers strength, earth slips from the fragile slopes cause traffic snarls to blockages and also accidents. Extensive studies have revealed that it is not feasible to improve the width or geometry of this Ghat Section of the NH 766 to cater to the ever-increasing traffic on the already saturated route. Hence, the Government of Kerala (GoK) has decided to construct a four-lane tunnel road connecting Anakkampoyil, Kalladi and Meppadi to ease the congestion of the Thamarassery Ghat road and also to provide a reliable, safe all-weather road connectivity between Kozhikode and Wayanad districts.

The proposed project is formed by connecting existing MDR (Anakkampoyil-Muthappanpuzha-Marippuzha road) to SH 59 (Meppadi-Kalladi-Chooramala road) with a 4 lane tunnel road. The new connectivity is expected to bring development opportunities in industrial, agricultural and tourism sectors not only to the region, but also to the entire Malabar region, contributing the social and economic growth of the State.

The proposed project is to develop the 4 lane tunnel road connecting existing MDR (Anakkampoyil-Muthappanpuzha-Marippuzha road) to SH 59 (Meppadi-Kalladi-Chooramala road).Project proponent plan to notify as State Highway under the The Kerala Highway Protection Act 1991. In view of this, the project attracts EIA Notification 2006 and falls under 7 (f) Highways – B Category for which prior Environmental Clearance to be obtained from State Environmental Impact Assessment Auhority.

Approximately, 17.263 Ha of forest land is to be utilised for the project, out of which 16.269 Ha forest land is for underground usage and 0.994 Ha forest land is for overground usage. Hence, the project has obtained Stage I Clearance from MoEF&CC under the Forest (Conservation) Act, 1980. The project road is not located within the declared eco-sensitive zone of a wildlife sanctuary or a national park and not within 15 km from the boundary of such protected areas. Further, the project road is not located within areas connecting tiger reserves, notified by National Tiger Conservation

Authority. Hence, the project road does not require wildlife clearance under the Wildlife (Protection) Act, 1972.

1.2. Purpose of the Report

Proposed development of the tunnel road is generally intended to improve the connectivity between two districts which will in turn benefit in better interstate connectivity between Kerala and Karnataka. At the same time, it may likely create adverse impact on the surrounding environment. Tunnel road development and operation should, therefore, be planned with careful consideration of environmental impacts. Identification and assessment of potential environmental impacts should be an integral part of any project cycle. Environmental Impact Assessment (EIA) Report is most necessary to minimize all adverse environmental effects of this development project.

1.3. Identification of Project Proponent

Kerala Public Works Department (KPWD) is the Project Proponent of the subject project. GoK through KPWD has nominated M/s. Konkan Railway Corporation Limited (KRCL) as a Special Purpose Vehicle (SPV) for the implementation and execution of the proposed road project availing funds from Kerala Infrastructure Investment Fund Board (KIIFB).

The work of EIA Study has been entrusted by KRCL with M/s. KITCO Limited, through W.O No CP/PD-I/NP/AKMTR/01-2019 dated 25.09.2020 with confirming expansion of scope through W.O No CO/PD-I/NP-AKMPTR-EIA-2022 dated 12th January, 2023 being an accredited agency by QCI-NABET for Schedule 7f – Highways Category B is identified as the Project Proponent. KPWD is the statutory authority for designing, planning, monitoring, constructing and undertaking maintenance of public works of the State Government such as Government Buildings, Roads, Bridges etc.,

The project will be handled by Roads Wing of the KPWD. Roads wing deals with the planning, project preparation, construction, maintenance and arrangement of works of all State Highways and Major District Roads under the State. This wing is having its headquarters at Thiruvananthapuram and is under the control of a Chief Engineer who is assisted by a Deputy Chief Engineer, a Senior Finance Officer and supported by technical and other administerial staff. This wing have field offices with Circle offices at regional level, division offices at district level, sub-division offices at taluk level and Section offices at the lowest level.

There are three Circle offices under the roads wing namely South circle, Central circle and North circle each headed by a Superintending Engineer. Under each Circle offices there are division offices headed by an Executive Engineer. The sub-division offices are headed by Assistant Executive Engineer and Section offices are headed by Assistant Engineer.

The subject project is coming under Kozhikode division and Executive Engineer, Kozhikode-PWD Roads has been authorized as Nodal Officer for the project.

1.3.1. Contact Details of the Project Proponent

Table 0.1 provides the contact details of the project proponent.

Table 0.1. Details of the Project Proponent

Sl. No.	Particulars	Description
1	Contact Address	The Executive Engineer, Kozhikode-PWD Roads
2	Phone	+91 8086395101
3	Fax	N/A
4	E-mail ID	eeroadskkd@gmail.com

1.3.2. Project Implementing Organization

GoK through KPWD has entrusted KRCL as SPV for the execution of the project and hence, KRCL will be the Project Implementation Organization for this project. KRCL is a Public sector undertakings headquartered at CBD Belapur in Navi Mumbai that operates Konkan Railway and also undertakes other railway-tunnel related projects.

1.3.3. Project Consultants

KITCO Ltd, Kochi, an accredited agency by QCI-NABET for conducting EIA Studies for Highways is the project consultants for the preparation of Environmental Impact Assessment Report for the subject project. **Table 0.2** provides the contact details of the project consultant.

Table 0.2. Details of the Project Consultants

Sl. No.	Particulars	Description
1	Contact Address	The Managing Director, KITCO Ltd MM Gardens, Church Landing Road, Near Kerala Fine Arts Hall, Ernakulam 682016
2	Phone	(+91-484) 4129000, 6129000
3	E-mail ID	mail@kitco.in

1.4. Brief Description of the Project and its Importance

1.4.1. Nature of the Project

Government of Kerala has decided to construct a four-lane tunnel road connecting Anakkampoyil, Kalladi and Meppadi to ease the congestion of the Thamarassery Ghat road and also to provide a reliable, safe all-weather road connectivity between Kozhikode and Wayanad districts.

The project is construction of 8.735 km long four-lane tunnel road including approaches (from existing roads) for providing connectivity between Anakkampoyil-Kalladi-Meppadi in the Kozhikode and Wayanad districts of Kerala.

This project road will connect Anakkampoyil-Muthappanpuzha-Marippuzha road (MDR) to Meppadi-Kalladi-Chooramala road (SH-59) with a new tunnel road. Anakkampoyil and Maripuzha are located on south of the hill and whereas Meppadi is located to the north of the hill. On the southwestern side, the existing Kunnmangalam –Kattangal –Mukkam-Thirumbady- Anakkampoyil –Maripuzha MDR route facilitates traffic movement between Anakkampoyil and Kozhikode. The Meppadi-Kalladi-Chooralmala road which is of SH category, that takes off as a spur to the south of Meppadi is proposed to be intersected as the northern end of the project further leading to NH 766.

1.4.2. Size of the Project

The project stretch is new twin tube unidirectional tunnel road (2+2 Lane), which connects existing MDR (Anakkampoyil-Muthappanpuzha-Marippuzha road) to SH 59 (Meppadi-Kalladi-Chooramala road). The proposed length of the project alignment is 8.735km out of which 8.11km is tunnel road. The shape proposed for the tunnel section is D-shaped, having an internal area of about 102 Sq.m with height and width of about 9.04m and 11.7m respectively. Since the tunnel is approximately 8.0km, laybys are proposed at every 750 m to cater for a refuge to park. Layby section having an internal area of 135 Sq.m, width 16.3, and height 9.04m.

1.4.3. Location of the Project

The proposed tunnel road is of 8.735km length including approaches (from existing roads) for providing connectivity between Anakkampoyil-Kalladi-Meppadi in the Kozhikode and Wayanad Districts in Kerala. Geographically the project road/tunnel runs from south-west to north-east between latitudes of 11°27'2.04"N and 11°31'20.67"N and Longitude of 76° 6'5.61"E and 76° 8'1.38"E.

It traverses through 2 districts (Kozhikode and Wayanad), 2 Taluks and 4 revenue villages. Details are presented in **Table 0.3.**

Table 0.3. Location of the Project Tunnel Road

Sl.No	District	Taluk	Village	Survey Numbers
1.	Kozhikode	Thamarassery	Thiruvambady	1663-/2,/3/4, 1665-1/2, 1666-1/2/3/4/5/6 1667-1/5/7, 1662-/4/6, 1664-/1, 1674/1, 1673/1, 1671/1, 1672/1,1670/1, 1418pt
			Kodenchery/ Nellipoyil[dj1]	163pt
2.	Wayanad	Vythiri	Vellarimala	36pt,43pt,79pt,80pt,87pt,88pt.

1.4.4. Importance of the Project to the Region and the Country

The main access from Kozhikode district to Wayanad district is Thamarassery ghat road (NH 766) which is having sharp hair pin curves and steep gradients. This ghat road is not highly enduring due to the intensified traffic which causes many accidents at present. It is not technically feasible to widen the existing road since it passes through forest land and hilly terrain. The search of another alternate route to this ghat road was reached finally at this proposed tunnel road (Churam Badal Road). It is seen that the distance savings between destinations by this road project is very significant. The introduction of this new road will bring significant development opportunities in industrial, agricultural and tourism sectors not only to the local level, but also to the entire Malabar region and surrounding districts. Consequently it will account for the social and economic growth of the State.

The main objective of the project is to provide safe and efficient service levels to growing traffic movements and better connectivity to the northern Kerala. All road users will be benefited from the proposed improvement on account of comfort, safety and reduced vehicle-operating costs. The proposed tunnel road will also become a part of the major road network in the proposed Kochi – Bengaluru Industrial Corridor Region (KBIC Region). *

A significant economic benefit of the improvement project is generation of employment opportunities during the construction activities, which will be available to the people, including affected community. Besides, they will also draw benefits from the economic activities as a result of increased traffic flow and movement of vehicles. The project road will help in the economic upliftment of the entire region.

1.5. Environmental Regulations Applicable to the Project

1.5.1. Introduction

A review of the existing legislations and institutions relevant to this project at the national and state levels are presented in this section. Regulations concerning procedures and requirements that may directly concern the project, the capacity of the concerned institutions and their ability to successfully implement the environmental management measures have been addressed.

1.5.2. Environmental Regulations of Government of India

The Indian constitution makes environmental protection an explicit duty for every citizen by the statement, “It shall be duty of every citizen of India to protect and improve the environment including forests, lakes, rivers, wild life, and to have compassion for living creatures.” In addition, GoI has laid out various policy guidelines, acts and regulations pertaining to sustenance of environment and these have been presented in the following sections.

1.5.2.1. Environment (Protection) Act, 1986

The Environmental (Protection) Act, 1986 is the umbrella legislation providing for the protection of environment in the country. This Act provided for the Environment (Protection) Rules, which were formulated in 1986 and has lead to various other notifications.

1.5.2.2. EIA Notification, 2006

The EIA notification S.O.1533 dated 14th September, 2006 imposes certain restrictions and prohibitions on new projects or activities, or on the expansion or modernization of existing projects or activities based on their potential environmental impacts as indicated in the schedule to the notification, being undertaken in any part of India, unless prior environmental clearance has been accorded in accordance with the objectives of National Environment Policy as approved by the Union Cabinet on 18th May, 2006 and the procedure specified in the notification, by the Central Government or the State or Union territory Level Environment Impact Assessment Authority (SEIAA).

The notification has listed out the Projects or activities requiring prior environmental clearance under Category “A” and “B” based on the spatial extent of potential impacts, and the intensity of those impacts on human health and natural and manmade resources. Category “A” projects require prior environmental clearance from MoEF&CC on the recommendations of an Expert Appraisal Committee

* Kochi Bengaluru Industrial Corridor –Draft Perspective Plan for overall KBIC region – Draft Report, 2019

(EAC) and Category "B" projects require prior environmental clearance from State or Union territory Level Environment Impact Assessment Authority (SEIAA) on the recommendations of a State or Union Territory Level Expert Appraisal Committee (SEAC). In the absence of a duly constituted SEIAA or SEAC, a Category 'B' project shall be considered at the Central Level as a Category 'B' project.

New National Highways and expansion of National Highways greater than 100 km, involving additional right of way or land acquisition greater than 40m on existing alignments and 60m on re-alignments or by-passes is categorized as "A." All New State Highway projects; and State Highway expansion projects in hilly terrain (above 1,000 m AMSL) and or ecologically sensitive areas are categorized as "B." Any project specified in Category 'B' will be treated as Category A, if located in whole or in part within 5 km from the boundary of: (i) Protected Areas notified under the Wild Life (Protection) Act, 1972, (ii) Critically Polluted areas as notified by the Central Pollution Control Board from time to time, (iii) Eco-sensitive areas as notified under section 3 of the Environment (Protection) act, 1986, such as, Mahabaleshwar Panchgani, Matheran, Pachmarhi, Dahanu, Doon Valley, and (iv) inter-State boundaries and international boundaries:

the project proponent has applied ToR application for the EIA study to the MoEF&CC as Category B project and the same was considered in the 283rd meeting of Expert Appraisal Committee held on 9th – 10th December, 2021. The EAC concluded that the project does not fall under the ambit of the schedule of the EIA Notification, 2006, as amended and the proposal is returned in the present form**.**

Further, the project proponent has approached State Level Environmental Impact Assessment Authoirty, Kerala for ToR Approval under Township and Area Development Project considering the total area of construction for developing the road on the basis of following calculations.

1. Area of road as open cut i.e., open to sky (m^2) = 61,325m^2
2. Area of road within tunnel(m^2) = 4,86,600m^2 .

Thus the approximate area works out to 5,47,925m^2. The ToR application was considered by SEIAA Kerala in the 115th meeting dated 30th June, 2022 and approved the draft ToR with additional studies advised. The additional studies are incorporated in the EIA Report. While the project has been categorized as Township and Area Development project, the essential activities proposed is construction of a tunnel road. Hence the detailed EIA report has been aligned incorporating all essential information with respect to tunnel road construction attending to the specific impacts such as drainage, resource requirement, waste management etc., which are specific to importance for the highway construction activities as well. Now the proponent has decided to apply under category 7f Highways for obtaining Environmental Clearance.

1.5.2.2.1. Additional Requirements under EIA Notification, 2006

- For the projects involving clearance under Coastal Regulation Zone Notification, 2011, the Project Proponent shall submit the application with a CRZ map duly demarcated by one of the authorized agencies, showing the project activities, w.r.t. CRZ (at the stage of ToR) and the recommendations of the State Coastal Zone Management Authority (at the stage of EC). Simultaneous action shall also be taken to obtain the requisite clearance under the provisions of the CRZ notification, 2011 for the activities to be located in the CRZ*. Since the proposed project road does not fall in any of the CRZ categories, this provision is not applicable to the present project.

- For the projects to be located within 10 km of the National Parks, Sanctuaries, Biosphere Reserves, Migratory corridors of wild animals, the project proponent shall submit the map duly authenticated by Chief Wildlife Warden showing these features vis-à-vis the project location and the recommendations or comments of Chief Wildlife Warden thereon (at the stage of EC).†. No National Parks, Sanctuaries, or any migratory corridor of wild animals located within 10 km from the project road. For the projects located in critically polluted areas as notified by CPCB, the project proponent shall make available a copy of their application for the ToR to the concerned SPCB. The SPCB should either send its representative at the time of consideration of the proposal by the EAC, at the stage of appraisal of the project for prescribing ToR or consideration of EC or provide their written comments with respect to pollution load in terms of ambient air quality, water quality or solid/hazardous waste management‡. No critically polluted areas are located along the project road; hence, this provision is not applicable to the present project.

The Forest (Conservation) Act, 1980

The Forest (Conservation) Act, 1980 prohibits diversion of forestland for non-forest use. As amended in 1988, no State Government or Authority shall make such diversions except with the prior approval of the Central Government.

Section 2 of the Act restricts the State Government on the de-reservation of forests or use of forestland for non-forest purpose. Section 3 of the Act empowers the Central Government to constitute an Advisory Committee (to advice the Government on the proposals received by it for the use of forestland for non-forest purposes).

Approximately, 17.263 Ha of forest land is to be utilised for the project, out of which 16.269 Ha forest land is for underground usage and 0.994 Ha forest land is for overground usage. Hence, the project requires forest clearance from MoEF&CC through Kerala State Forest Department under Forest Conservation Act, 1980. Hence, this act is applicable for the project and Stage I clearance has been accorded by MoEF&CC for the subject work.

1.5.2.2.2. Applicability of Forest (Conservation) Act to Roadside Strip Plantations

Large-scale plantations have been taken up by different state governments under social forestry and other programmes along the linear strips of lands, which had been acquired by Government Departments like Railway, Irrigation, PWD, etc. for specific purposes like laying of roads, railway lines and canals. In order to have a better control and management of these linear patches, in many places these have been notified as protected forests. In the case of road projects, although the land is

* *S.O No. 3067 (E) dated 1st December 2009 of MoEF&CC. While CRZ Notificaiton,2019 has came in to force, the same has not been implemented in the State of Kerala since the CZMP for the State in line with said notification is to be approved by MoEF&CC.*

† *S.O No. 3067 (E) dated 1st December 2009 of MoEF&CC*

‡ *Circular dated 25th August 2009 of MoEF&CC*

under the control of the highways department, due to its protected status, clearance is required to cut roadside trees. Applicability of the provisions of the Forest (Conservation) Act, 1980 to the linear (road or canal side) plantations was modified by a notification from the GoI, MoEF&CC, dated 18th February 1998. The new notification recognizes that the spirits behind the Forest (Conservation) Act was conservation of natural forests and not strip plantations.

In the case of roadside plantations notified to be protected, the clearance now may be given by the concerned Regional Offices of the MoEF&CC, irrespective of the area of plantation lost. While issuing the approval, in place of normal provision for compensatory afforestation, the Regional Offices will stipulate a condition that for every tree cut at least three trees should be planted. If the concerned Regional Office does not accord the decision within 30 days of the receipt of fully completed application, the proponent agency may proceed with the widening / expansion under intimation to the State Forest Department and MoEF&CC.

In the case of roadside plantations not yet notified as protected forests, it will not attract the provisions of Forest (Conservation) Act, 1980 for the purposes of widening or expansion or re-alignment. However, permission from Divisional Forest Officers (DFOs) of Territorial Forest Division of each district is required for the cutting and transportation of trees along the road.

The Water (Prevention and Control of Pollution) Act, 1974

This provides for the prevention and control of water pollution and the maintaining and restoring of the wholesomeness of water. 'Pollution' means such contamination of water or such alteration of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to, create a nuisance or health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms.

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

The Air (Prevention and Control of Pollution) Act, 1981

This provides for prevention, control and abatement of air pollution. 'Air Pollution' means the presence of any 'air pollutant' in the atmosphere, which means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentrations as may be or tend to be injurious to human beings or other living creatures or plants or property or environment.

The KSPCB is empowered to set air quality standards and monitor and prosecute offenders under The Air (Prevention and Control of Pollution) Act, 1981. The project requires consent to establish from the State Pollution Control Board of Kerala as per the Air (Prevention and Control of Pollution) Act, 1981, since project involves operation of WMM Plants and Diesel Generator Sets.

The Noise Pollution (Regulation and Control) Rules, 2000

The ambient air quality standards in respect of noise for different areas/zones are specified in the Schedule of these rules. The State Government may categorize the areas into industrial, commercial, residential or silence areas/zones for the purpose of implementation of noise standards for different areas. As per these rules, an area comprising not less than 100 meters around hospitals, educational institutions and courts may be declared as silence area/zone.

The noise levels in any area/zone shall not exceed the ambient air quality standards in respect of noise as specified in the Schedule. The State Pollution Control Board is responsible for the enforcement of noise pollution control measures and the due compliance of the ambient air quality standards in respect of noise. The proposed project in its construction and operation phases may attract the provisions of these rules if the noise level from the construction machinery and the vehicles are above the standards.

The Ancient Monuments and Archaeological Sites and Remains Act, 1958 and its Amendments

According to this Act, area within the radii of 100 m and from 100 m to 300 m from the "protected area" are designated as "prohibited area" and "regulated area" respectively. No development activity (including building, mining, excavating, blasting) is permitted in the "protected area" and development activities likely to damage the protected property are not permitted in the "regulated area" without prior permission of the Archaeological Survey of India (ASI) if the site/remains/ monuments are protected by ASI or the State Directorate of Archeology, if these are protected by the State. No archaeologically protected monuments are present along the proposed alignment. Hence, provisions of the said act are not applicable for the project road.

The Explosives Act (& Rules), 1884 (revised in 1983)

This Act specifies regulations regarding the use of explosives and precautionary measures while blasting and quarrying. Provisions of these rules are applicable to this project.

Solid Waste Management Rules, 2016

The Solid Waste Management (SWM) Rules, 2016 establish consistent regulation governing collection, segregation, transportation and disposal of solid wastes throughout India. This rule is applicable for all kind of activities, which generate solid waste except industrial waste, hazardous waste, hazardous chemicals, bio medical wastes, *e*-waste, lead acid batteries and radio-active waste, which are covered under separate rules framed under the Environment (Protection) Act, 1986. The SWM Rules seeks to minimize the burden of landfills for the disposal of solid waste by adopting appropriate waste segregation and treatment technologies. Provisions of these rule is applicable for the project, as waste generation from labour camp and construction camp during construction phase is anticipated.

Construction and Demolition Waste Management Rules, 2016

To manage Construction and Demolition waste (C&D waste) in more effective way, the central government has made this rule to improve the collection, segregation, recycling, treatment and disposal of C&D waste in an environmentally sound manner. It emphasis on the roles and accountability of waste generators and various stakeholders, give thrust to segregation, recovery, reuse, recycle at source, address in detail the management of C&D wastes. Since, the project envisages dismantling of existing structures; clearing of site & vegetation, etc., provisions of this rule is applicable for the project.

Hazardous & Other Wastes (Management and Transboundary Movement) Rules, 2016

The Hazardous Wastes (Management, Handling and Trans boundary movement) Rules, 2016 and its subsequent amendments were created to provide 'cradle-to grave' or comprehensive guidance to the generators, transporters and operators of disposal facilities among others, and monitoring norms for State governments. As per the provisions of Rules, every occupier handling, or recycler recycling, hazardous wastes including facility for collection, reception, treatment, transport, storage and disposal of such wastes is required to obtain authorization from concerned State Pollution Control Board (SPCB) / Pollution Control Committee (PCC) in UT for any of the said activities.

E-Waste (Management) Rules, 2016

These rules shall apply to every manufacturer, producer, consumer, bulk consumer, collection centers, dealers, e-retailer, refurbished, dismantler and recycler involved in manufacture, sale, transfer, purchase, collection, storage and processing of e-waste or electrical and electronic equipment listed in Schedule I of this rule, including their components, consumables, parts and spares which make the product operational.

The project is likely to generate e-waste from the equipment and machineries used in construction activity. Hence, the said rule is applicable for the subject project.

Workers engaged in dismantling and handling of e-waste are to be issued with proper personal protective equipment (gloves, dust mask etc.) The recoverable items are to be sold only to authorized recyclers.

Plastic Waste Management Rules, 2016

These rules more effectively give thrust on plastic waste minimization, source segregation, recycling, involving waste pickers, recyclers and waste processors in collection of plastic waste fraction either from households or any other source of its generation or intermediate material recovery facility and adopt polluter's pay principle for the sustainability of the waste management system. During construction and operation stages, plastic wastes will be generated in various forms such as plastic wastes in drains, waste generated from construction camp etc., Hence provision of this rule is applicable to the proposed project.

Batteries (Management and Handling) Rules, 2001

These rules shall apply to every manufacturer, importer, re-conditioner, assembler, dealer, recycler, auctioneer, consumer and bulk consumer involved in manufacture, processing, sale, purchase and use of batteries or components thereof. Establishing construction camp may attract these kinds of activities and applicable to the subject project.

National Environmental Policy, 2006

This policy intends to mainstream environmental concerns in all developmental activities. The policy stresses on conservation of critical environmental resources, intra-generational and inter-generational equity, efficiency in environmental resource use and adoption of a precautionary approach.

Other Legislations

The other legislations relevant to the project include The Motor Vehicles Act, 1988, Workmen Compensation Act, 1923, The Public Liability Insurance Act, 1991, Contract Labour (Regulation & Abolition) Act, 1970, Minimum Wages Act, 1948, Payment of Wages Act, 1936, Equal Remuneration Act, 1979, Child Labour (Prohibition & Regulation) Act, 1986, The Building & Other Construction Workers (Regulation of Employment & Conditions of Service) Act, 1996 and the Cess Act of 1996.

1.5.3. Environmental Regulations of State Government

1.5.3.1. Kerala State Water Policy, 2007

Kerala State Water policy came into force in 2007 to prevent the exploitation of natural water. The policy aims to create greater social awareness about the rights and responsibilities in the use of water and to put in place better management practices in the utilization of water as it is an invaluable natural resource. The policy also ensures peoples participation in water sector within the framework of decentralized democratic institutions and to evolve suitable frameworks and strategies for the continuous up gradation of water environment.

1.5.3.2. Kerala Highway Protection Act, 1999

Kerala Highway Protection Act, 1999 provides protection and development of highways in the state as well as to prevent ribbon development along highways, encroachment. The Act prevents erection of building or any other permanent or temporary structure, balcony, porches, facades or projections on, over or overhanging along the highway. It also prevents occupation of highway for stacking building materials or goods of any other description, for parking automobiles for maintenance and repair, for exhibiting articles for sale, for erecting poles, awnings, tents, pandals, arches, platforms, rostrums, hoardings, display boards statues, monuments of all kinds, steps, ramps and other similar structures or stabling domestic animals and poultry and cultivation of any kind including horticulture or for any other purpose.

1.5.3.3. The Kerala Ground Water Control and Regulation Act, 2002

The Kerala Ground Water (Control and Regulation) Act, 2002 provides provisions for the conservation of Ground Water and for the regulation and control of its extraction and use in the State of Kerala. It also provides regulation and control of extraction and use in the State of Kerala. The law prevents erratic extraction of ground water, which may leads to undesired environmental problems. It also controls and regulates any form of development of ground water in the state of Kerala as it is considered as critical resource of the State.

1.5.3.4. Kerala State Environmental Policy, 2009

Kerala State Environmental Policy, 2009 ensures conservation of natural resources, including species, ecosystems and genetic wealth of the State. It also provides equitable access to natural resources to all sections of the society, particularly the poor, whose survival depends on the availability of natural resources, and to ensure sustainable and equitable use of environmental resources for meeting their basic needs of present as well as future generations. The policy ensures efficient use of environmental resources by reducing their consumption per unit of economic output, to minimize adverse environmental impacts. It provides measures to mitigate the damage already caused to the environment and the ecosystems by suitable restoration/ameliorative measures and, to prevent and control further deterioration of land, biomass, water and air, which constitute our basic life support systems. Promulgate guidelines and policies for the waste disposal especially for those emanating from industrial and municipal sources.

1.5.4. International Agreements

India is signatory to a number of multilateral environment agreements (MEA) and conventions. An overview of some of the major multilateral environment agreements and India's obligations under these is presented below. These are discussed in the following sections.

1.5.4.1. Convention on International Trade in Endangered Species (CITES) 1973

The aim of CITES is to control or prevent international commercial trade in endangered species or products derived from them. CITES does not seek to directly protect endangered species or curtail development practices that destroy their habitats. Rather, it seeks to reduce the economic incentive to poach endangered species and destroy their habitat by closing off the international market. India became a party to the CITES in 1976.

1.5.4.2. Montreal Protocol on Substances that deplete the Ozone Layer 1987

The Montreal Protocol to the Vienna Convention on Substances that deplete the Ozone Layer came into force in 1989. The protocol set targets for reducing the consumption and production of a range of ozone depleting substances (ODS). In a major innovation the Protocol recognized that all nations should not be treated equally. The agreement acknowledges that certain countries have contributed to ozone depletion more than others. It also recognizes that a nation's obligation to reduce current emissions should reflect its technological and financial ability to do so. Because of this, the agreement sets more stringent standards and accelerated phase-out timetables to countries that have contributed most to ozone depletion. India acceded to the Montreal Protocol along with its London Amendment in September 1992. The Ministry of Environment, Forests and Climate Change, Government of India has established an Ozone Cell and a steering committee on the Montreal Protocol to facilitate implementation of the India Country Program, for phasing out ODS production by 2010. To meet India's commitments under the Montreal Protocol, the Government of India has also taken certain policy decisions.

2. Goods required to implement ODS phase-out projects funded by the Multilateral Fund are fully exempt from duties. This benefit has been also extended to new investments with non-ODS technologies.

3. Commercial banks are prohibited from financing or refinancing investments with ODS technologies

The Gazette of India on 19 July 2000 notified rules for regulation of ODS phase-out called the Ozone Depleting Substances (Regulation and Control) Rules, 2000. They were notified under the Environment (Protection) Act, 1986. These rules were drafted by the Ministry of Environment, Forests and Climate Change, Government of India following consultations with industries and related government departments.

1.5.4.3. Basel Convention on Trans boundary Movement of Hazardous Wastes, 1989

Basel Convention, which entered into force in 1992, has three key objectives:

4. To reduce trans- boundary movements of hazardous wastes;
5. To minimize the creation of such wastes; and
6. To prohibit their shipment to countries lacking the capacity to dispose hazardous wastes in an environmentally sound manner.

India ratified the Basel Convention in 1992, shortly after it came into force. The Indian Hazardous Wastes Management Rules Act 1989 encompasses some of the Basel provisions related to the notification of import and export of hazardous waste, illegal traffic, and liability.

1.5.4.4. UN Framework Convention on Climate Change (UNFCCC), 1992

The primary goals of the UNFCCC were to stabilize greenhouse gas emissions at levels that would prevent dangerous anthropogenic interference with the global climate. The convention embraced the principle of common but differentiated responsibilities which has guided the adoption of a regulatory structure. India signed the agreement in June 1992, which was ratified in November 1993. As per the convention the reduction/limitation requirements apply only to developed countries. The only reporting obligation for developing countries relates to the construction of a GHG inventory. India has initiated the preparation of its First National Communication (base year 1994) that includes an inventory of GHG sources and sinks, potential vulnerability to climate change, adaptation measures and other steps being taken in the country to address climate change. The further details on UNFCC and the Kyoto Protocol are provided in Atmosphere and climate chapter.

1.5.4.5. Convention on Biological Diversity, 1992

The Convention on Biological Diversity (CBD) is a legally binding, framework treaty that has been ratified until now by 180 countries. The CBD has three main thrust areas: conservation of biodiversity, sustainable use of biological resources and equitable sharing of benefits arising from their sustainable use. The Convention on Biological Diversity came into force in 1993. Many biodiversity issues are addressed in the convention, including habitat preservation, intellectual property rights, bio-safety, and indigenous peoples' rights. India's initiatives under the Convention are detailed in the chapter on Biodiversity. These include the promulgation of the Wildlife (Protection) Act of 1972, amended in 1991; and participation in several international conventions such as CITES.

1.5.4.6. UN Convention on Desertification, 1994

Delegates to the 1992 UN Conference on Environment and Development recommended establishment of an intergovernmental negotiating committee for the elaboration of an international convention to combat desertification in countries experiencing serious drought and/or desertification. The UN General Assembly established such a committee in 1992 that later helped formulation of Convention on Desertification in 1994. The convention is distinctive as it endorses and employs a bottom-up approach to international environmental cooperation. Under the terms of the convention, activities related to the control and alleviation of desertification and its effects are to be closely linked to the needs and participation of local land-users and non-governmental organizations. Seven countries in the South Asian region are signatories to the Convention, which aims at tackling desertification through national, regional and sub-regional action programs. The Regional Action Program has six Thematic Program Networks for the Asian region, each headed by a country task manager. India hosts the network on agro-forestry and soil conservation.

1.5.4.7. International Tropical Timber Agreement 1983, 1994

The ITTO established by the International Tropical Timber Agreement (ITTA), 1983, came into force in 1985 and became operational in 1987. The ITTO facilitates discussion, consultation and international cooperation on issues relating to the international trade and utilization of tropical timber and the sustainable management of its resource base. The successor agreement to the ITTA (1983) was negotiated in 1994, and came into force on 1st January 1997. The organization has 57 member countries. India ratified the ITTA in 1996.

1.5.5. Summary of Clearances to be obtained under Environmental Regulations

Table 0.4. Environmental Permits / Approvals Required for the Sub-project

Sl. No	Type of Clearance	Statutory Authority	Applicability	Project Stage	Responsibility
1.	Forest Clearance Under Forest Conservation Act, 1980	Kerala State Forest Department and MoEF&CC	Diversion of Forest land	Pre construction	KPWD & KRCL
2.	Tree felling permission	Kerala State Forest Department	Felling of trees	Pre construction	KPWD & KRCL
3.	Consent to Establish under The Air (Prevention & Control of Pollution) Act, 1981	Kerala State Pollution Control Board	For establishing WMM plants, crushers and batching plants	Construction (Prior to work initiation)	Concessionaire / Contractor
4.	Consent to Establish under The Water (Prevention & Control of Pollution) Act, 1974	Kerala State Pollution Control Board	For discharging of domestic waste water through soak pit	Construction (Prior to work initiation)	Concessionaire / Contractor
5.	Permission to store Hazardous Materials under Hazardous Waste (Management and Handling) Act 1989	Kerala State Pollution Control Board	Storage and Transportation of Hazardous Materials and Explosives	Construction (Prior to work initiation)	Concessionaire / Contractor
6.	Explosive license under The Explosives Act (& Rules), 1884 (revised in 1983)	Chief Controller of Explosives, Petroleum & Explosive Safety Organization	Storage of explosive materials	Construction (Prior to work initiation)	Concessionaire / Contractor
7.	PUC certificate for vehicles for construction under Central Motor and Vehicle Act 1988	Transport Department of Kerala	For all construction vehicles	Construction (Prior to work initiation)	Concessionaire / Contractor

Sl. No	Type of Clearance	Statutory Authority	Applicability	Project Stage	Responsibility
8.	Quarry lease deeds and license under The Mines Act, 1958	Mines and Geology Department of Kerala	Quarrying and borrowing operations	Construction (Prior to work initiation)	Concessionaire / Contractor

1.5.6. Details of Litigations Pending Against the Project

No litigations are pending against the project.

1.6. Environmental Compliance Status for the Existing Project

1.6.1. Status of Environmental Clearance

The project is development of new tunnel road connecting Anakkampoyil-Kalladi-Meppadi and hence, environmental clearance was not obtained earlier.

1.7. Environmental Standards and Code of Practices

1.7.1. National Environmental Standards Relevant to the Project

1.7.1.1. Standards for Air Quality

National Ambient Air Quality Standards are presented in **Annexure 1**. While conducting environmental monitoring during the construction stage, the ambient air quality results should be compared with these standards and if results are found to be exceeding the standards, then necessary mitigation measures should be carried out. Further, air quality modeling should be conducted for construction and operation stages of the project and mitigation measures should be carried out where air pollution is expected to be exceeding the standards.

The vehicles used for construction should meet the emission standards set by CPCB, which are presented as **Annexure 1**.

1.7.1.2. Standards for Noise Level

National Ambient Air Quality Standards for noise are presented as Annexure 2. While conducting environmental monitoring during the construction stage, the noise level results should be compared with these standards and mitigation measures should be carried out if noise levels are exceeding the standards. Further, based on noise level modeling for sensitive receptors, if the traffic noise during the operation stage of the project is expected to exceed the standards, then noise barriers should be constructed at those locations. The Central Pollution Control Board (CPCB) has specified that the maximum permissible sound pressure level for new diesel generator (DG) sets with rated capacity up to 1000 KVA, manufactured on or after the 1st January, 2005 shall be 75 dB(A) at 1 m from the enclosure surface. The diesel generators used for the project should meet this noise limit.

Further, the vehicles used for construction should meet the noise limits set by CPCB, which are presented as Annexure 2**.**

1.7.1.3. Standards for Water Quality

National standards for drinking water (IS: 10500) are presented as Annexure 3**.** National Standards for inland surface waters subject to pollution are presented as Annexure 4**.** During environmental monitoring, groundwater quality results should be compared with IS: 10500 and surface water quality results should be compared with water Qulity criteria of CPCB. Pollution sources should be identified and mitigation measures should be carried out where water pollution is exceeding the standards.

National standards for discharge of effluents in presented as **Annexure 5** Any effluent discharge from the construction camps should meet these standards.

1.7.1.4. Standards for Sampling and Analysis of Air and Water

Various Indian Standards (IS) published by the Bureau of Indian Standards for sampling and analysis of air and water should be followed of the laboratories conducting environmental monitoring of the project.

1.7.2. Codes of Practice of Indian Road Congress

Codes of Practice of Indian Road Congress (IRC), particular to environmental issues, which are relevant to the proposed project. These guidelines should be followed by the implementing agency during construction.

1.8. Scope of the Study

1.8.1. Scope Identified by the Project Proponent

Scope of the present EIA study includes the following:

- Delineating the Project Impact Zone (project's deemed area of influence) by reviewing the project activities.
- Establishing the existing environmental setting of the Project Impact Zone (PIZ) based on information obtained from primary data and compilation of secondary data.
- Identifying and evaluating the potential environmental impacts of the project during pre-construction, construction and operational phases and formulating appropriate mitigation measures.
- Identifying and evaluating various alignment options to minimize impacts on environmental and social profile of the PIZ.
- Identifying the requirements of various environmental regulations applicable to the project and identifying the environmental clearances required for the project.
- Preparation of an effective Environmental Management Plan (EMP) including an Environmental Monitoring Plan and proposing an institutional framework for proper implementation and monitoring of mitigation measures.
- Preparation of cost estimates for the implementation of mitigation measures suggested in the EMP, including the Environmental Monitoring Plan.

1.9. Approach and Methodology

The EIA report has been prepared and presented as per requirements of the Environmental Impact Assessment Notification, 2006 of MoEF&CC under the Environment Protection Act, 1986. The guidelines of the Indian Road Congress (1989) and Environmental guidelines for Rail / Road / Highway/Township and Area Development projects of MoEF&CC have also been followed.

The EIA process involves a number of steps in a logical sequence to be followed in order to have a clear insight into each and every aspect of the project. The findings of the Environmental Impact Assessment provided important feedback to the design / technical team especially in terms of the environmentally sensitive areas, utilities / facilities affected and drainage patterns. It helped to modify the designs at locations where impacts had to be avoided and incorporate mitigation measures wherever the impacts were unavoidable due to other constraints. The major steps and their sequence adopted for the EIA of the present study are as follows:

1.9.1. Environmental Screening

The Environmental Impact Assessment of the project tunnel road began with the adoption of an Environmental Screening procedure during the feasibility stage. The purpose of the screening was to review the project activities and broadly identify the key environmental issues related to the project such as environmentally sensitive receptors along the alignment, change of land use; impacts on surface water bodies, availability of borrow areas, impacts on community facilities, impacts on ecologically sensitive areas, etc., The information gathered during the screening process helped in identifying the areas of concern along the stretch and critical issues to be studied in detail.

1.9.2. Scoping

The scope of this assessment was determined based on the EIA Technical Guidance Manual issued by MoEF&CC, the scope of work as defined in work order, earlier experience of the Consultant on similar projects and discussion with qualified NABET experts. In addition, critical environmental issues identified during the screening process were also added to the scope of the study.

1.9.3. Delineation of Project Impact Zone

To study the impacts of the project, two major zones have been identified that shall give a fair idea of the impact on the project corridor:

- **Direct Impact Zone (DIZ):** This consists of a strip of land on either side of the centre line of the proposed alignment. 500 m width on either side of the centre line has been adopted for a detailed inventory of environmental features.
- **Indirect Impact Zone (IIZ):** This consists of a strip of land of 15 km width on either side of the proposed carriageway. Here, the existence of sensitive features was identified and possible impacts on them due to the project corridor were assessed.

1.9.4. Reconnaissance Surveys

The environmental and the design consultants visited the project area and information on each kilometer was collected using formats specifically prepared for each environmentally sensitive feature. A detailed tree enumeration for the areas where tree cutting is warranted was also carried out. Identification of forest land along the alignment was conducted with forest officials. A field level assessment of ecology and biodiversity of the study area was also conducted with the help of experts in the subject field.

1.9.6. Baseline Environmental Monitoring

Environmental monitoring was carried out for determination of ambient air quality, water quality, soil quality and noise level at various locations along the proposed alignment to establish the baseline status of these environmental parameters along the project area.

1.9.7. Establishing Baseline Environmental Profile

Documentation of the baseline conditions was completed as per the MoEF&CC guidelines. The data collected through the screening exercise, reconnaissance surveys and environmental monitoring were entered into specific data entry formats for ease of analysis. Qualitative analysis was also carried out for parameters requiring descriptive data. Baseline environmental profile of the project impact zone was established by the compilation of all the above mentioned information.

1.9.5. Secondary Data Collection

Secondary informations were collected from Survey of India Topo Sheets, District Planning Maps, Forest Working Plans, District Gazetteers, District Census Handbooks and other Government publications as well as earlier project reports prepared for the project region. Data on different meteorological parameters for the project area was collected from the India Meteorological Department.

1.9.8. Identification and Evaluation of Potential Impacts

Impacts of the project on various environmental components were identified at pre-construction, construction and operation phases of the project on the basis of assessment of proposed project activities and analytical review of baseline environmental status of the project impact zone. Further, the impacts were categorized into permanent or temporary and highly significant, moderately significant, less significant and non-significant based on the character and magnitude of impacts.

1.9.9. Identification and Evaluation of Alternates Considered

Various alternatives were assessed during the entire process of the study and a detailed study on identified alternatives were carried out during feasibility stage to minimize the impacts on environmental and social profile of the project impact zone.

1.9.10. Identification of the Requirements of Environmental Regulations

Various government policies, laws, regulations and guidelines applicable to the project were reviewed with respect to identified environmental impacts. This established the need of various environmental clearances required for the project from respective government agencies.

1.9.11. Integration of Impacts in the Design Process

The environmental impacts identified through the earlier tasks were used in the design formulation process to integrate environmental issues and for early identification of suitable mitigation measures. This task helped in identification of the required shifts in alignment based on environmental sensitive features and cultural resources along proposed alignment. It also helped in finalizing the bypass alignments.

1.9.12. Preparation of Environmental Management Plan

An Environmental Management Plan (EMP) has been prepared suggesting various mitigation measures to avoid or minimize the impacts of the project on the environment during the pre-construction, construction and operation phases. Responsibilities have been assigned for the various actions identified to limit the adverse impacts of the project. An environmental monitoring plan and an institutional framework have been proposed as part of the EMP for proper implementation and monitoring of mitigation measures. The cost for implementing the proposed environmental mitigation measures and carrying out the environmental monitoring has been worked out and is presented as part of the EMP for necessary budgetary allocations as part of the project cost.

Chapter 2. Project Description

2.1 Broader Details of the Project and Location

2.1.1. Type of the Project

The present project covering the stretch of 8.735 km, four lane tunnel road connecting Anakkampoyil-Kalladi-Meppadi in Kozhikode and Wayanad districts of Kerala State. i.e., this project is formed by connecting existing MDR (Anakkampoyil-Muthappanpuzha-Marippuzha road) at Anakkampoyil side and SH 59 (Meppadi-Kalladi-Chooramala road) at Meppadi side, with a tunnel road.

2.1.2. Size of the Project

The project stretch is new Twin Tube Unidirectional Tunnel Road (2+2 Lane), which connects existing MDR (Anakkampoyil-Muthappanpuzha-Marippuzha road) at Anakkampoyil side and SH 59 (Meppadi-Kalladi-Chooramala road) at Meppadi side. The proposed length of the project alignment is 8.735 km. The shape proposed for the tunnel section is D-shaped. Since the tunnel is approximately 8.1 km laybys are proposed at every 750 m to cater for a refuge to park vehicles in case of any emergencies. Crosspassages at every 300m are proposed.

2.1.3. Location of the Project

The proposed tunnel is a 8.735 km long 4-lane Tunnel Road including approaches (from existing roads) for providing connectivity between Anakkampoyil-Kalladi-Meppadi in the Kozhikode and Wayanad Districts in Kerala. Geographically the project road / tunnel runs from south-west to north-east between lattitudes of 11°27'2.04"N and 11°31'20.67"N and Longitude of 76° 6'5.61"E and 76° 8'1.38"E.

It traverses through 2 districts and 2 Taluks. Details of the same is presented in the following table.

Table 0.1. Location of Project Tunnel Road in terms of Revenue Administrations

Sl.No	District	Taluk	Village	Survey Numbers
1.	Kozhikode	Thamarassery	Thiruvambady	1663-/2,/3/4, 1665-1/2, 1666-1/2/3/4/5/6 1667-1/5/7, 1662-/4/6, 1664-/1, 1674/1, 1673/1, 1671/1, 1672/1,1670/1, 1418pt
			Kodenchery/ Nellipoyil	163pt
2.	Wayanad	Vythiri	Vellarimala	36pt,43pt,79pt,80pt,87pt,88pt.

1. Location map of the project road is presented as **Figure 0-2**.

2. Key Plan of the project road in Survey of India Toposheets is presented as Annexure 7**.** This map shows the nature of terrain, drainage and other geographical features.

3. Satellite imagery of the project area within 15 km on either side of the project showing environmental sensitive areas is presented as **Annexure 8**.

4. Alignment Plan with revenue administration boundaries in is presented as **Annexure 9.**

5. Land use map of the project area based on recent satellite imagery is presented as Annexure 10**.**

6. Detailed ground surveyed map showing the existing features falling within the right of way of the project road is presented as Annexure 11**.**

Start Point (km 0+000)

End Point (km 8+735)

Irunvanjipuzha

Location of South Portal of Tunnel

Chooralmala Hill Range

Figure 0-1. View of the Project Tunnel Road Location

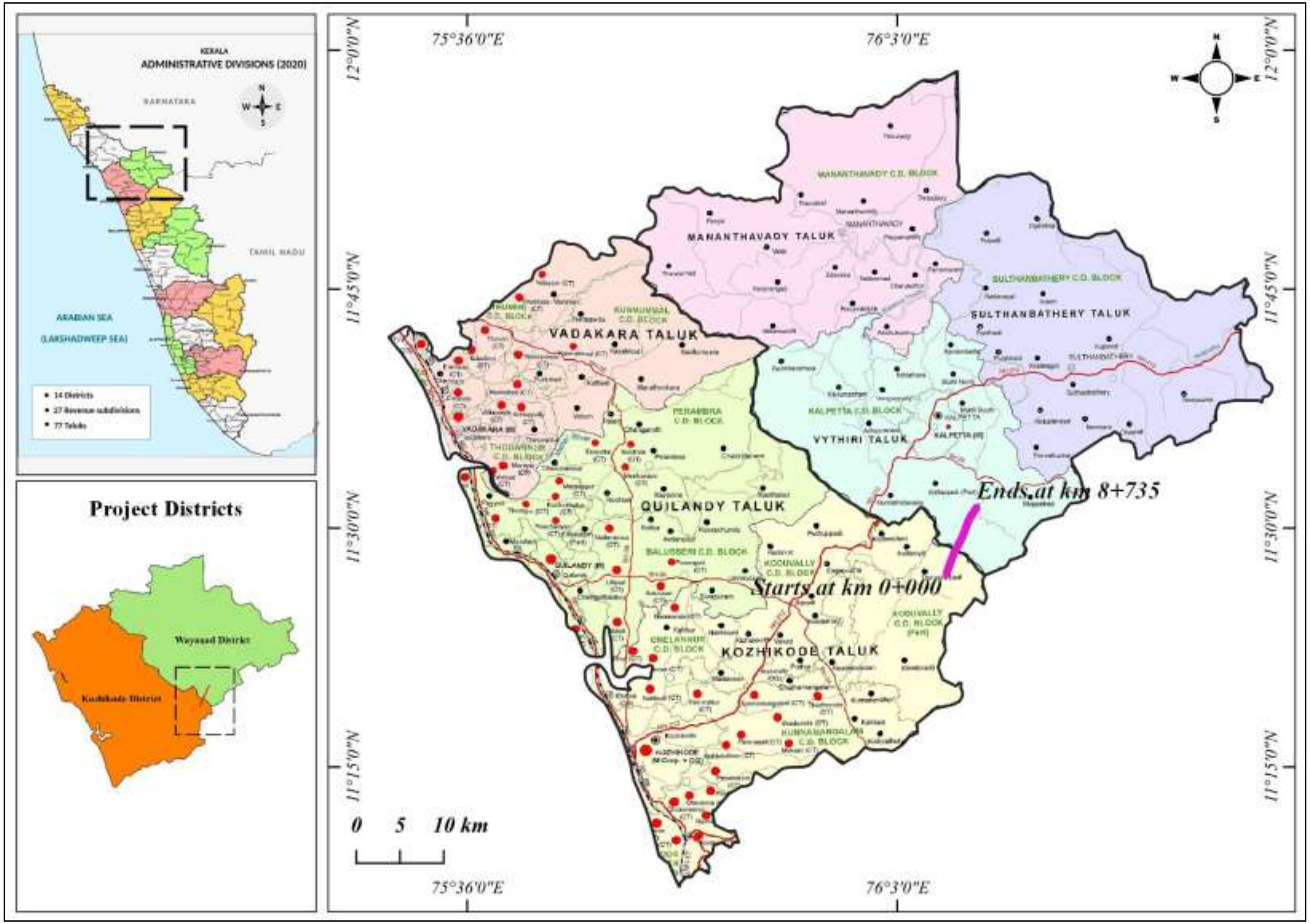


Figure 0-2. Location Map of the Project Tunnel Road

2.2. Need for the Project (Relevance of the Project)

The proposed project is formed by connecting existing MDR (Anakkampoyil-Muthappanpuzha-Marippuzha road) at Anakkampoyil side and SH 59 (Meppadi-Kalladi-Chooramala road) at Meppadi side with a tunnel road. The new connectivity is expected to bring development opportunities in industrial, agricultural and tourism sectors not only to the region, but also to the entire Malabar region contributing for the social and economic growth of the state of Kerala.

The main objective of the project is to provide safe and efficient service levels to growing traffic movements and better connectivity to the region.. The proposed tunnel will also become a part of the major road network in the proposed Kochi – Bengaluru Industrial Corridor Region (KBIC Region).

2.2.1. Need for Improvements of the Project Road

The National Highway NH-766 connecting Kozhikode & Muthanga passes through Thamaraserry ghat has a very steep gradient and sharp horizontal curves in the alignment. NH-766 comprises of a two-lane bituminous carriageway with earthen shoulder on either side of it. Being the primary connectivity between Kozhikode and Wayanad Districts, the Highway is over-saturated with very high density of traffic. Widening or smoothening of geometry of the existing Thamaraserry Ghat road is not feasible. Also, it is not feasible to develop alternate alignments to the north and west of the Ghat road as Forest land would have to be extensively diverted for the same. Thus the proposal of providing an alternate connectivity via Anakkampoyil-Meppadi is revalidated.

2.3. Project Details

2.3.1. Pre Construction Phase

2.3.1.1. Land Acquisition

Approximately 7.482 ha of additional land is to be required for the project. 10 ha of additional land is supposed to be acquired for muck disposal. Approximately, 17.263 ha of forest land is to be utilised for the project, out of which 16.269 ha forest land is for underground usage and 0.994 ha forest land is for overground usage. Hence, the impacts of land acquisition are addressed in the present study.

2.3.2. Activities for Site Preparation

2.3.2.1. Diversion of Forest Land

The project road passes through reserved and protected forests. Hence, sufficient care has been taken during design stage to minimise the impact on forestland by proposing a tunnel road. As per the proposed design, Approximately, 17.263 ha of forest land is to be utilised for the project, details of the same is presented as **Table 0.2**.

Table 0.2. Details of Forest Area proposed to be diverted for the Project

Sl. No.	District	Village	Forest Area (ha)	Forest Area village wise (ha)
1	Kozhikode	Thiruvambadi	7.956	0.052
2		Kodencherry /Nellipoyil		7.903
3	Wayanad	Muppainad/ Vellarimala	9.307	5.104
4		Meppadi/ Kottapadi		4.203
5	**Total**		**17.263**	**17.263**

2.3.2.2. Tree Cutting

The project development involves cutting and removal of a total number of 177 trees, including 103 trees from forestland and 74 trees from private land (see Annexure 15 for species-wise and girth class-wise enumeration of trees in the development sites). The construction of road/bridge in Anakkampoil area involves removal of 103 trees from forestland (covering also the riparian belts of Iruvazhanjipuzha) belonging to 27 species, of which the majority is constituted by *Melicope lunu-ankenda* (16 trees) followed by *Macaranga peltata* (15 trees) and *Artocarpus heterophyllus* (12 trees). Among the affected trees, nine species (*Baccaurea courtallensis*, *Cynometra travancorica*, *Elaeocarpus munronii*, *Flacourtia montana*, *Myristica malabarica*, *Palaquium ellipticum*, *Reinwardtiodendron anamalaiense*, *Syzygium mundagam* and *Vateria indica*) are endemic to the Western Ghats. *Cynometra travancorica* is Endangered, *Myristica malabarica* and *Vateria indica* are Vulnerable, and *Elaeocarpus munronii* is Near Threatened as per the IUCN Red List of Threatened Species. Further, it requires removal of 44 trees (belonging to 10 species) from private land holdings of Anakkampoil area and 30 trees (covering seven species) from Meppadi area. Of the 44 trees in Anakkampoil area, majority is formed by *Vateria indica* (10 trees) followed by *Macaranga peltata* (9 trees) and four trees each of *Tectona grandis, Lagerstroemia macrocarpa* and *Artocarpus heterophyllus*. Whereas, majority of the affected trees in Meppadi area is formed by *Tectona grandis* (13 trees) followed by *Macaranga peltata* (5 trees). *Tectona grandis* is Endangered, and *Vateria indica* and *Dalbergia latifolia* are Vulnerable as per IUCN Red List; *Lagerstroemia macrocarpa* and *Vateria indica* are endemic trees.

2.3.2.3. Cutting of Earth

Total volume of earth to be cut is 1916753 Cum.

2.3.2.4. Filling

Total quantity of filling material required for project is 91261.70 Cum.

2.3.3. Restriction / Limitation from Environmental Aspect

Table 0.3. Details of Restriction / Limitation from Environmental Aspect

Sl. No.	Description	Remarks
1	By district administration, State or Central for any construction activities	There are no restriction by district administration / State / Central for the construction activities
2	Due to the proximity to forest	Prior clearance to be obtained from Dept. of Forest / MoEFCC for the forest land to be utilized for the project
3	Due to proximity to WLS	There are no wildlide sanctuaries within 15 km radii of the project alignment. Hence, not applicable
4	Due to the proximity to Dam	Karapuzha Dam is the nearest Dam / Reservoir close to the project alignment and situated around 11 km away from the project alignment. Hence, not applicable
5	Due to the proximity to Eco-Sensitive Area of Western Ghat	As per the S.O. 5135(E) [03.10.2018] Fourth Draft Notification dated 03.10.2018 on ESA for Western Ghats by MoEF&CC, in cases of diversion of forest land for non-forestry purposes in the Eco-sensitive Area, all information of the project, from application stage to approval shall be placed in the public domain on the website of the Ministry of Environment, Forest and Climate Change and of the Forest Department of the respective States. Details of ESA is presented in **Sec: 0**

2.3.4. Accident Data

Summary of accident data for last 10 years for the project influenced area are collected from Kerala Police and is presented in **Table 0.4.**

Table 0.4. Summary of Accident Data for Last Ten Years[*]

Year	Injury	Grevious Injury	Died	Total	% Increase
2011	46	56	11	113	-
2012	106	129	26	261	130.97%
2013	41	52	10	103	-60.354
2014	49	65	17	131	27.18%
2015	46	70	9	125	-4.58%
2016	29	65	18	112	-10.40%
2017	46	86	18	150	33.93%
2018	30	71	12	113	-24.67%
2019	40	80	17	137	21.24%
2020	13	45	5	63	-54.01%
Total	**446**	**719**	**143**	**1308**	**6.57**

[*]Source: Vol I: Main Report

2.4. Improvement Proposals

Improvement proposals were prepared for the project and presented in the following sections. Summary of improvement proposals are presented in **Table 0.5.**

Table 0.5. Summary of Improvement Proposals*

Sl No	Chainage (km)		Length (m)	Remarks
	From	To		
1	0+000	0+100	100	Merging of 2 lane to 4 Lane + PS – Main Road
2	0+100	0+215	115	4 Lane + PS (Main Road) with Service on both side
3	0+215	0+310	95	4 Lane + PS (Main Road) with Service on RHS side
4	0+310	0+430	120	120m long, two separate Bow String Bridges (in each traffic direction) across Iravnjipuzha
5	0+430	0+510	80	4 Lane + PS - Main Road
6	0+510	8+540	8030	4 Lane ‘D’ Shape unidirectional Twin Tube Tunnel
7	8+540	8+620	80	Cut & Cover – unidirectional Twin Tube Tunnel
8	8+620	8+735	115	Merging of 4 lane to 2 Lane + PS – Main Road

2.4.1. Tunnel

Twin Tube Tunnel of 2 Lane in each traffic direction has been proposed from Chainage from km 0+510 to km 8+620.

2.4.1.1. Topography and Geology

The proposed tunnel alignment is 8.11 km long connecting Meppadi and Anakkampoyil. The tunnel passes through Charnockite and its variants in major portion of the alignment and through Hornblende Gneiss formations in northern part of the tunnel alignment. In the upper stretches of the tunnel alignment near the north portal weak formation consisting of completely weathered rock and overburden soil is encountered (Vol. 1: Main Report).

With respect to the geology and stratigraphy of the region, the alignment has been divided into 3 major parts.

- Part 1: km 0+510 to km 6+650 (Majorly Charnockite rock formation)
- Part 2: km 6+650 to km 8+420 (Majorly Gneiss rock formation)
- Part 3: km 8+420 to km 8+ 620 (Majorly completely weathered rock and overburden soil).

2.4.1.2. Salient Features about the Tunnel

The shape of the tunnel is proposed as D-shaped along major portion of the alignment (between km 0+510 to km 8+540) where charnockite and gneiss formations are observed. For the remaining stretch of the tunnel alignment, cut and cover tunnel is proposed to cater to the presence of weak formations on the north portal side. Cut and cover tunnel is proposed between chainage km 8+540 to km 8+620.

*Source: Vol I: Main Report

Since the tunnel is approximately 8.1 km long, lay-bys are proposed at every 750 m to cater for a refuge to park vehicles in case of any emergencies. Cross- passages at every 300m are proposed.

Tunnel niches with modified horse-shoe shape has been proposed in between two tubes at chainage km 1+800 and km 7+300 to house Electrical Substations inside the tunnel.

Drainage pipe of 400 mm dia running along the length of the tunnel has been proposed between chainage km 0+510 to km 6+650 to account for seepage envisaged from Kalladi river flowing above the alignment. Water proofing measures such as PVC water proofing membrane, geotextile and geo composite has been proposed around the tunnel lining to prevent seepage in to the tunnel.

Salient features of the tunnel is as follows:

- Twin tube Tunnel of 2 lane in each traffic direction
- **Length:** 8.110 km for Four-lane traffic (Two tubes of 2 lane each-unidirectional)
- **Shape (cross-section) of Tunnel:** D-shaped, fully lined.
- **Finished width:** 10.00 m at road level. (8.0m pavement and 1.0m footpath on both sides) in each direction
- **General altitude of ground at tunnel:** 701m (South) to 865m (North) wherein highest altitude in-between is 1831m above mean sea level
- **General altitude of the tunnel profile:** 679m (South) to 852m (North) above mean sea level
- **Designated vehicular speed:** 80 km/h (50 mph)
- **Geology of tunneling media:** The tunnel passes through Charnockite and its variants in major portion of the alignment and through Hornblende Gneiss formations in northern part of the tunnel alignment.
- **Overburden:** Maximum, approximately 1,080 metres (3542 ft), average more than 600 m (1,970 ft).
- **Lay-bys with width** 14.0m width (12.0m pavement and 1.0m footpath on both sides) in each direction have been proposed at every 750m interval to cater for a refuge to park vehicles in case of any emergencies.
- **Cross-passages** between the tunnel at every 300m shall be provided to divert the traffic through emergency times.
- **Construction technique:** Drill & Blast with NATM

2.4.1.3. Tunnel Support System

For the D-shaped tunnel section, Layby section, Cross Passage section between Chainage km 0+510 to km 0+700 and km 8+300 to km 8+400, initial lining of 100 mm thick steel fibre reinforced shotcrete with 25 mm dia rock bolts of 4 m length at 2 m c/c spacing both ways and final lining of 300 mm thick fibre reinforced cement concrete is proposed.

From km 0+700 to km 8+300, , initial lining of 50mm thick steel fibre reinforced shotcrete with 25mm dia rock bolts 4m long rock-spot bolts in arch portion both ways and final lining of 300 mm thick fibre reinforced cement concrete is proposed.

From km 8+400 to km 8+480, initial lining of ISMB 200 at 1.0 m c/c spacing with steel fibre reinforced shotcrete and final lining of 300mm thick fibre reinforced cement concrete is proposed.

From km 8+480 to km 8+540, initial lining of ISMB 200 at 0.5m c/c spacing with steel fibre reinforced shotcrete and final lining of 300mm thick fibre reinforced cement concrete is proposed.

From km 8+540 to km 8+620, 900mm thick RCC with ISMB 200 at 0.5m c/c spacing, cut and cover section has been proposed.

Table 0.6. Summary of Tunnel Support System

Sl No	Section Type	Particular	Length (m)	Q value	RMR	Primary Lining	Secondary Lining	Anchoring	Remark
1	Type I	Km 0+700 to km 8+300	7600 m	10-40	60-100	50mm thick SFRS	300mm thick FRC concrete	25mm dia 4m long rockbolts at 2m c/c spacing in Arch portion	Major Tunnel portion
2	TYPE II	Km 0+510 to 0+700 and km 8+300 to 8+400	290 m	4-10	40-60	100mm thick SFRS	300mm thick FRC concrete	25mm dia 4m long rockbolts at 2m c/c spacing Arch + Sides	
3	TYPE III	Km 8+400 to 8+480	80m	4-10	40-60	ISMB 200 at 1.0m c/c spacing + SFRS	300mm thick FRC concrete+ Reinfor	Nil	
4	TYPE IV	Km 8+480 to km 8+540	60m	<1	<20	ISMB 200 at 0.5m c/c spacing + SFRS	300mm thick FRC concrete + Reinfor.	Nil	
5	CUT AND COVER	Km 8+540 to km 8+620	80m	<1	<20	Nil	900mm thick RCC with ISMB 200 at 0.5m c/c spacing	Nil	
		Total	**8110m**						

2.4.1.4. Portal Protection Measures

On south portal location, the LHS and RHS cut slope shall be excavated at 70° inclination up to 2nd berm and at 60° inclination thereafter with 3m wide berms at every 6m rise. The face of the cut slope shall be lined with shotcrete of 150mm thickness with single layer of wire mesh (150x150x6mm). Rockbolts 2m long at 1.3mx1.3m c/c spacing shall be provided on the cut slope in completely to highly weathered strata. The cut slope along the alignment shall be excavated at 70° inclination up to 2nd berm and at 60° inclination thereafter with 3m wide berms at every 6m rise. The face of the cut slope shall be lined with 150mm thickness with single layer of wire mesh (150x150x6mm). Rockbolts 4m long at 1.3mx1.3m c/c spacing shall be provided on the cut slope in completely to highly weathered strata.

On north portal, temporary excavation shall be carried out for constructing the cut and cover tunnel. Cut slope of inclination 600 up to 2nd berm, 450 up to 3rd berm and 340 thereafter with 1.5m wide berm at every 6m is proposed on LHS, RHS and along alignment. Backfilling shall be done simultaneously on either side of cut and cover tunnel. Backfilling shall be done from toe of temporary excavation at 2:1 slope up to cut and cover tunnel height and then at 120. Diaphragm wall of the cut and cover tunnel shall be constructed with face at 2:1 inclination. Gabion wall of 2.5m height with 0.5m embedment shall be provided as toe wall at cut and cover tunnel portal end to retain the backfill and to provide toe protection. Gabion wall shall be extended towards existing road on LHS and RHS to protect road form any disturbance during construction activities. Gabion wall shall be closed on either side of the cut and cover tunnel as per site feasibility. Backfilled slope shall be kept in vegetated state. Erosion control mat shall be provided to protect from soil erosion.

2.4.1.5. Tunnel Ventillation

Ventilation plant is planned on both portals. During detailed design, depending upon the space available inside the tunnel and portals, decision regarding location of plants can be decided.

There will be two ventilation plant rooms. Plant room shall be located at each portal. Each ventilation plant room at portal shall contain two supply and twoexhaust fans with all accessories such as sound attenuators, guide vanes in the exhaust duct, auxiliary equipment (e.g. hydraulic unit for exhaust fans).

The ventilation rooms would be placed above the road surface, with cover openings under the fan positions. The fans can be lifted directly from a lorry to the ventilation room with a crane, which is installed on the ceiling of the ventilation room.

The exhaust fans and all accessories such as dampers, attenuators etc. which are exposed to hot smoke shall be high temperature resistant, minimum 400 deg C for 2 hours. When sizing the damper for smoke control, leakage factor must be considered in line PIARC or CETU guidelines. The air extraction dampers shall also be fire resistant enabling an operation of 400 deg C for 2 hours. The jets fans will be fire rated for 250 deg C for 2 hours.

For the ventilation control, the following instruments are required per tunnel

- 9 Anemometers (with temperature sensors) per tunnel.
- 4 combined CO sensors /opacity meters/ NO sensor with high resolution, per tunnel.

2.4.1.6. Fire Fighting System

1. Fire Hydrant: A double headed fire hydrant shall be provided at every 85 m on one side of the tunnel. The emergency lane side shall be adopted for placing the fire hydrants. The fire extinguisher cabinet shall also be provided at every 85 m along the tunnel length. The minimum pressure required for hydrants and fire hose shall be 6.9 bar (100 psi). Tunnel control building, substation and fan rooms are proposed on both the north and south portals. Additionally, water tanks and pump room is proposed on the north portal. While the flow required shall be 250 gpm (945 L/min) for each 65 mm connection.The design should be allowing to flow minimum 3 connections of 65 mm with 250 GPM for 1-hour duration.

2. Fixed Firefighting System: The tunnel to be provided with high pressure water mist in zone arrangement. Each zone shall be of 30 m length, a higher or lower length zone is permitted provided the performance is justified by detailed hydraulic calculations. In the event of fire all three zones shall flow together for minimum 1-hour duration. The water mist system to be activated using fire alarm/detection system and flow must be controlled by section valves specified for such applications. An arrangement of water mist nozzles, piping and section valve is shown in the above figure.

3. Manual Fire Extingushers: Two manual extinguishers are to be provided in following locations.

a) Every 85 m inside the tunnel in both tube, 5 kg ABC type.

b) In all technical rooms/office a set of one ABC type and one CO_2 type, both being 4.5 kg.

4. Fire Pumps: The fire pumps for hydrant system shall be located at the elevated portal to supply the entire tunnel. The pump capacity shall be 750 gpm (2839 L/min). Two fire pumps (1 working + 1 standby) shall be used along with jockey pump. The main fire pump shall be electrical type while standby pump shall be diesel operated.

The required capacity of the fire pump shall be 8bars(110 psi) at 750 gpm (2839 L/min) flow. The jockey pump shall be sized for 20 gpm (75 L/min) at 9 bar pressure. The power requirement for the main fire pump shall be 80 HP and 7.5 HP for the jockey pump.

The water flow requirements for water mistpumps are 480L/minat 120 bars per pump (preliminary), the total flow shall be 2400 L/min at 120 bars. A different water flow can be used if justified by hydraulic calculations meeting the recommendations of fullscale fire test data for such applications.A total 5 numbers of working and 1 standby water mist pumps are required along with booster pump and Jockey pump sets.

5. Fire Water Tank: The fire tank shall be made of concrete in two equal compartments. The tank capacity shall be to cater a minimum 60 minutes operation of firefighting systems. The fire tank shall be separate for hydrant system and water mist system. The fire tank for hydrant system shall be of 200 m^3 water capacity while the water mist tank shall be of 175 m^3 water capacity.

Tunnel control building, substation and fan rooms are proposed on both the north and south portals. Additionally, water tanks and pump room is proposed on the north portal.

Since the tunnel is likely to witness heavy traffic, CCTV cameras shall be placed at regular intervals in the tunnel which are connected to two monitoring rooms on both ends of the tunnel for vehicular management and pollution monitoring.

The Extra Low Voltage Services (ELV) for the tunnel shall include the following:

- Tunnel emergency lighting.
- Emergency call system (ECS).
- CCTV monitoring.
- Variable message signs (VMS).
- Traffic lights.
- Over height vehicle detection.
- Traffic logging equipment.
- Guidance system.
- Tunnel radio system.
- Internal telephone system.
- Sound system/ Public addressing (PA) system.
- Tunnel physical variables measurement system.
- Escape route lighting.

2.4.2. Proposed Right of Way (PRoW)

The proposed RoW for the tunnel road adopted is as follows.

Table 0.7. Chainage-wise Summary of PRoW

Sl No	Design Chainage (m)		Length (m)	Existing ROW (m)	Proposed ROW (m)
	From	To			
1	-25.00	40.00	65.00	12.00	25.00 to 50.00 (Varying)
2	40.00	100.00	60.00	12.00	77.00 to 93.00 (Varying)
3	100.00	180.00	80.00	12.00	80.00
4	180.00	224.00	44.00	Nil	80.00 to 102.0 (Varying)
5	224.00	317.00	93.00	Nil	73.00
6	317.00	380.00	63.00	Nil	Nil
7	380.00	530.00	150.00	Nil	145.00
8	530.00	610.00	80.00	Nil	60.00
9	610.00	8440.00	7830.00	Nil	Nil
10	8440.00	8620.00	180.00	Nil	60.00
11	8620.00	8660.00	40.00	Nil	105.00
12	8660.00	8735.00	75.00	12.00	100.0 to 124.0 (Varying)
Total Length (m)			**8735.00**		

2.4.3. Typical Cross Sections (TCSs)

As per the traffic studies and analysis a four lane wide carriage-way with paved shoulder has been proposed. 1.50m wide earthen shoulders are proposed on either side of Paved shoulders. Therefore, the total roadway width proposed is 12.0m for approach road and 8.0m for Tunnel section in each direction. The width of Major bridge at deck level is 13.50m whereas for culverts it is 12.50m in each direction. Cross sectional elements are presented in **Table 0.8**.

Table 0.8. Details of Cross Section Elements

Description	Approach	Tunnel
Proposed carriageway	14.00m (7.00m + 7.00m)	14.00 m (7.00m +7.00m)
Proposed paved shoulder	5.00m (2.50m + 2.50m)	1.00m (0.50m + 0.50m)as shy marking in each tube
Median	Varying (1.50m minimum)	Nil
Proposed earthen shoulder	3.00m (1.50m + 1.50m)	Nil
Cross camber on Proposed carriageway (Rigid pavement)	2 %	2 %
Cross camber on proposed Earthen shoulder	3 %	NA
Footpath / Drain	Unlined and Lined (Varies)	2.00m (1.0m + 1.0m) in each tube

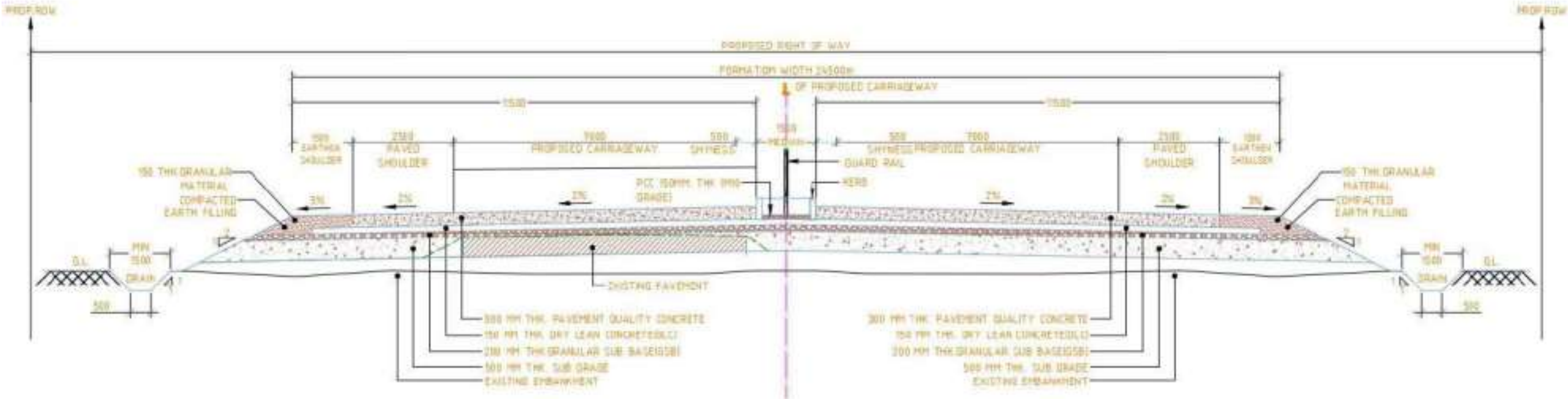
Chainage-wise details of TCSs adopted are presented in the **Table 0.9.**

Table 0.9. Chainage-wise Summary of TCS Adopted

Sl No	Design Chainage (m)		Length (m)	Type of TCS	Description
	From	To			
1	0.00	100.00	100.00	TCS-1	Typical cross section for 4-Lane highway with paved shoulder in embankment (Merging of 2 Lane to 4 lane road)
2	100.00	215.00	115.00	TCS-2	Typical cross section for 4-Lane highway with Paved Shoulder and Service Road on both side
3	215.00	310.00	95.00	TCS-3	Typical cross section for 4-Lane highway with paved shoulder in cutting
4	310.00	430.00	120.00	TCS-4	Typical cross section for Major Bridge
5	430.00	460.00	30.00	TCS-1	Typical cross section for 4-Lane highway with paved shoulder in embankment
6	460.00	510.00	50.00	TCS-3	Typical cross section for 4-Lane highway with paved shoulder in cutting
7	510.00	700.00	190.00	TCS-6	Typical Cross Section of Tunnel Section – Type - II
8	700.00	8300.00	7600.00	TCS-5	Typical Cross Section of Tunnel Section- Type - I
9	8300.00	8400.00	100.00	TCS-6	Typical Cross Section of Tunnel Section - Type - II
10	8400.00	8480.00	80.00	TCS-7	Typical Cross Section of Tunnel Section- Type - III
11	8480.00	8540.00	60.00	TCS-8	Typical Cross Section of Tunnel Section- Type - IV
12	8540.00	8620.00	80.00	TCS-9	Typical Cross Section of Tunnel Section- Cut & Cover
13	8620.00	8700.00	80.00	TCS-3	Typical cross section for 4-Lane highway with paved shoulder in cutting including junction improvement
14	8700.00	8735.00	35.00	TCS-1	Typical cross section for 4-Lane highway with paved shoulder in embankment (Merging of 2 Lane to 4 lane road)

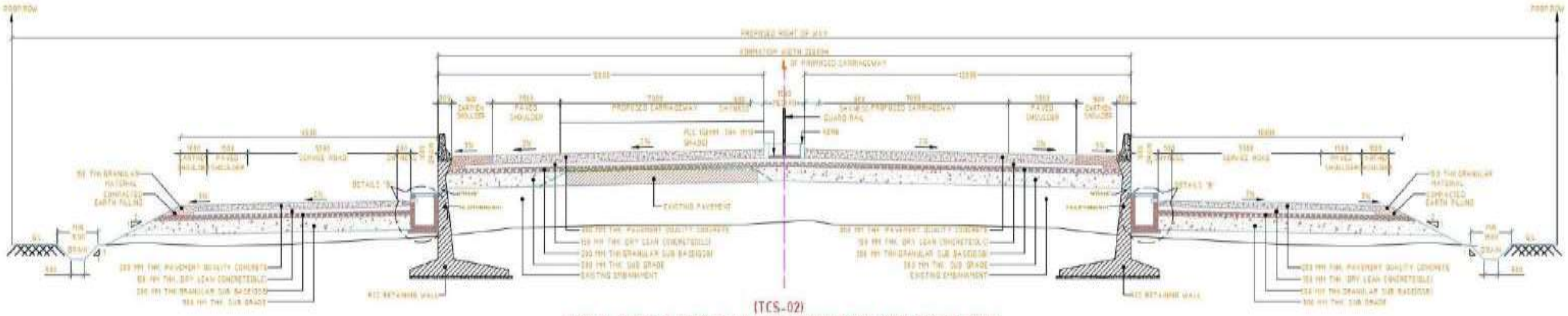
Sl No	Design Chainage (m)		Length (m)	Type of TCS	Description
	From	To			
Total Length (m)			**8735.00**		

Note – Separate cross sections are proposed for the cross drainage structures (Culverts) and Vehicular Underpass (VUP) falling in this section



(TCS-01)

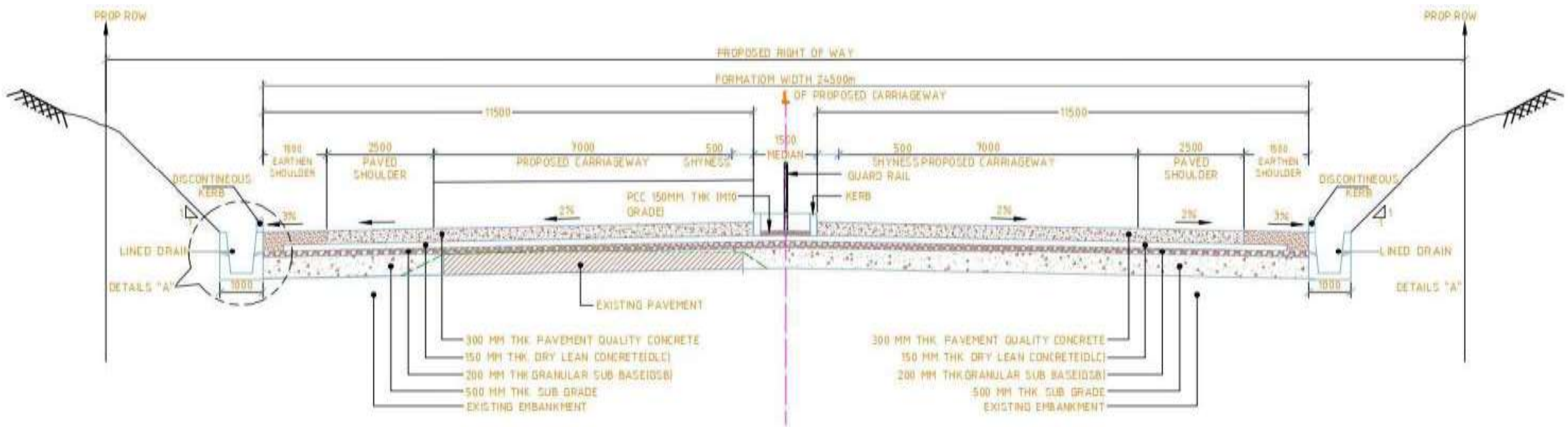
TYPICAL CROSS SECTION FOR 4-LANE HIGHWAY WITH PAVED SHOULDER IN EMBANKMENT.



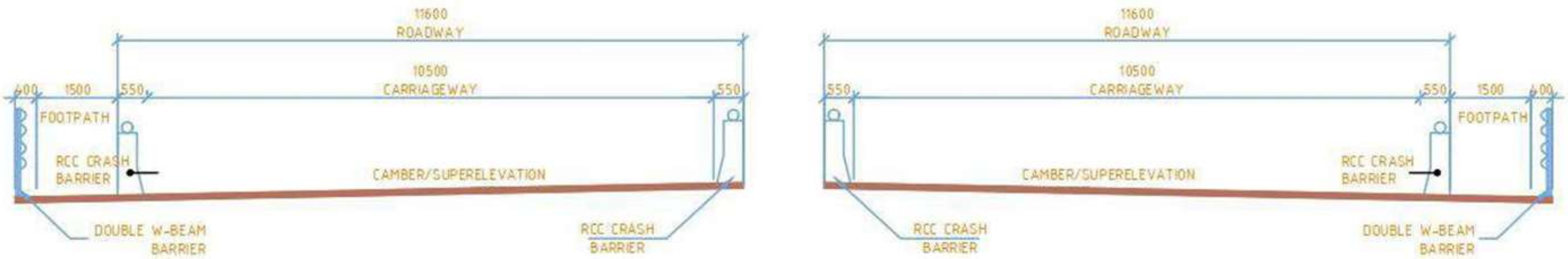
(TCS-02)

TYPICAL CROSS SECTION FOR 4-LANE CARRIAGEWAY WITH SERVICE ROAD

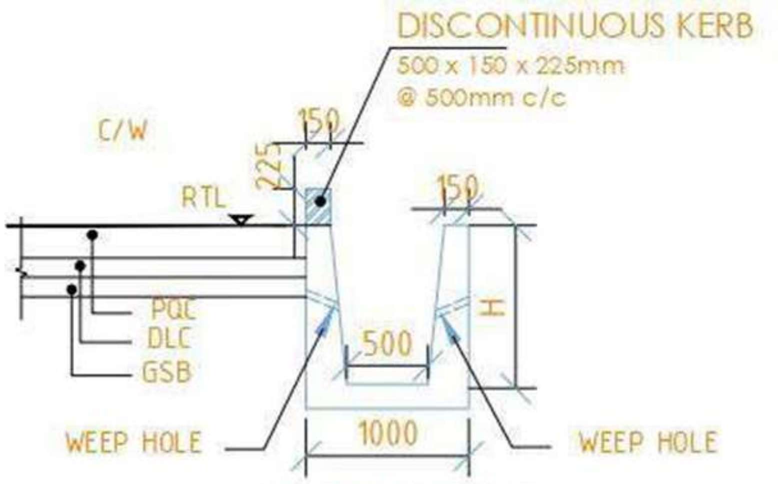
(OPEN COUNTRY - PLAIN/ROLLING TERRAIN)



(TCS-03)
TYPICAL CROSS SECTION FOR 4-LANE CARRIAGEWAY WITH PAVED SHOULDER IN CUTTING

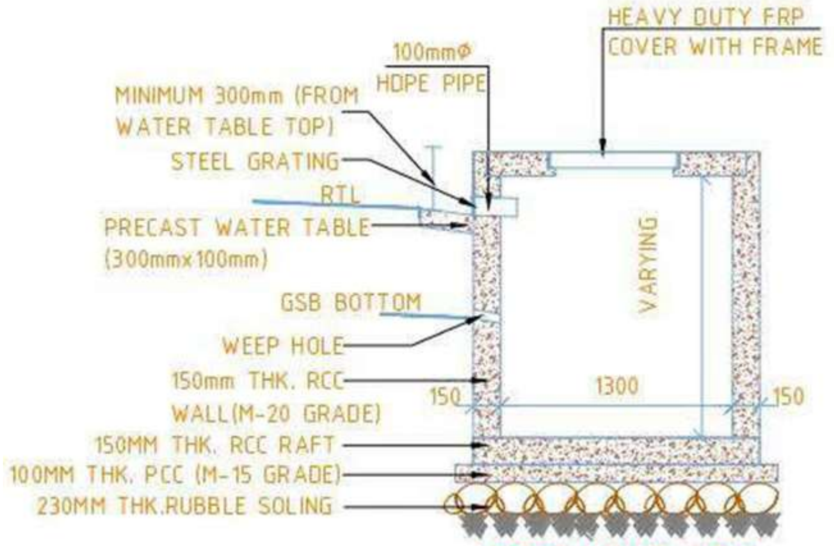


(TCS-04)
TYPICAL CROSS SECTION OF BRIDGE AT DECK LEVEL FOR 4-LANE HIGHWAY



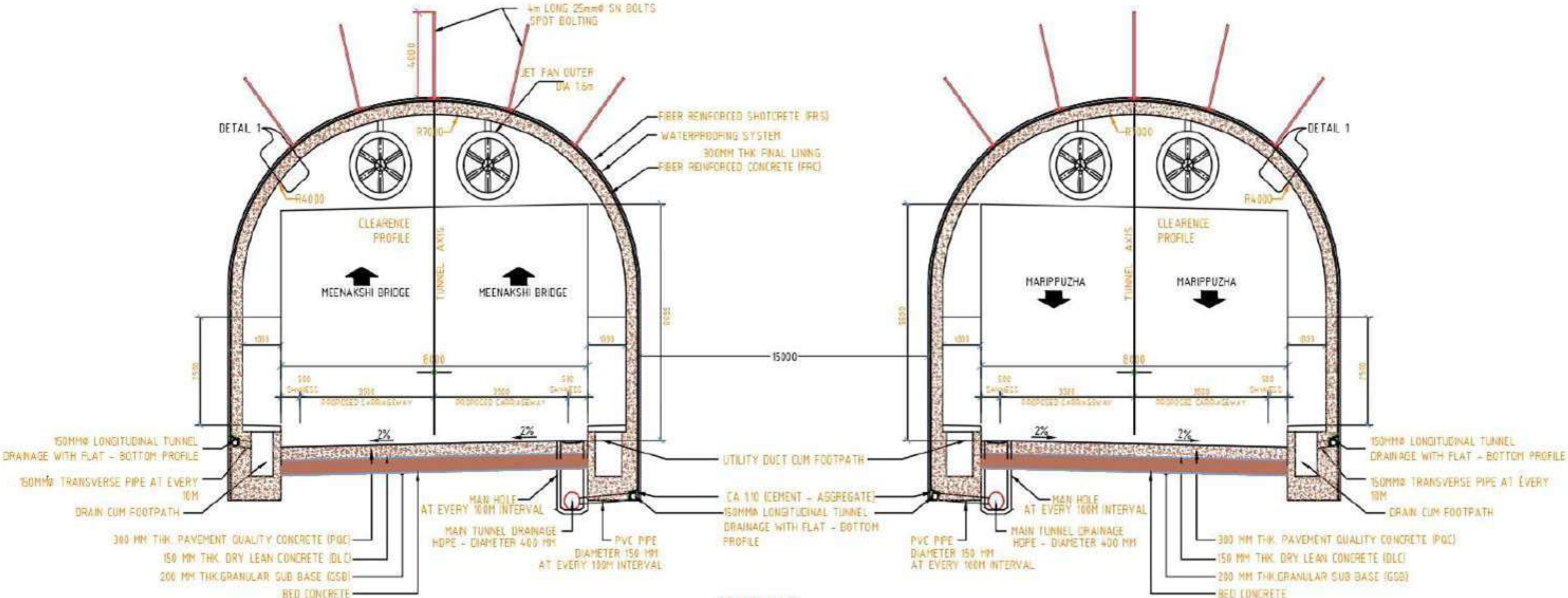
DETAILS "A"

DETAILS OF LINED DRAIN



DETAILS "B"

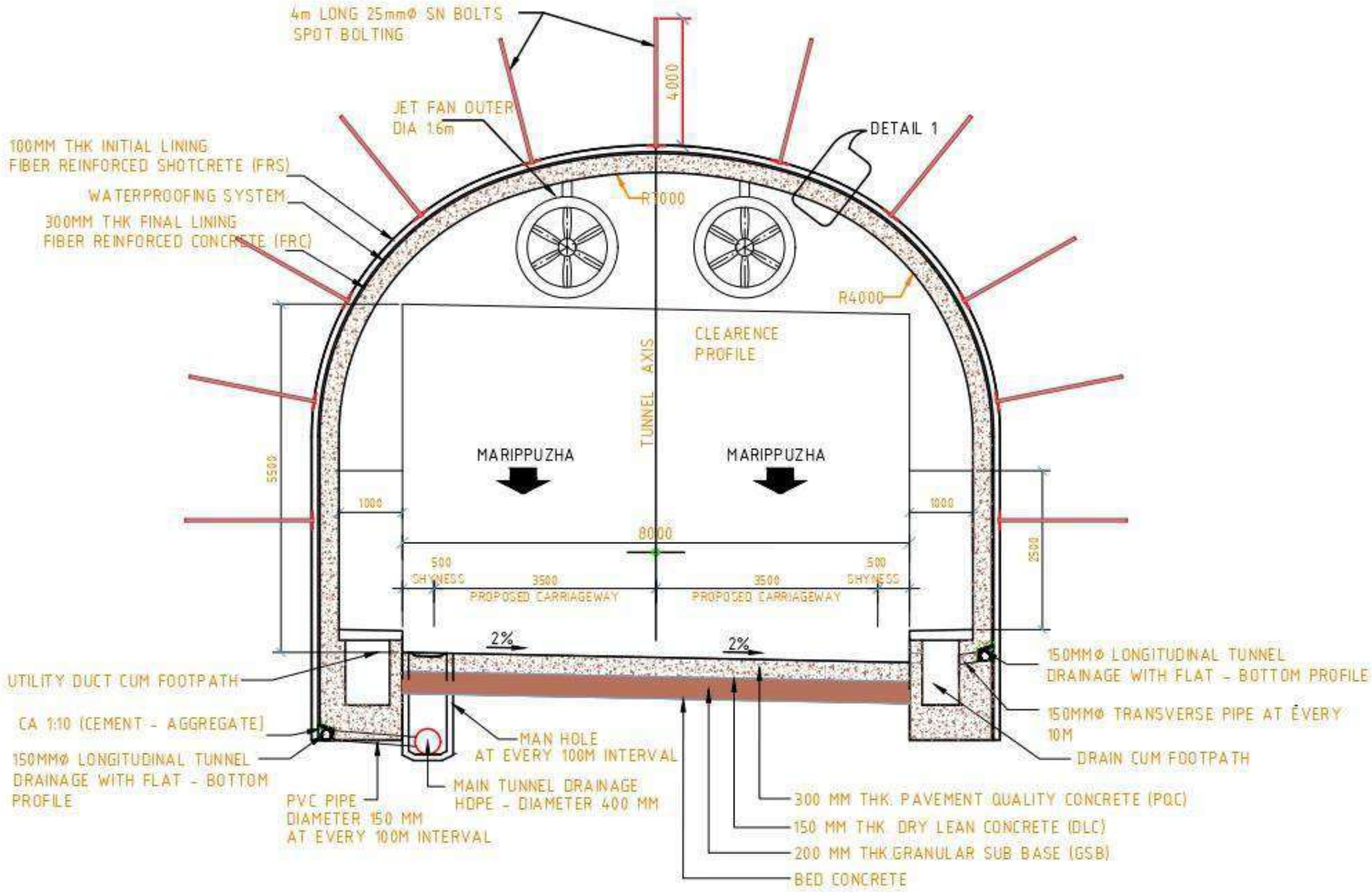
DETAILS OF DRAIN



(TCS-05)

TYPICAL CROSS SECTION OF TUNNEL TYPE I

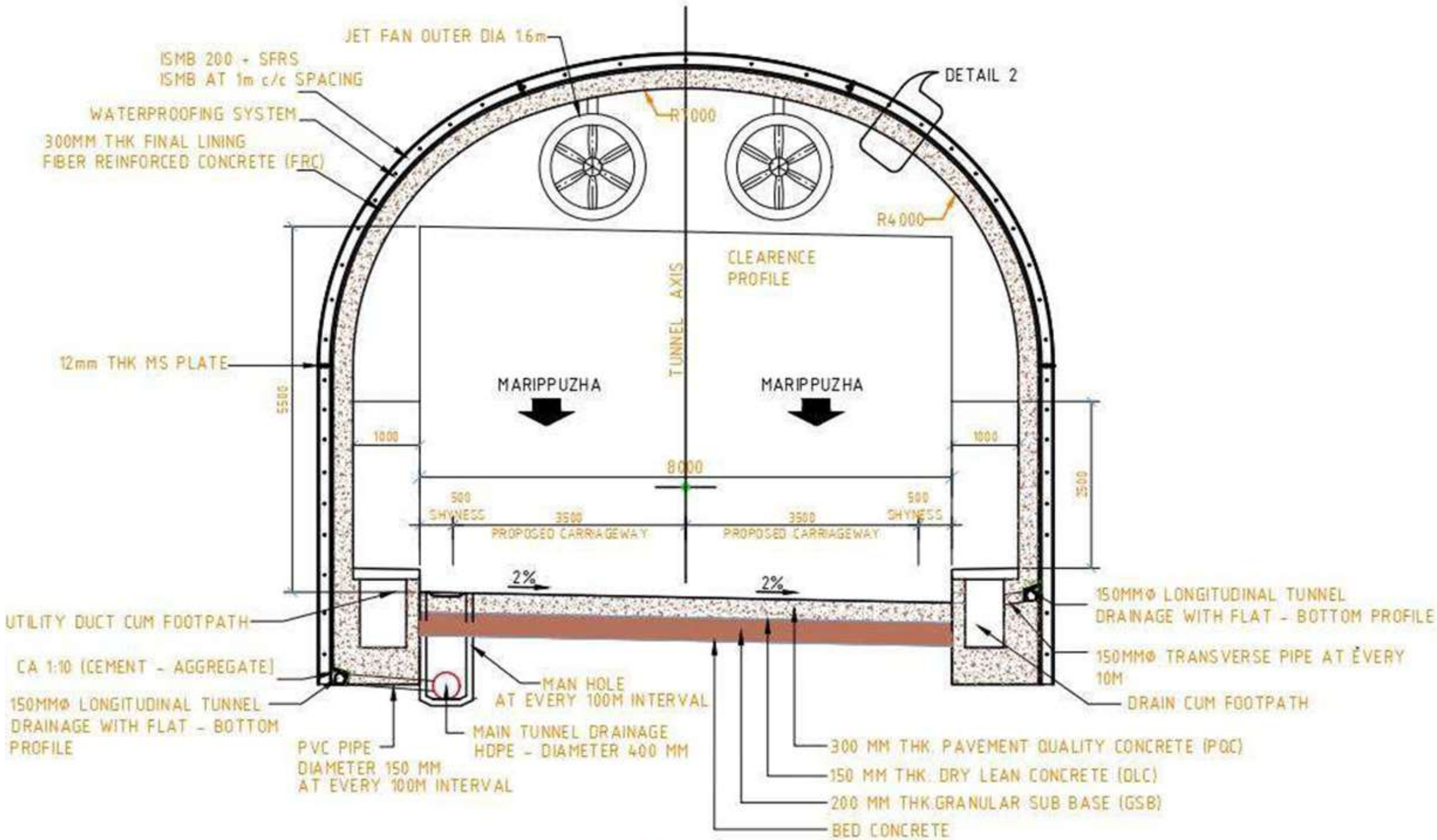
FINISHED AREA	67.523 Sq.m
EXCAVATED AREA	85.609 Sq.m



(TCS-06)

TYPICAL CROSS SECTION OF TUNNELTYPE II

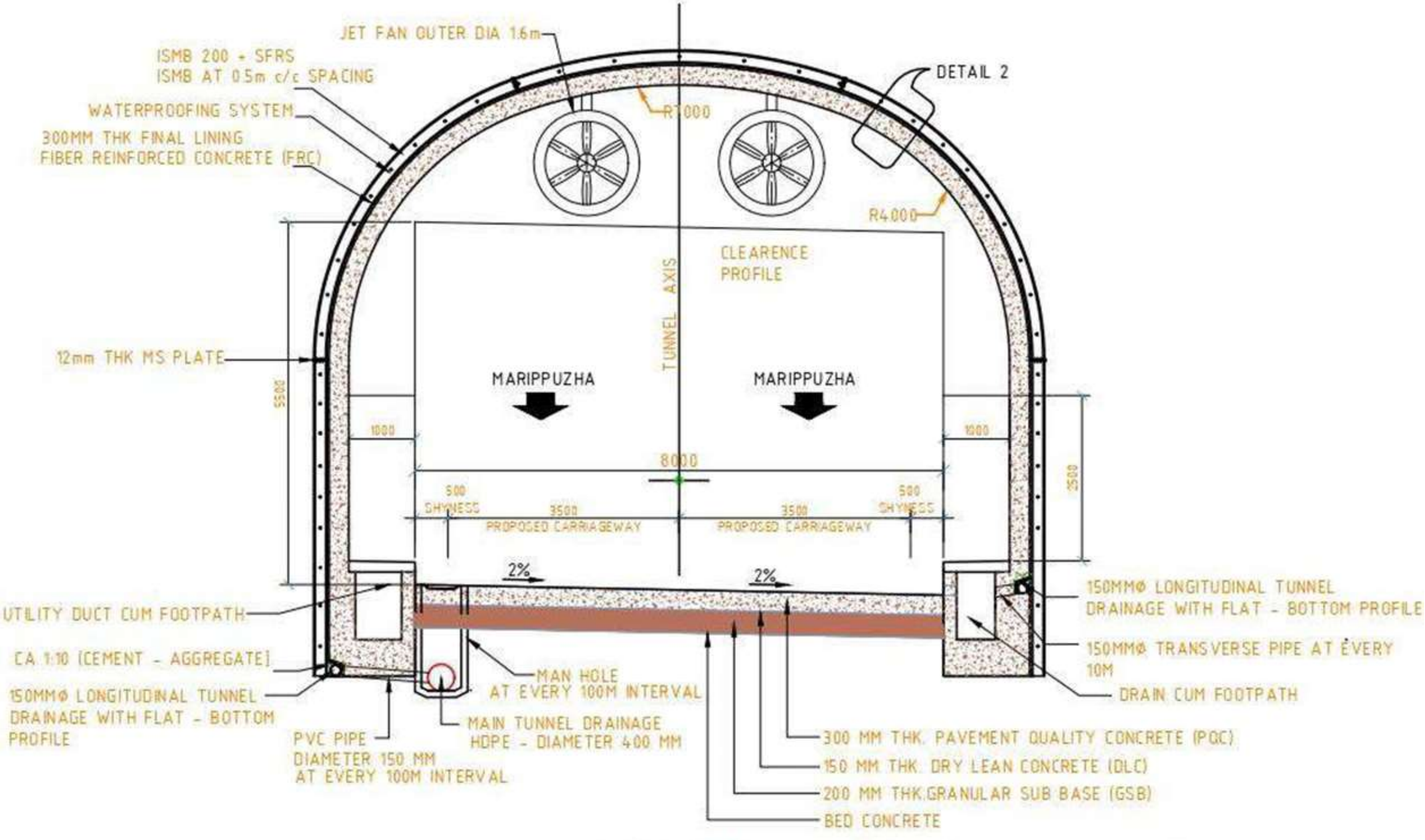
FINISHED AREA	67.523 Sq.m
EXCAVATED AREA	86.882 Sq.m



(TCS-07)

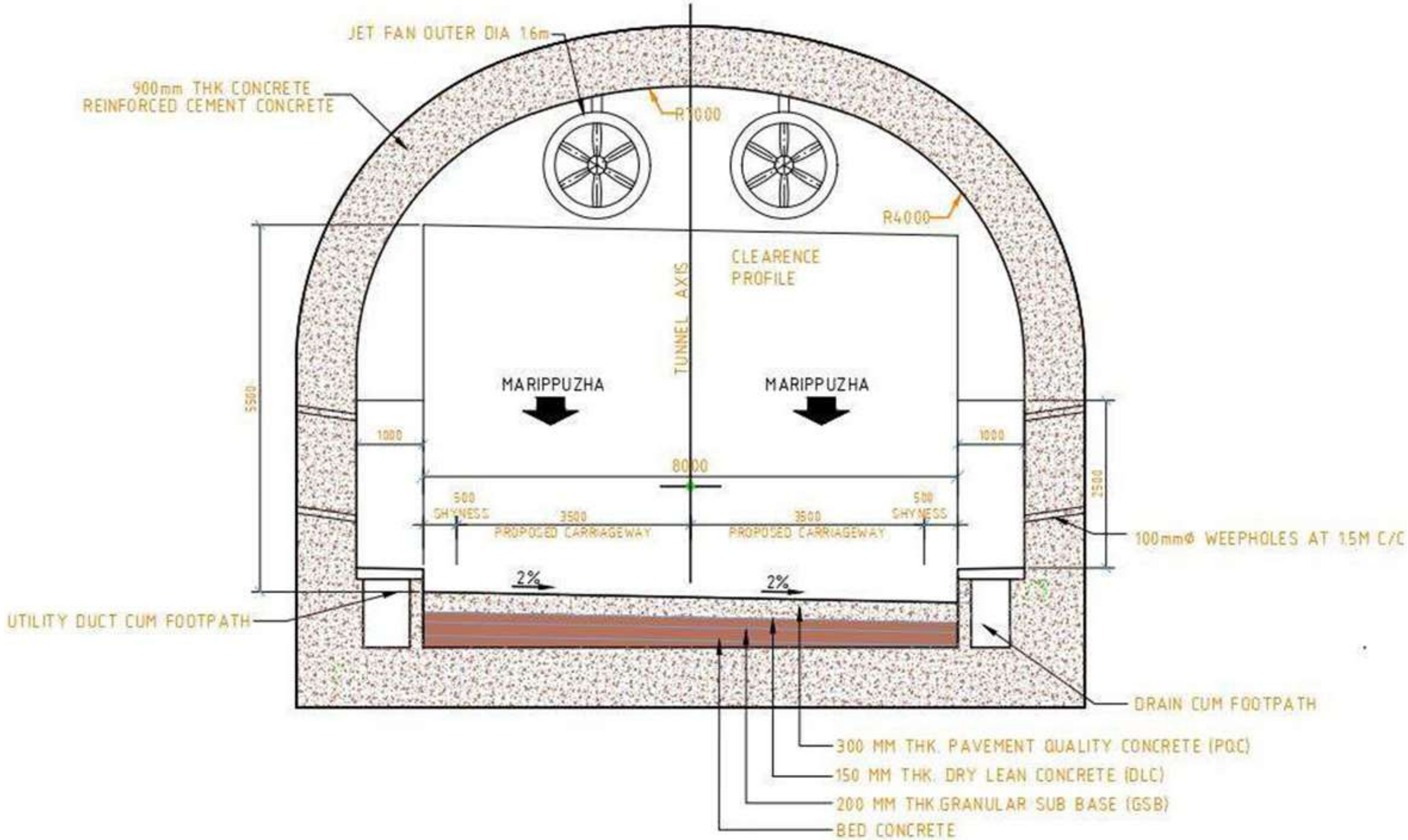
TYPICAL CROSS SECTION OF TUNNELTYPE III

FINISHED AREA	67.523 Sq.m
EXCAVATED AREA	89.451 Sq.m



(TCS-08)
TYPICAL CROSS SECTION OF TUNNEL TYPE IV

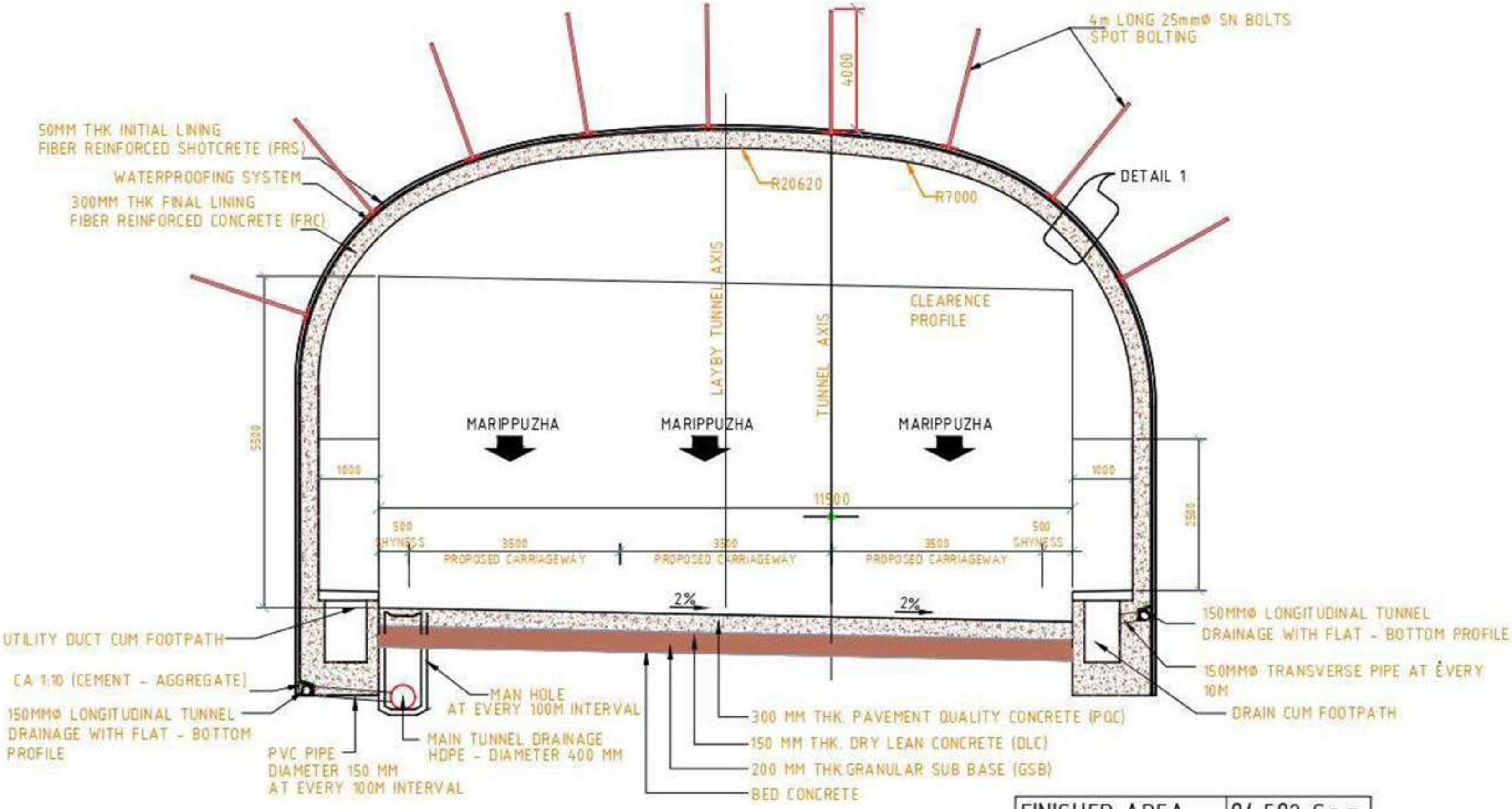
FINISHED AREA	67.523 Sq.m
EXCAVATED AREA	89.451 Sq.m



(TCS-09)

TYPICAL CROSS SECTION OF CUT AND COVER

FINISHED AREA	67.523 Sq.m
EXCAVATED AREA	108.593 Sq.m



FINISHED AREA	94.592 Sq.m
EXCAVATED AREA	116.322 Sq.m

(TCS-10)

TYPICAL CROSS SECTION FOR TUNNEL-LAYBY

2.4.4. Pavement Design

Rigid pavement is proposed for entire stretch of the project alignment. The largest advantage of using rigid pavement is its durability and ability to hold a shape against traffic and difficult environmental conditions. Concrete Road is more preferable in a water-prone area than an Asphalted road. They provide good visibility for traffic during night hours. They have high bearing capacity, wear resistance, and fire safety as well. The initial construction cost of concrete pavement is more expensive as compared with flexible pavement but has less maintenance and good design life. Summary of rigid pavement design is presented in **Table 0.10.**

Table 0.10. Summary of Rigid Pavement Design

Summary of Rigid Pavement Design	
Slab Dimension	
Slab thickness, h	0.300m
Length of Slab, L	4.50m
Width of Slab, B or W	3.50m
Design of Joints	
Dowel Bar	
Diameter of dowel bar	32mm
Length of Dowel Bars	500mm
Spacing of Dowel bars	300mm
No of dowel bars participating in load transfer	3 nos
Plain Tie Bars	
Diameter of Plain Tie bar	12mm
Length of Plain Tie Bars	580mm
Spacing of Plain Tie bars	374mm
Deformed Tie Bars	
Diameter of Deformed Tie bar	12mm
Length of Plain Tie Bars	640.00mm
Spacing of Deformed Tie bars	599.00mm
Area for steel for Slab Reinforcement to control cracking	147.27 mm^2/m

The proposed thickness of the different layers computed according to the guidelines of IRC: 58- 2015 and are presented as follows.

Table 0.11. Details of Pavement Composition

Homogeneous Section	Design CBR (%)	PQC (mm)	DLC (mm)	Granular Sub base (mm)	Total Thickness (mm)
Complete Stretch	**8**	**300**	**150**	**200**	**650**

2.4.5. Culverts

Based on the Culvert Inventory & Condition survey, geometry improvement of the highway alignment and submergence locations, a culvert treatment proposal has been proposed. The new box culverts are proposed in the following locations in order to avoid the stagnation of water at the valley point as presented in **Table 0.12.**

Table 0.12. List of Proposals for Culverts

Sl No	Detials of Existing Structures			Improvement Proposals			
	Design Chainage (km)	Type of Structure	Span Configuration (No. x m)	Recommendation	Type of Structure	Span Configuration (No. x m)	Remarks
1	0+154	Pipe culvert	1x1	Reconstruction	Box culvert	1 x 3.0 x 4.0	Main Road
2	8+645	Nil	Nil	New Construction	Box culvert	1 x 2.0 x 2.0	Meppadi-Kalladi-Chooralmala Road
3	8+690	Nil	Nil	New Construction	Box Culvert	1 x 2.0 x 2.0	Cross Road

2.4.6. Bridges

Based on the Bridge Inventory & Condition survey, geometry improvement of the highway alignment and submergence locatsions a construction proposal for bridges has been proposed and is presented in **Table 0.13.**

Table 0.13. List of New Construction of Major Bridges

Sl No	Detials of Existing Structures				Improvement Proposals					
	Design Chainage(km)	Type of Structure		Span Configuration (No. x m)	Recommendation	Type of Structure	Span Configuration (No. x m)	Proposed Lane ConfigurationT	Total Width of Structure (m)	Remarks
		Super Structure	Sub-Structure							
1	0+370	Nil	Nil	Nil	New Construction	Bow-String Girder	1x120	2 lane	13.5	LHS CW
2	0+373	Nil	Nil	Nil	New Construction	Bow-String Girder	1x120	2 lane	13.5	RHS CW

2.4.7. Vehicular Underpass (VUP)

For better connectivity of eastern area of the proposed project road, a full height Vehicular Underpass (VUP) has been planned near Marripuzha village at km 0+200. Lane configuration of this VUP is 2 lane carriageway with 5.50m clear vertical clearance.

2.4.8. Major and Minor Intersections

There are no major junctions on project alignment.

In total there are 2 minor junctions proposed for development on project road.

Table 0.14. Proposals for Minor Intersections

Sl No	Chainage (m)	Location	Type of Junction	Type Road (SH/MDR/VR)
1	30.00	Maripuzha Junction	+	VR
2	8645.00	Meenakshi Temple	+	MDR & VR

2.4.9. Drainage

For earthen drain, 500 mm bed width is proposed, for lined drain, 1.0 m width is proposed and for RCC box Drain in tunnel.

Any stagnation of water at intersections would reduce the capacity of the junction resulting in queuing up of traffic. Many times ponding of water affects vehicles with low chassis height and any vehicle stalled at an intersection during heavy downpour can create unmanageable traffic jams. So, preferably the level of junctions should be slightly higher than the roads meeting it so that water can reach the main drainage system proposed along the roads.

2.4.10. Traffic Control and Safety Devices

A. Road Signs

Traffic control devices, whether used singly or in combination, must contribute to the safe and effective control of traffic. The traffic sign face details and the specifications are designed as per the codal provisions of IRC: 67:2012. The siting and location of Road signs on the project facility are to improve the safety of road users including pedestrians who are vulnerable to the motorised traffic. General principles for using signs described in IRC: SP: 44 Code to Highway safety are followed.

B. Road Markings

Road Markings are an important means of traffic control on roads. In some cases, the road markings are used to supplement general traffic regulations, or regulations and warnings given by signs and signals. In other cases, markings can be used without supplement by other devices. The principal advantage of road markings is that they convey guidance or information to the road user without diverting attention from the roadway. In bad weather conditions, this may be of vital importance to road safety. Road markings should therefore be given special attention with respect to both application and maintenance The longitudinal markings and the road alignment should always be in harmony with each other. Road markings and the specifications on the project facility are carried as per the codal provisions of IRC:35-2015 and Specifications for Road and Bridge Works. Road markings design are not only limited to lane markings, edge markings, centre line of the project facility but also to mark bus stops, bus lay bye, cross roads at major junctions, direction arrows and pedestrian crossings.

C. Traffic Safety Devices

Traffic Safety devices are required to improve safety on proposed facilities. Following Safety devices are considered on project facility:

- Crash Barriers – provided where canal is running parallel to the project facility
- Pedestrian guard rails – provided front face of footpath
- Pedestrian railing – Provided at back of footpath where pond is located

- Speed Breakers – Provided on cross roads where it meets to main road
- Road Studs – provided on approaches of project facility in junction areas

D. Illumination

Road lighting has been designed in accordance with the recommendations of IS codes. An average illumination level of 30 lux has been considered

2.5. Summary of Project Details

Summary of the project details are given in **Table 0.15.**

Table 0.15. Summary of Project Details

Sl. No.	Attributes	Details
1	Start Point (South end location)	Maripuzha (Kozhikode District) on MDR (Elevation=678m above MSL)
2	End Point (North end location)	Meenakshi River Bridge (Wayanad District) on SH-59 (Elevation=851m above MSL)
3	State	Kerala, India
4	Length falls in Each district	
a)	Route Length in Kozhikode District (m)	3150
b)	Route Length in Wayanad District (m)	5585
5	Total Route length (m)	8735
	Existing Traffic - AADT (PCU)	1. At Adivaram, Thamnarassery Ghat)-18955 2. At Meeppadi Junction – 12,129
	Projected Traffic (PCU)	14,027 (2030), 23,183 (2040), 35,992 (2050)
6	Number of curves	06
7	Minimum Radius of curve (m)	800
8	Length of road on curves (m)	2705
9	Lane configuration	4 Lane with Paved Shoulder
10	Carriageway width (m) (Tunnel) Carriageway Width (m) (Approach Road)	7.0m with 0.5m kerb shyness on either side 7.0m with 2.50m paved shoulder one side & 0.5m kerb shyness on other side
11	Pavement type	Rigid Pavement
12	Tunnel length (m)	8110 unidirectional Twin Tube Tunnel
14	Cross Passages	At every 300m
15	South approach Road length (m)	510
16	North approach Road length (m)	115
17	Major Bridges	2 Nos. on Iravajipuzha
18	Minor Bridges/Culverts	3 Nos.
19	Vehicular Underpass (VUP)	1 No.
20	Service Road / Slip Road	200m
21	Junction improvement	2 Nos.
22	Design Speed (KMPH)	80
23	Maximum Tunnel gradient (%)	2.50
24	Total Route length in Private land (m)	2964
25	Total Route length in Forest land (m)	5771
26	Highest elevation along route	1831m above MSL. (Maximum overburden 1090m.)
27	Land requirement including dumping site (ha)	Approx.19.2

Sl. No.	Attributes	Details
28	Geology	Good
29	Period of construction	60 Months
30	Estimated cost	
a)	Cost of Works	₹ 1471.57 Cr.
b)	Project Cost including Centages	₹ 2008.20 Cr.
c)	Total Project Cost	₹ 2043.74 Cr.

2.6. Mitigation Measures Incorporated in Project Design

2.6.1. Restriction of Proposed RoW

Based on findings from field studies, considering the environmental and social criteria of highway design, traffic forecast study; it has been decided to restrict the proposed RoW to 4 lane tunnel road. This resulted in reducing the impacts in following ways:

- Reduction in diversion of forestland (direct impact) and resultant reduction in impact on flora and fauna.
- Reduction in no. of trees to be felled down within the existing RoW.
- Reduction in R&R issues

2.7. Natural Resources Requirement

For proposed tunnel-road construction, raw materials need to be sourced from various natural resources pools present along the project road. Estimated quantity of raw materials is presented in **Table 0.16** and the same for water is presented in **Table 0.16.** During the feasibility study, material investigations were carried out along the vicinity of the project area to identify the natural resource pool. Based on that, a schematic diagram showing the source of raw materials with respect to the project road is prepared and is presented here as **Figure 0-3**.

Table 0.16. Estimated Raw Material Requirements

Sl. No	Item	Quantity (Tonnes)	Source	Mode of Transport
1	Blue metal	657415	Mepaddi	Road
2	Bricks	180	Wayanad	Road
3	Sand	288922.60	Mepaddi	Road
4	Cement	124247.61	Wayanad/ Kozhikode	Road
5a	Steel - HYSD/Mild	7998.93	Wayanad/ Kozhikode	Road
5b	Steel - Structural	3955.67	Wayanad/ Kozhikode	Road
6	Fly Ash	0		
7	Bitumen	161.42	Kochi Refinery	Road
8	Diesel	19.87 ML	Local Purchase, Petrol pumps are available near to Project location (Mepaddi, Wayanad)	Road
9	Water			
9a	For road preparation	47.86 ML	Wayanad/ Kozhikode	Road

Sl. No	Item	Quantity (Tonnes)	Source	Mode of Transport
9b	For dust suppression	8.00 ML	Wayanad/ Kozhikode	Road
9c	For Drinking	166.98 ML	Wayanad/ Kozhikode	Road
9d	Others	16.00 ML	Wayanad/ Kozhikode	Road

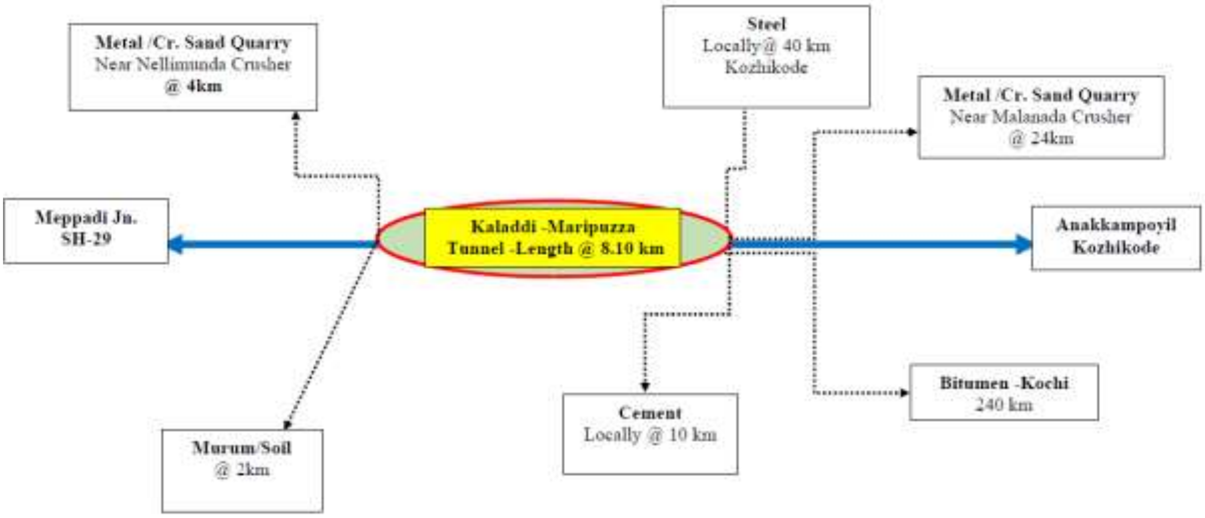


Figure 0-3. Schematic Diagram Showing Sources of Raw Materials

2.8. Man Power Requirement

Project activity envisages requirement of various categories of manpower such as skilled, semi-skilled workers, technicians, engineers, managers and other professionals for both construction and operation phases. Details of manpower requirement for the construction phase of the project is follows.

Table 0.17. Details of Manpower Requirement

Sl No.	Type of Manpower	Approx. No
1	Managers/Engineer (Highly Skilled)	39
2	Supervisory (skilled)	56
3	Skilled	148
4	Semi-skilled	158
5	Unskilled	514
	Total	**915**

2.9. Machinery Requirement

Details of the machinery to be used at this project is as follows.

Table 0.18. Details of Machinery Requirement

Sl No.	Description	Approx. No
A. Plants with DG Set		
1	Stone Crusher	1
2	WMM Plant	1
3	Batching Plant	2
4	DG for other	16

Sl No.	Description	Approx. No
B. Machineries		
1	Motor Grader	2
2	Wheel Loader	4
3	Excavator	8
4	Bachoe Loader (JCB)	8
5	Sensor Paver	1
6	WMM Paver	1
7	Tandem roller	2
8	Vibro roller	2
9	Tipper (14 Cum) /Dupers	12
10	Water Tanker	6
11	Tractor with Trolley / Ripper	4
12	Dewatering Pump	6
13	Transit Mixer	4
14	Concrete Pump	2
15	Rock Breaker	8
16	Hydra Crane	4
17	Diesel Tanker 5000 Ltr	1

2.10. Project Cost

Details of estimated cost of the project is presented in **Table 0.19**.

Table 0.19. Details of Estimated Project Cost

Sr.No	Item		Amount in Rs.	Cost in Crs.	% Cost
I	**Civil Work Cost**				
1	Site Clearance & Temp. Approach road		31841729.87	3.18	0.22%
2	Earthwork		61763311.51	6.18	0.42%
3	Base and Sub Base		7079631.00	0.71	0.05%
4	Cement Concrete Pavement		21234500.00	2.12	0.14%
5	Traffic Signs, Markings & Other Road Appurtenances		14353933.24	1.44	0.10%
6	Drainage and Protective Works including Metal Beam Crash barrier		124113683.15	12.41	0.84%
7	Bridges		613600788.38	61.36	4.17%
8	Culverts		16345166.12	1.63	0.11%
9	Vehicular Underpass		11475806.13	1.15	0.08%
10	Junctions		5645022.46	0.56	0.04%
11	Twin Tube Tunnel (2+2 Lane)-		13794482520.97	1379.45	93.74%
12	Utility shifting Cost- Electrical, Water Lines & Misc		13725000.00	1.37	0.09%
	Total Civil Cost (A) in Rs.		**14715661092.84**	**1471.57**	**100.00%**
a	Contingency 2.8% on A	2.80%	412038510.60	41.20	
	Total civil works with Contingency = (B)		**15127699603.44**	**1512.77**	
i	**Add GST @ 12% on B**	**12.00%**	**1815323952.41**	**181.53**	
ii	**Cost of Civil work including GST = C = (A +i) for tendering purpose**		**16943023555.85**	**1694.30**	
iii	**Centages charges (Inclusiveof Consultancy charges)- 8.75% on B**	**8.75%**	**1323673715.30**	**132.37**	

Sr.No	Item		Amount in Rs.	Cost in Crs.	% Cost
iv	Price escalation 5% per year of B as per Phasing for 5 years	11.00%	1664046956.38	166.40	
v	Environmental Charges	1%	151276996.03	15.13	
	Total Project Cost Rs.		**20082021223.56**	**2008.20**	**229.90**
12	**LA & Utility Cost**				
i	Land Acquisition cost				
	A) LA For road Part (7.20 Hec for 4Lane)		192430077.50	19.24	
	B) LA For Muck disposal (5 hectare)		127903385.00	12.79	
	C) LA For Muck disposal on Lease basis (5 hectare) - for 5 yrs		25000000.00	2.50	
	D) Labour Camp on Lease basis (2 hec) for 5 yrs		10000000.00	1.00	
	Sub-Total		**355333462.50**	**35.53**	
13	**Total Capital Cost Rs.**		**20437354686.06**	**2043.74**	

Project Implementation Schedule

Project implementation schedule is presented in the following figure.

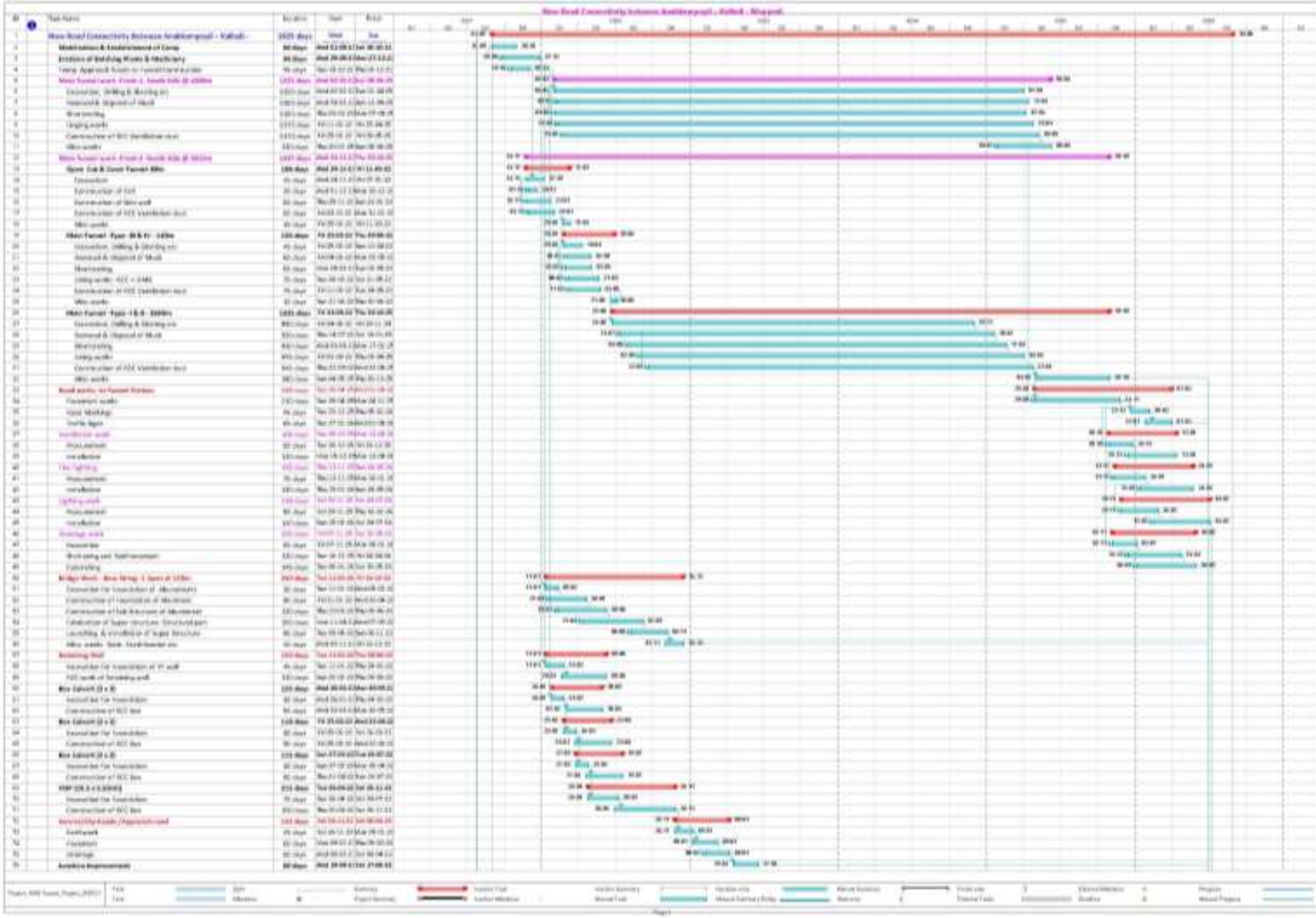


Figure 0-4. Project Implementation Schedule

Chapter 3. Analysis of Alternatives

3.1. Introduction

As part of the feasibility study conducted during the initial stages of the project, detailed field reconnaissance was conducted and data on land use of the project area was collected and over laid on existing alignment. Moreover, a detailed land use analysis using SoI toposheets and Google Earth was also undertaken. The findings of these studies identified project stretches with sensitive social and environmental features and revealed the intensity of socio-economic impact in terms of land acquisition, loss of buildings and livelihood that the widening of the existing highway could generate at these locations. Hence, various alternatives were explored to route the alignment in such a way that these impacts are minimized, while at the same time overall highway design standards stipulated for national highways are achieved. This section take a detailed look at the various alternatives considered while finalizing alignment and RoW for the project.

3.2. With and Without Project Alternatives

The “With” project scenario with positive/beneficial impacts on the traffic conditions shall vastly improve the environment, resulting in the improvement of social and economic development of the region.

3.2.1. ‘With Project’ Scenario

The ‘with Project’ scenario includes development of four-lane tunnel road connecting Anakkampoyil in Kozhikode district and Meppadi in Wayanad district of Kerala State. The ‘with project’ scenario has been assessed to be economically viable and will alleviate the existing conditions. It would thereby, contribute to the development goals envisaged by the Government of Kerala as well as Government of India, and enhance the growth potential of the state as well as region.

3.2.2. ‘Without Project’ Scenario

In the case of ‘without project’ scenario the existing road will be considered as it is. Considering the present traffic volume and potential for growth in near future, the capacity of the present road is insufficient for handling expected traffic volume and calls in for bypassing.

The project tunnel road provides shortest connectivity for the NH 766. This shall also reduce the distance to Kozhikode and Wayanad districts. The poor road conditions, population growth, increase in traffic volumes and the economic development along the project corridor would continue to occur and will exacerbate the already critical situation. The existing unsafe conditions and the adverse environmental consequences, in terms of the environmental quality along the roads, would continue to worsen in the absence of the proposed improvements.

Therefore, the no-action alternative is neither a reasonable nor a prudent course of action for the proposed project, as it would amount to failure to initiate any further improvements and impede economic development. Keeping in view the site conditions and the scope of development of the area, the 'With' and 'Without' project scenarios have been compared as shown in **Table 0.1**. By looking at the table it can be concluded that "With" project scenario with positive/beneficial impacts will vastly improve the environment and enhance social and economic development of the region compared to the "Without" project scenario, which will further deteriorate the present environmental setup and quality of life. Hence the "With" project scenario with minor reversible impacts is an acceptable option than the "Without" project scenario. The implementation of the project therefore will be definitely advantageous to achieve the all – round development of the economy and progress of the State.

3.2.3. Comparison of 'With' and Without' Project Scenarios

Comparison of positive and negative impacts of 'With' and 'Without' project scenario is as follows.

Table 0.1. Comparative Statement of the 'With' and Without' Project Scenarios

With Project Impacts		Without Project Impacts	
+ve	**-ve**	**+ve**	**-ve**
• With the proposed improvement, the traffic congestion due to obstructed movement of vehicles along the existing Thamarassery Ghats will be minimized and thus wastage of fuel emissions from the vehicles will be reduced. • Tourism will flourish. • Better access to other part of the region as the project road is a lifeline of the region. • Providing better level of service in terms of improved riding quality and smooth traffic flow. • Will reduce accident rate.	• To ensure the benefit due to project, the connectivity to Anakkampoyil side need to be critically improved. • Minor change in topography is expected due to construction of tunnel. • Minor changes in land use pattern. • Minor Loss to properties and livelihood.	Nil	• Increase in travel time. • Increase case of landslide and soil erosion. • Increase in fuel consumptions. • Increase in dust pollution and vehicular emission. • Increase in accident rate. • Overall economy of the region and the State will be affected.
• Better access and reduced length by direct connecting instead by current route via Thamarassery ghat.	• Change in land use.	Nil	• Increase in travel time. • Increase case of landslide and soil erosion. • Increase in fuel consumptions. • Increase in dust

With Project Impacts		Without Project Impacts	
+ve	**-ve**	**+ve**	**-ve**
			pollution and vehicular emission. • Increase in accident rate. • Overall economy of the State will be affected.
• All weather access reliability. • Minimal impact to the forest land as the tunnel is proposed	• Removal of vegetative cover along the road at selected locations and loss of trees. • Impacts of flora and fauna. •		• Increase in accidents
• Reduced transportation costs.	• Increase in air pollution due to vehicular traffic. • Short term increase in dust due to earth work during construction at micro-level.	Nil	• Existing road will further deteriorate.
• Employment to local workers during the execution of the project.	Nil	Nil	• Arrest of possible significant enhancement and economic development of the region.
• Strengthening of local economies.	Nil	Nil	• In absence of the project, it is extremely difficult to generate funds for such a massive improvement of the road infrastructure from its own resources.
• The widened and paved road will reduce impacts due to multiple tracking on soil and vegetation along the road.	Nil	Nil	• Increased adverse impacts on soil and vegetation.

3.3. Alternatives for Alignment

The alignment study includes a comprehensive identification and evaluation process to determine transportation problems, and identify and evaluate potential improvement alternatives. In addition, possible improvement alternatives are discussed and evaluated, and recommendation are made with regard to the feasibility of each alternative, the findings of the initial alignment study will be used to identify the alternatives that best address the need for improving the existing highway while avoiding and minimising the impacts to important environmental and community resources.

3.3.1. Methodology

Possible alternative road alignments between Anakkampoyil and Meppadi were prepared based on the nature of topography as studied from Topo sheets and geospatial data, land use/forest maps, geological information and primary data collected during several site visits of expert teams. Design parameters like horizontal geometry, vertical geometry, design speed, etc. were studied for each possible alternative. In order to minimize complexities to construction activities involving diversion of Forest land, Forest area is avoided to the possible extent. As the land cost in this region is very high, it is desirable to minimize the degradation of existing land while planning alternatives of road alignments. Following Socio- Enviro-techno - economic parameters were also been taken into account and the alternative alignments were checked against each individual parameter.

- **Route Length:** It is desired to connect origin and destination with minimum route length complying IRC design standards.
- **Minimum tunnel length:** Since the project alignment is passing through the Hilly and mountainous terrain, alignment alternative with minimum length of tunnel stretch is favoured while selecting most feasible and suitable alignment. Moreover, construction of a tunnel for a two-lane carriageway is highly expensive with an approximate cost of Rs.95 crores per km.
- **Forest Area to be affected:** While developing infrastructure there should be endeavour to minimize degradation of Forestland to the extent possible.
- **Geological features:** It will be prudent to align the tunnel and its portal locations on stable Geological strata.
- **Connectivity to important villages:** Main objective of project is to connect desired origin and destinations and also villages or habitats enroute. Possibility of spurs to settlements in the vicinity could then be explored vide other Projects.
- **Land requirement:** Nowadays, land acquisition is the most time-consuming and a costly affair. The alignment will be selected such that minimum land requirement is involved.
- **Approximate Project cost:** Indeed, while selecting feasible alternative alignment cost will be prime criteria and hence the endeavour would be to optimize cost.

In the fore-going paras, increasing chainage order is considered from south to north direction. Based on desk studies, site inspection, aforesaid mentioned parameters, best possible routes were envisaged. The four possible Project Road alignment alternatives were prepared and map showing in **Figure 0-5**. The details of alternatives are briefed as follows:

3.3.2. Alt-1 Maripuzha (South) to Vellarimala (North)

With a view to arrive at a feasible alternative with the shortest length of tunnel and a minimum length, the Maripuzha –Vellarimala route has been envisaged. On south side of proposed tunnel, the present road connectivity is upto Maripuzha village from which south take-off has been proposed. Thus the utilization of the available road connectivity is maximized.

A major bridge at km 0+425 with a length of 130 m was proposed across Irunvanjipuzha on the southern approach road. Irunvanjipuzha flows in forest area and narrow strips of land adjoining banks of either side of the river area belongs to private owners. Immediately after crossing Irunvanjipuzha, the south portal of the tunnel was proposed at km 0+580 m from where the proposed road takes a right turn to emerge out at the north portal at km 7+45. At km 7+642 the proposed project road joins the Meppadi- Chooralmala road. All locations on the Meppadi-Chooralmala road further south of the proposed junction are at much lower elevations and the existing road has several sharp curves and steep gradients that would render the drive from and to Meppadi as a more tortuous experience. Hence junction / take-off points at locations further south on the Chooralmala road i.e. at Mundakkai, etc, were not explored. Approach roads having length of 580 m and 192 m were envisaged on the south and the north sides respectively of the proposed tunnel with a length 6870 m.

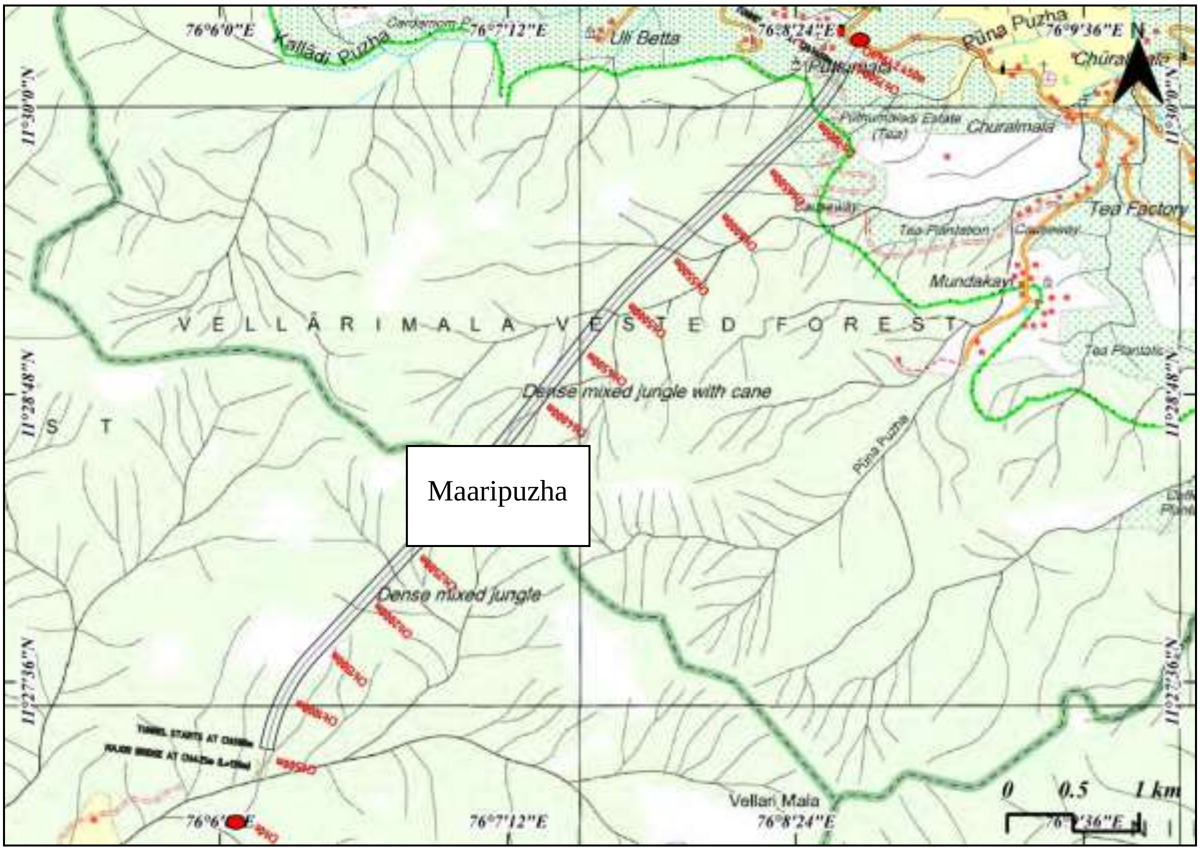


Figure 0-1. Alt-1 Maripuzha (South) to Vellarimala (North)

Thus the total route length from Maripuzha to Vellarimala is 7642m. The gradient in Tunnel stretch of this alternative is 2.89%.

The present connectivity of Meppadi town from this proposed north end is very poor and partially passing through forest area as well. Hence, it’s widening and improvement will be a complex task.

North end and further 2.0 km is in landslide prone areas where a massive landslide disaster had occurred on 8th August 2019. Around 20 people were killed and many families lost their homes in the same tragedy. As the northern end of the Project road happens to be at the farthest distance from Meppadi amongst all alternatives, additional cost in widening and improvement of geometry of the stretch would be involved apart from the recurring cost of maintenance.

3.3.3. Alt-2 Maripuzha (South) to Meenakshi Bridge (North)

On the south side, the existing road at Maripuzha village from which a take-off had been proposed in Alternate-1, has been retained. On the north side, it was proposed that the project approach road join the existing Meppadi – Chooralmala road at a feasible location closest to Meppadi, i.e., at Meenakshi Bridge.

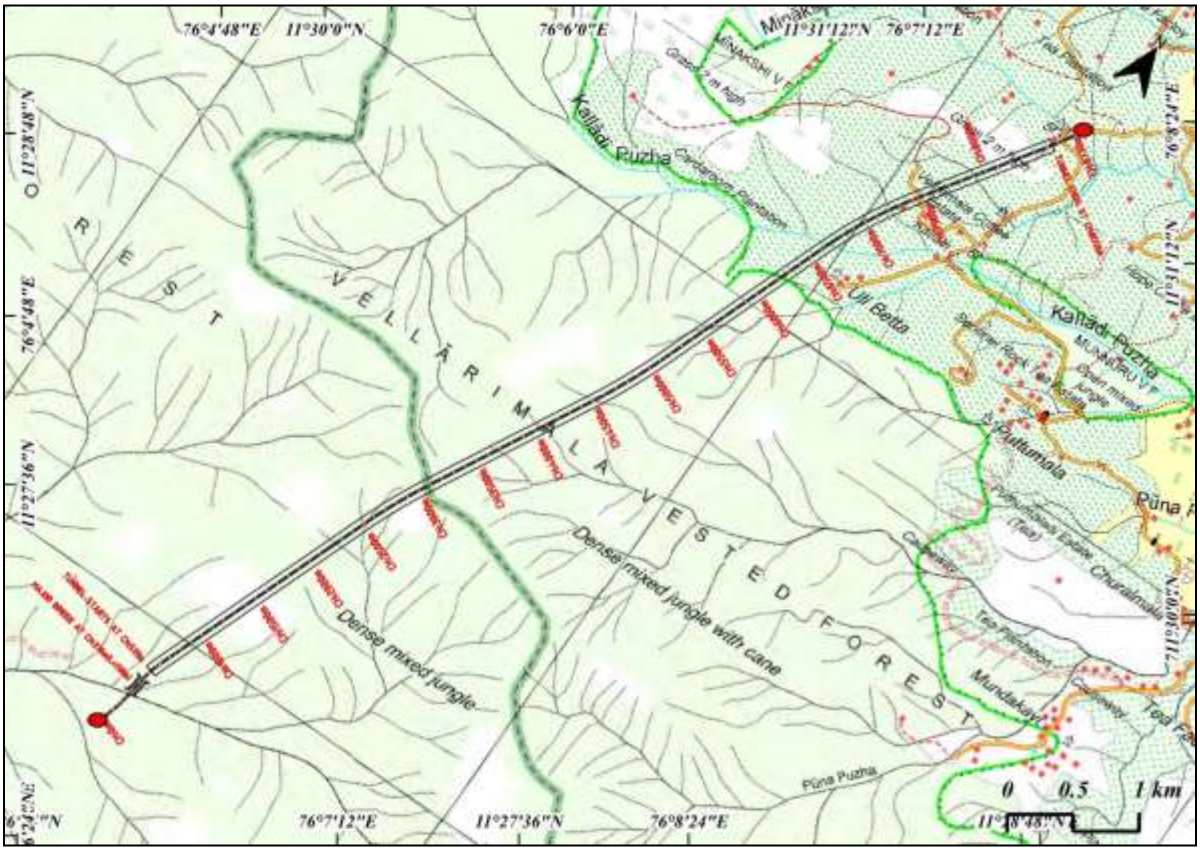


Figure 0-2. Alt-2 Maripuzha (South) to Meenakshi Bridge (North)

After taking off from Maripuzha, the alignment is practically straight all the way to Meenakshi bridge. Mild curves are proposed based on site conditions and to break monotony of the road users. The proposed alignment crosses Irunvanjipuzha at km0+370 where a major bridge is proposed for a length of 120m. Irunvanjipuzha is located in the forest area under Edathara Section of Kozhikode Division. South portal of the tunnel was proposed in private land at km 0+510 and the north portal is at km 8+620 m. Thus, the tunnel length is 8110 m with a maximum gradient of 2.50%. This road alignment meets Meenakshi bridge on existing Meppadi-Kalladi- Chooralmala road at the north end. Approach roads of 510 m on south side and 115m on north side are envisaged in this option. Total route length of this alternative from Maripuzha to Meenakshi Bridge is 8735m.

In this option, length of approach roads is reasonably low. The portal areas are on stable ground. North end of this option is meeting near Meenakshi bridge which is approximately 6 km from Meppadi town. The present connectivity of Meppadi town from this proposed north end has comparatively better geometry. The strengthening of this present road is in progress under Executive Engineer, Wayanad, PWD, Kerala.

3.3.4. Alt-3 Muthappanpuzha (South) to Meenakshi Bridge (North)

The existing MDR from Muthappanpuzha to Maripuzha is 1.5 km length which involves 17 sharp curves and steep gradients in elevation. In consideration of this, Alt-3 was envisaged to avoid need for development of this existing stretch but to take off the proposed project from Muthappanpuzha village.

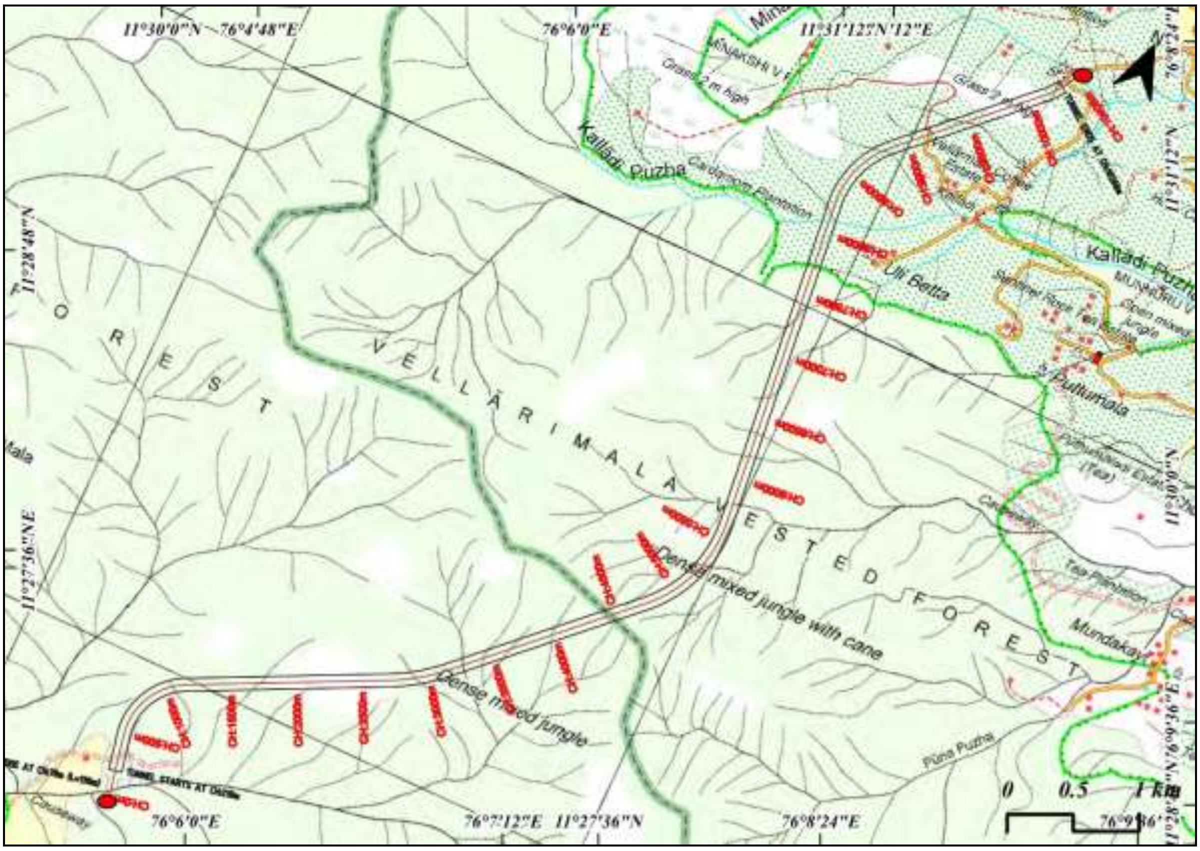


Figure 0-3. Alt-3 Muthappanpuzha (South) to Meenakshi Bridge (North)

This option starts from Muthappanpuzha village which is located on Anakkampoyil to Maripuzha road on south side of route under Study. A bridge of 130m was necessary across Irunvanjipuzha at km 0+070. Immediately after crossing Irunvanjipuzha, the road alignment reaches the proposed south portal at km 0+210. Later, it negotiates right hand curve and moves in north-east direction. The route length has been increased by introducing horizontal curves at appropriate locations in order to keep the gradient within permissible limits. In this trial, tunnel length works out to 10,050 m with a maximum grade envisaged at 2.97%. The alignment ends near Meenakshi Bridge located on Meppadi-Kalladi-Chooralmala road. Approach roads of 210 m on south side and 145 m on north side are envisaged in this option. Total new route length of this option was 10,405 m.

In this option, the location of south end was selected at Muthappanpuzha to avoid development of the difficult part of present road having sharp curves with steep gradient. There will be substantial saving towards the cost of development of existing road by State PWD with better road geometry than other alternatives. The length of approach road planned is reasonably low which is 210 m and 145 m on south and north ends respectively. As the total length of approach road is 355 m only, the land requirement would be the least amongst all alternatives. North end of this option is meeting near Meenakshi Bridge which is hardly 6 km away from Meppadi town. The present connectivity of Meppadi town from this proposed north end is being developed by PWD Kerala. Comparing with all the options, the elevation difference between south and north end of this option is the highest. Hence, the length of tunnel is the maximum compared to other alternatives. The tunnel is longer by about 2020 m than the tunnel proposed in Alt-2, thereby increasing in cost towards tunnel construction by about Rs. 242 crores.

3.3.5. Alt-4 Maripuzha (South) to Kalladi (North)

With a view to reduce tunnel length in comparison to Alt-3 and also to connect Kalladi Village in Kalpetta Block of Wayanad District on north side, this option was explored.

Figure 0-4. Alt-4 Maripuzha (South) to Kalladi (North)

Approach roads having length of 580 m and 462 m were envisaged on south end and north end respectively. As was the case in Alternates 1 and 2, on south side, the take-off was proposed from Maripuzha village. Thus the available road connectivity was maximized. The alignment crosses Irunvanjipuzha at km 0+425m where a major bridge having length of 130 m was envisaged. River flows in forest land under Edathara Section of Kozhikode Division and strips of land on either side of river area belong to private owners. Immediately, after crossing Irunvanjipuzha, road alignment negotiates a right hand curve where the south portal of tunnel is proposed at km 0+580. With a view to provide gradients within permissible limit inside the tunnel, the length of the tunnel is increased with introduction of three curves. The north portal is at km 8+150 on right bank of Kalladi River. The length of tunnel is around 7570 m with a maximum grade of 2.98%. The alignment ends near Kalladi bridge at km 8+612 on Meppadi-Kalladi-Chooralmala existing road. Total new route length from Maripuzha to Kalladi Bridge is about 8612m.

The total length of both approach roads is 1042 m which is the maximum amongst all the four alternatives. North end of this option is meeting near Kalladi Bridge which is about 8 km away from Meppadi town. The present connectivity of Meppadi town from this proposed north end is being developed by PWD Kerala.

Due to the nature of topographic and site constraints, the design speed of north approach road for Alt-4 is restricted to 65 kmph.

3.3.6. Comparison of Alternatives

The four technically feasible alternate alignments are compared as per the following Techno - Economic parameters:

Route Length: The overall length between the two take-off points as per Alt-1 is the lowest at 7.64 km with cumulative length of approach roads of 0.58 km. However, the project road length between Maripuzha and Meenakshi Bridge is 11.642 km. The disadvantages of Alt-1 are:

- The need for improvement and annual maintenance of the additional length of 4 km of existing MDR of Meppadi-Chooralmala road in comparison to Alt-2 and Alt-3 where the Approach road joins the Meppadi-Chooralmala road at Meenakshi Bridge.
- The fragile geological settings of the additional stretch of Chooralamala road.

Minimum tunnel length: Alt-1 provides the least length tunnel at 6.87 km followed by Alt-4 and Alt-2 with tunnel lengths at 7.57 km and 8.03 km respectively.

Forest Area to be affected: Approach roads are of short lengths. Alt-3 would place the minimum requirement of land for approach roads as well as for widening / improvement of existing MDRs followed by Alt-2 and Alt-4. North end of Alt-1 passing through forest area which demands additional requirement of forestland.

Geological features: The tunnel and portal locations are on stable Geological strata. However, stronger supports would need to be provided at the northern end of tunnel in Alt-1.

Connectivity to important villages: The alignments in Alt-1 and Alt-4 would pass through Kalladi while the remaining two alternates take-off at the north side at Meenakshi Bridge.

Land requirement: For a project of such a magnitude, the land required for the project is very low even after accounting for semi-permanent requirement of dump yards. The requirement ranges between 19 to 30 Ha.

Approximate Project cost: The cost of construction would be the least in Alt-1 which has the least length of tunnel. The existing MDR from Vellarimala rises by 35 m up to Kalladi and falls by 20 m to Meenakshi Bridge. The overall length of project road is 11.642 km. Hence, the cost of widening and protection works of the additional stretch of the Chooralamala road would off-set the savings due to reduced length of the tunnel. The length of tunnel in Alt-2 is comparatively longer w.r.t to Alt-1 and 4, however the length of approach roads is reasonably low as the north end is nearer to Meppadi town. However, the effective length of the project road at 8.730 km is the lowest. The tunnel gradient is of 2.5% and horizontal geometry is also superior to other alternatives.

Comparitive Statement of each alternative considered is given below table and alignment plan of the same is presented in **Table 0.2 & Figure 0-5**.

Table 0.2. Comparative Statement

Sr. No.	Details	Alt-1	Alt-2	Alt-3	Alt-4
1	South end Location	Marippuzha	Marippuzha	Muthappanpuzha	Marrippuzha
2	North end Location	Vellarimala	Meenakshi Bridge	Meenakshi Bridge	Kalladi Bridge
3	Route Length (m)	7642	8735	10405	8612
4	Tunnel Length (m)	6870	8110	10050	7570
5	South approach Road (m)	580	510	210	580
6	North approach Road (m)	192.5	115	145	462
7	Major Bridges	2	2	2	3
8	Length of Major Bridge (m)-120m per bridge	240	240	240	340 (260+80)
9	Minor Bridges/Culverts	3	3	3	3
10	Design Speed in Approach (KMPH)	80	80	80	65
11	Tunnel Gradient (%)	2.89	2.50	2.97	2.98
12	Land Requirement including dumping site (Ha)	Approx. 26	Approx.19.5	Approx. 29	Approx. 28
13	Improvement required for Chooralamala road to the south of Meenakshi Bridge	Yes (4.0 km)	Nil	Nil	Yes (1.6 km)
14	Geology	North end & further 2.0 km is in highly land slide prone areas	Good	Good	North end & further 1.0 km is in land slide prone areas
15	Degradation of forest	46 Ha	17.263 Ha	45 Ha	40 Ha
16	Feasibility for improvement of existing North Road	Complex task due to Forest land	Feasible	Feasible	Feasible with additional cost
17	Travel Time	Maximum	Least	Minimum	Moderate
18	Vehicle operating Cost	Maximum	Minimum	Minimum	Moderate

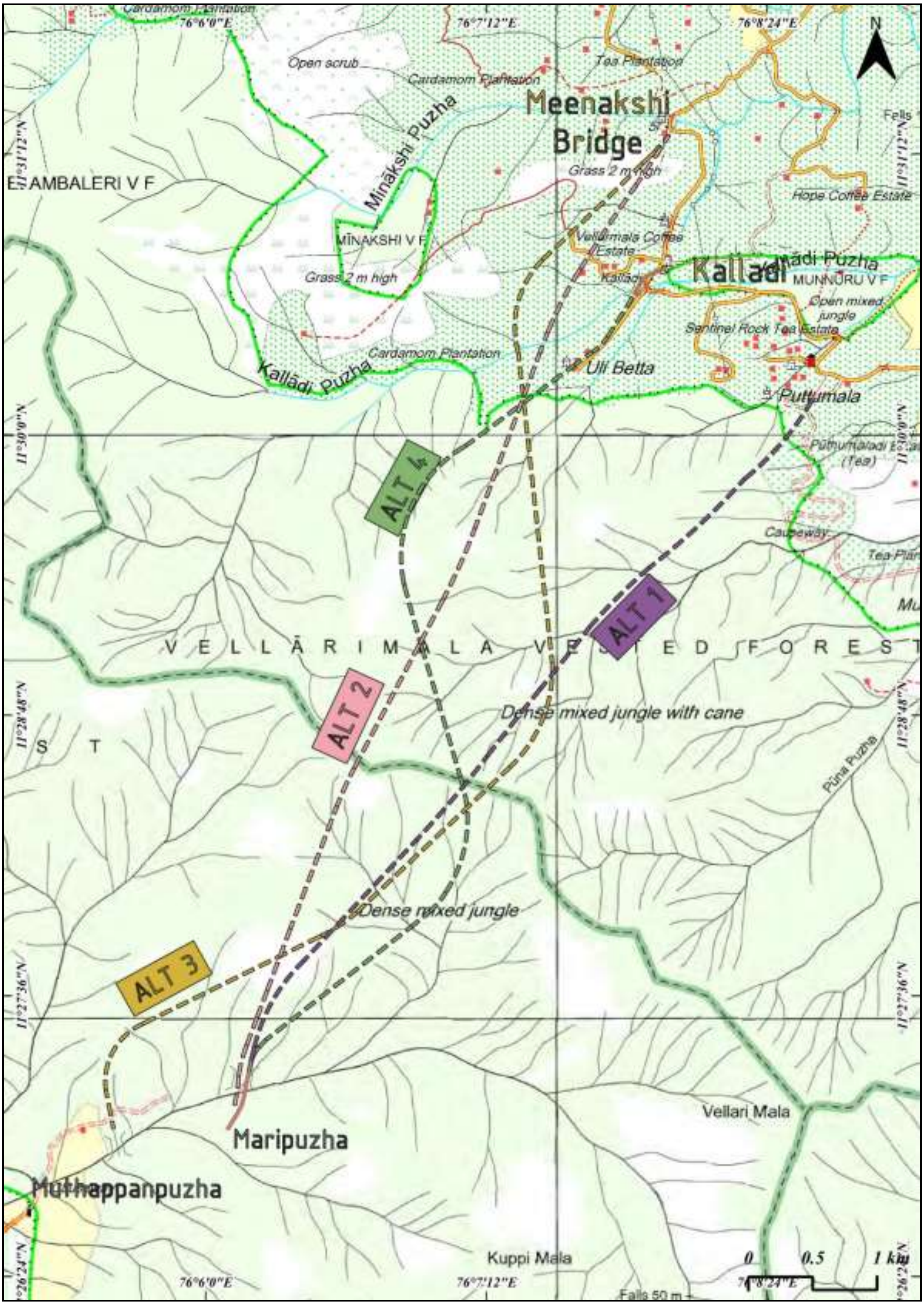


Figure 0-5. Comparison of Alternatives Considered

3.3.7. Conclusion

In Alt-1, the horizontal alignment is within acceptable parameters and the tunnel gradient is 2.89%. Tunnel and portal area at the north end may need heavy supports. The length of tunnel at 6.87 km is the least amongst the four alternatives. North end of this option meets the Meppadi-Chooralmala road at Vellarimala, approximately 10 km far from Meppadi town which is the farthest compared to other options.

Moreover, on back drop of 2019 landslide disaster, further developments in same vicinity can not a permanent solution. Landslide is the most frequent geo-environmental natural hazard which significantly affects human life and environment. Well-planned mitigation measures, the severe landslide susceptible sites can be stabilized and minimize the landslide hazard. However, effective engineering measures involve considerable capital cost with heavy civil engineering works. The global stability of the area south of Vellarimala is in question. In view of above disadvantages, Alt-1 is not advisable for further engineering study.

Alt-3 has longest Tunnel length though it is technically feasible, but not favourable due to the longer length of tunnel.

Alt-4though it is technically feasible, the proposal of alt-4 also fails in comparison with the proposed Alt-2. Overall length, habitations at North Portal, sharp bend, reduction of design speed to 65kmph at north approach, an additional River bridge and above all, more global stability of the slopes are in question.

In Alt-2, the horizontal alignment is much superior as well as is the vertical alignment with the tunnel gradient at 2.50%, among all the alternatives. The portal area is also found to be on a stable ground. The length of approach road planned is the bare minimum resulting in the least impact to land parcels. North end of this option is near Meenakshi Bridge, approximately 6 kms far from Meppadi town which is nearest compared to other options.

Benefits from highway are varied in nature, some of them are direct and some indirect. Direct benefits such as construction cost, maintenance cost can be easily measured, whereas Vehicle Operating Cost, value of passenger time savings, value of reduced noise levels and improved aesthetics cannot be measured easily. As this is shortest connectivity to Meppadi, indirect benefits are also added to its credit.

After examining the various aspects of the four alternatives, based on the anticipated impacts, purpose and objectives, it is recommended to adopt Alt- 2 in view of constructability, geometry, shortest connectivity economic and socio-environmental advantages.

3.4. Alternatives for Pavement Design

In general, there two types of pavements laid in India - rigid pavement and flexible pavement. A flexible pavement can be defined as a pavement layer comprising of a mixture of aggregates and bitumen, heated and mixed properly and then laid and compacted on a bed of granular layer. Rigid pavements on the other hand, are made from cement concrete or reinforced concrete slabs, laid over a low strength concrete layer (Dry lean concrete, DLC) or on a well-compacted layer of aggregates or both.

The largest advantage of using rigid pavement is its durability and ability to hold a shape against traffic and difficult environmental conditions. Concrete Road is more preferable in a water-prone area than an Asphalted road. They provide good visibility for traffic during night hours. They have high bearing capacity, wear resistance, and fire safety as well. The initial construction cost of concrete pavement is more expensive as compared with flexible pavement but has less maintenance and good design life.

Pavement design alternative has been studied for the project road are given in the table below:

Table 0.3. Alternative Study for Pavement Design

Options	**Option – 1: Conventional Flexible Pavement**	**Option – 2: Flexible Pavement (RAP + CT Sub Base)**	**Option -3: Semi Rigid (CT Base and Granular Subbase)**	**Option 4: Flexible pavement with CTB & GSB layer**	**Option 5: Rigid Pavement**
Layers	BC	BC	BC	BC	PQC
	DBM	DBM	DBM	DBM	DLC
	WMM	RAP	AG Layer	AG Layer	GSB
	GSB	CT Sub Base	CT Base	CT Base	-
	-	-	-	CT Sub-base	-

Hence, rigid pavement has been proposed for entire stretch and the pavement composition proposed is as follows.

Table 0.4. Details of Pavement Composition

Homogeneous Section	**Design CBR (%)**	**PQC (mm)**	**DLC (mm)**	**Granular Sub base (mm)**	**Total Thickness (mm)**
Complete Stretch	**8**	**300**	**150**	**200**	**650**

3.5. Alternatives for Tunneling

Types of tunnel construction method can be grouped as shown below.

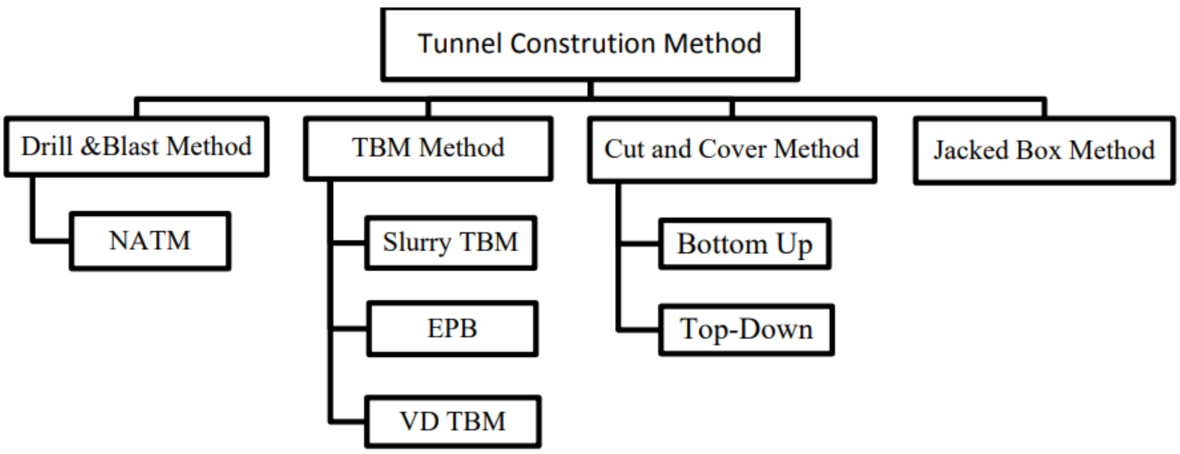


Figure 0-6. Alternatives Considered for the Tunneling Methods

Note: TBM=Tunnel Boring Machine, EPB=Earth Pressure Balance, VD-TBM= Variable Density Tunnel Boring Machine, NATM= New Austrian Tunneling Method.

3.5.1. Alt-1 Drill and Blast Method

This method is suitable for the weak strength rocks (like chalk, clay, marl) as well as for the rocks having high strength (such as quartz, basalt, gneiss, granite). Therefore, drill and blast method is appropriate for the rock mass of varying properties. Furthermore, it is beneficial for the non-circular cross sections, very hard rocks and comparatively tunnels of shorter length, where a TBM is not consider suitable for use. Drill and blast method is the most often used method for underground excavation and tunneling purposes, which consist of several steps such as drilling of balstholes, charging of boreholes, tamping, blasting, fumes extraction by ventilation, mucking and support installation.

3.5.1.1. NATM (New Austrian Tunneling Method)

The New Austrian Tunneling Method (NATM) is also referred as to Sequential Excavation Method (SEM). This method is based on the idea to stabilize the tunnel itself by using the surrounding rock mass geological stress. This method assimilates the principle of rock mass behaviour and monitors the underground construction performance during construction. In NATM method, during the excavation process of tunnels a flexible, thin and closed shell shotcrete is applied on to the walls of tunnel after excavating a tunnel cross section. Strong interaction between viscous rock/soil mass and hardening shell of shotcrete is the characteristic feature of this method. In this method, hand-mining equipment is used for excavation purpose and shotcrete uses as pre-support in order to stabilize the tunnel walls and roof. After tunneling, installation of the permanent liner is done to make sure the long-term stability of the tunnel. NATM design always needs data on the thrusts and moments for the settlements and liners at the ground surface.

Recently NATM tunneling method has been the most common and popular method for the excavation of any type of tunnel cross-sections because of its flexibility in term of geometric shapes as well as its adaptability to varying ground conditions.

3.5.2. Alt-2 TBM (Tunnel Boring Machine) Method

TBM (Tunnel boring machine) is used for the excavation of tunnels with a cross section of circular as well as rectangular shape through the different types of rock and soil strata. TBMs have limitations in term of fixed or predetermined tunnel diameter and shape. Once the shape and diameter of tunnel is decided then it is impossible to change it along the length of TBM drive. Anything from sand to hard rock can be bored by using the tunnel boring machines, therefore nowadays TBMs are using as an alternative to drill and blast methods in soil and hard rock mass. During the excavation process of tunnel, tunnel-boring machines limit the surrounding ground disturbance and produce a smooth wall of tunnel.

3.5.2.1. Slurry Tunnel Boring Machine

Slurry shield machine consist of a plenum chamber, which is filled by a slurry that is made from the water and bentonite, a closed chamber in which the pressure is applied on the slurry to balance the pressure of ground water and a cutting wheel that used for the excavation of ground. This machine is especially used in the ground, which consist of gravel and soil mass, but it has a limited use in the clayey ground mass. It provides the support to the face of tunnel in front of machine by using the pressurised fluid that applied on the basis of surrounding ground permeability.

3.5.2.2. Earth Pressure Balance Machine

Earth pressure balance (EPB) tunneling machine is used to provide the support to the tunnel face by the excavated soil itself during the excavation process of tunnel. EPB consists of several devices like cutting wheel that used to excavate the soil, screw conveyor which used to remove soil from working compartment, pressure cells used to monitor the pressure in the working chamber, excavation chamber which is closed from face of tunnel by pressure bulkhead, mixing vane that located on the pressure bulkhead and on the cutting wheel assist the remoulding of the soil to workable consistency. EPB tunneling machine mostly used in the variable and poor ground conditions like low cohesion ground, high permeable ground, ground with high water pressure and clay with gravel, boulder and sand interfaces.

3.5.2.3. Variable Density Tunnel Boring Machine

The variable density TBM is a high flexible type of boring machine that can be operated in both slurry mode and EPB mode in order to control the face pressure by using the air bubble and muck volume technique respectively. Operation modes of this machine should be changed gradually when needed from slurry to EPB or EPB to slurry mode while machine is in the safe and full face pressure control. Variable density machine during the excavation of tunnel in slurry mode uses a high density or bentonite suspension to control the face pressure that coming from in front of the machine. The concept of using the bentonite suspension to stabilize the tunnel face increases the uses of this machine and makes the variable density machine a worldwide solution for tunnel excavation through any type of mixed ground.

3.5.3. Alt-3 Cut & Curve Method

Cut-and-cover method is frequently used for the construction of several shallow depth tunnels such as rapid transit tunnels, vehicular tunnels and sewer tunnels. Construction of tunnel is termed as “cut-and-cover” when a trench is excavated (“cut”) at the shallow depth and then backfilled (“covered”) with the combination of a support system, which has enough strength to carry the load of the structure to be built on the ground surface above the tunnel. At the depth of 18 m and more “cut and cover method” is commonly used for the construction of rapid transit tunnels and depth from 10 m to 14 m this method is more practical and cheaper as compared to the underground tunneling. This method has the significant disadvantages of construction duration, construction easement requirement and high surface distortion. Cut and cover tunneling method is divided in to two basic forms:

3.5.3.1. Bottom up Method

In bottom up conventional tunneling method, tunnel construction takes place in a trench, which is excavated from the ground surface at the shallow depth and subsequently back filled and supported with the necessary support system. The tunnel is completed before it is covered up and the surface reinstated. The tunnel may be of in situ concrete, precast concrete and precast arches and corrugated steel arches. This method has the benefits of allowing good access to the construction area, urban areas may be unacceptable.

3.5.3.2. Top-down Method

In bottom up conventional tunneling[dj2] method, tunnel construction takes place in a trench, which is excavated from the ground surface at the shallow depth and subsequently back filled and supported with the necessary support system. The tunnel is completed before it is covered up and the surface reinstated. The tunnel may be of in situ concrete, precast concrete and precast arches and corrugated steel arches. This method has the benefits of allowing good access to the construction area, urban areas may be unacceptable.

3.5.4. Alt-4 Jacked Box

Jacked box is a method of tunnel construction, which provides a non-intrusive technique to engineers, designers and planners to excavate or create underground space at the shallow depth under the existing valuable infrastructure and reduces the impacts on the surrounding human environment. Jacked box tunneling method based on the basic concept of the use of a single piece site-cast box structure, which is constructed in a jacking pit situated on the site of tunnel. A tunneling shield and hydraulic jacks are provided respectively at the front and rear end of the box. The box is tunnelled at the site under the railway track after the ground excavation within the shield and jacking the box forward. In order to maintain the support of tunnel face, excavation and jacking processes are generally carried out alternatively in a small increment of the advance. This method is used only to construct under-ground space mainly for road, rail, pedestrian, car parking, office access, machinery rooms, archive and cold storage.

3.5.5. Comparison of Alternatives – Tunneling

Alternatives for tunneling considered are compared and summarized in the following table.

Table 0.5. Comparison of Alternative Study for Tunneling Method

Method	Advantage	Disadvantage
Drill & Blast - NATM	• Very adaptable and flexible • Short mobilization time requirement • Any required shape tunnel cross section is possible • Primary rock support can be installed • Total investment cost is less • Tunnel shape can be changed along the drive length • Dust, noise and visual impact mainly in the portal areas • Lower dust, noise and visual impact compared to C&C • Less vegetation clearance compared to C&C • Less disturbance of land compared to C&C • Less duration of vibration compared to TBM	• Performance rate of advance excavation is lower • Total labor cost is high • Involvement of hard and high manual labor • Low level of automation and mechanization of tasks • Safety risks related to use of explosives • Structural support measures required • Higher vibration level compared to TBM
TBM	• Very high performance and low labor costs	• Limited flexibility in response to extremes of geologic conditions

Method	Advantage	Disadvantage
	• High progress rate, especially in soft ground soil • Excellent cost efficiency and high automation level • Continuous operation Less noise and disturbance to surrounding structures • Best way for constructing deep and long tunnels	• High investment costs and require high backup systems • TBM mobilization take considerable time • Fixed circular geometry and tunnel diameter Longer mobilization time and higher capital costs
Cut & Cover	• Preservation of the environment • Safe initiation and completion of highway tunnels • Safe work progress in unstable weak ground • May applied as sequential construction in case of most adverse geotechnical conditions • Cheaper and more practical than other underground tunneling • Small risk, relative to other construction techniques	• Not suitable for very deep excavations • More dust and noise impact may arise • Cause interference with traffic and other urban activities • Vegetation clearance is required
Jacked Box	• Economical and Better quality control • Time of completion is less • Saving in man power & Machinery • No involvement of crane & heavy equipment • Less involvement of other Departments	• Needs trained staff and skilled supervision • Imposition of caution order exists for a longer period • No scope of the night working • Once the vertical & the lateral alignment of box disturbed it becomes almost impossible to rectify it

There are some technical limitations related to the methods listed above:

- In relation to the curve radius for D&B, there are normally no practical limitations, whereas for TBMs, narrow curves may cause problems.
- TBM is unable to bore a niche.
- Cut and cover is not reasonable for long tunnels, besides, restriction related to landform are also worth to mention

It is important to highlight that the risk for accidents from handling explosives is eliminated by TBM tunneling. The risk of accidents related to stability of excavation face is also much lower with the TBM option since the machine works under the protection of a steel shield.

Both operators of a TBM or drilling rig are exposed to noise and vibrations. This can be reduced to an acceptable level by installing an insulated and vibration dampened operator's cabin. The problem for the crew occurs when additional tasks have to be done outside the operator's cabin, like rock support, rail erections, charging during boring etc. The noise from a jumbo is still higher than from a TBM, but on the whole, there is no significant difference between the methods (drill and blast vs TBM) regarding noise.

Air pollution from the blasting is a problem in D&B tunnels, because of gas emissions and reduced sight. The main pollution problem in TBM tunnels is dust, especially if the quarts content in the rock is high. The content of fines in the muck is higher than in the D&B muck.

Mucking in D&B tunnels is normally executed with diesel engine loaders. Loaders with electrical motors are an option. In TBM tunnels the mucking is carried out by the TBM itself and the TBM is always electrical driven.

With consideration of the length of the tunnel (> 8 km), advancement rates of D&B and TBM, geotechnical characteristics of the rocks – use of a D&B-NATM for the tunnel is considered as advisable.

Chapter 4. Description of Environment

4.1. Introduction

Collection of the baseline environmental data of the project influence area helps to predict the magnitude of impacts that are likely to be caused due to the proposed activity. It also helps to identify critical environmental attributes required to be monitored during and after the proposed improvements. In order to assess the baseline environmental status of the project influence area, monitoring of various environmental attributes were conducted by the EIA Consultants from August 2022 to August 2023.

The sampling and monitoring locations were identified based on the different land use and the sensitive receptors present along the project road. Ambient air quality was measured at 2 locations and at same locations were selected to measure the ambient noise levels, 2 locations for water quality (3 surface and 2 ground water samples) and 2 locations for soil quality along the project road. For the section of road where tree cutting is warranted chainage wise tree count was also carried out to find out the total number of trees to be felled for the project. In addition to the baseline environmental monitoring, field inspection at all the sensitive locations, collection of secondary information for all the environmental components and discussions with the officials and local public were conducted by the Consultants.

The baseline environmental status is presented in the following seven environmental attributes:

- Land Environment
- Water Environment
- Air Environment
- Noise Environment
- Biological Environment
- Socio- economic and Health Environment

4.2. Study Area

To study the baseline environmental profile of the project area, the project impact zone has been classified in to two:

- **Direct Impact Zone (DIZ):** This consists of the RoW and a strip of land within 500 m on either side of the RoW of the proposed alignment. Detailed inventory of environmental features has been carried out in this zone.
- **Indirect Impact Zone (IIZ):** This consists of a strip of land within 15 km aerial distance on either side of the proposed RoW. The presence of sensitive environmental features specifically mentioned in Section III of Appendix I (Form I) to the EIA Notification, 2006 was identified in this zone.

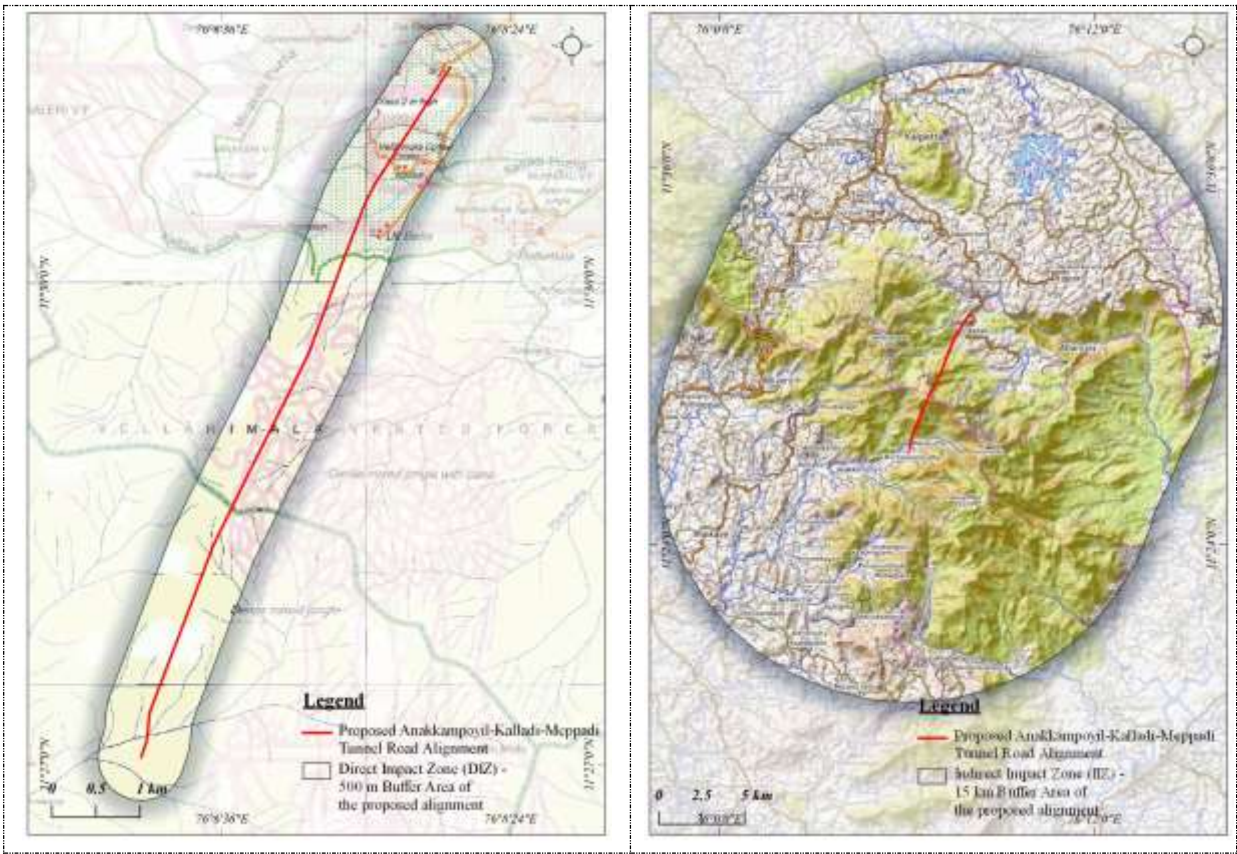


Figure 0-1. Map Sowing the Study Area

4.3. Study Period

Recent data on baseline environment component were collected from various sources of government departments such as India Meteorological Department at Thiruvananthapuram, Central Ground Water Board, District and Taluk offices, Forest Department, Disaster Management Authority etc., The general information of each district were collected from district handbook and their official websites. All meteorological data such as rainfall, temperature, relative humidity, wind speed and wind direction have been prepared by IMD, Thiruvananthapuram. Baseline Environmental Monitoring Studies conducted for Ambient Air Quality from August 2022 to August 2023 through NABL Accredited, MoEF&CC recognized M/s Cochin Test House, Cochin.

4.4. Land Environment

The components of land environment discussed in this section includes,

- Geography and Topography
- Geology and Minerals
- Soil characteristics
- Land Use
- Landslide / Landslip Problem
- Agriculture

4.4.1. Land Availability and Regional Setting

The project road passes through hilly terrain of Western Ghat. The proposed project road is a 8.735 km long four-lane tunnel road including approaches (from existing roads) for providing connectivity between Anakkampoyil-Kalladi-Meppadi in the Kozhikode and Wayanad Districts in Kerala.

The project is formed by connecting two existing roads i.e. Anakkampoyil- Muthappanpuzha-Marippuzha road (MDR) and Meppadi-Kalladi-Chooralmala road (SH-59) with a tunnel road. Anakkampoyil and Maripuzha are located on south of the hill and whereas Meppadi is located to the north of the hill. On the southwestern side, the existing Kunnamangalam –Kattangal –Mukkam-Thirumvambady- Anakkampoyil – Maripuzha MDR route facilitates traffic movement between Anakkampoyil and Kozhikode. The Meppadi-Kalladi-Chooralmala road which is of MDR category, that takes off as a spur to the south of Meppadi is proposed to be intersected as the northern end of the project.

Connectivity of the project area is presented in **Figure 0-2** and the immediate surroundings of the project area is presented as **Figure 0-3.**

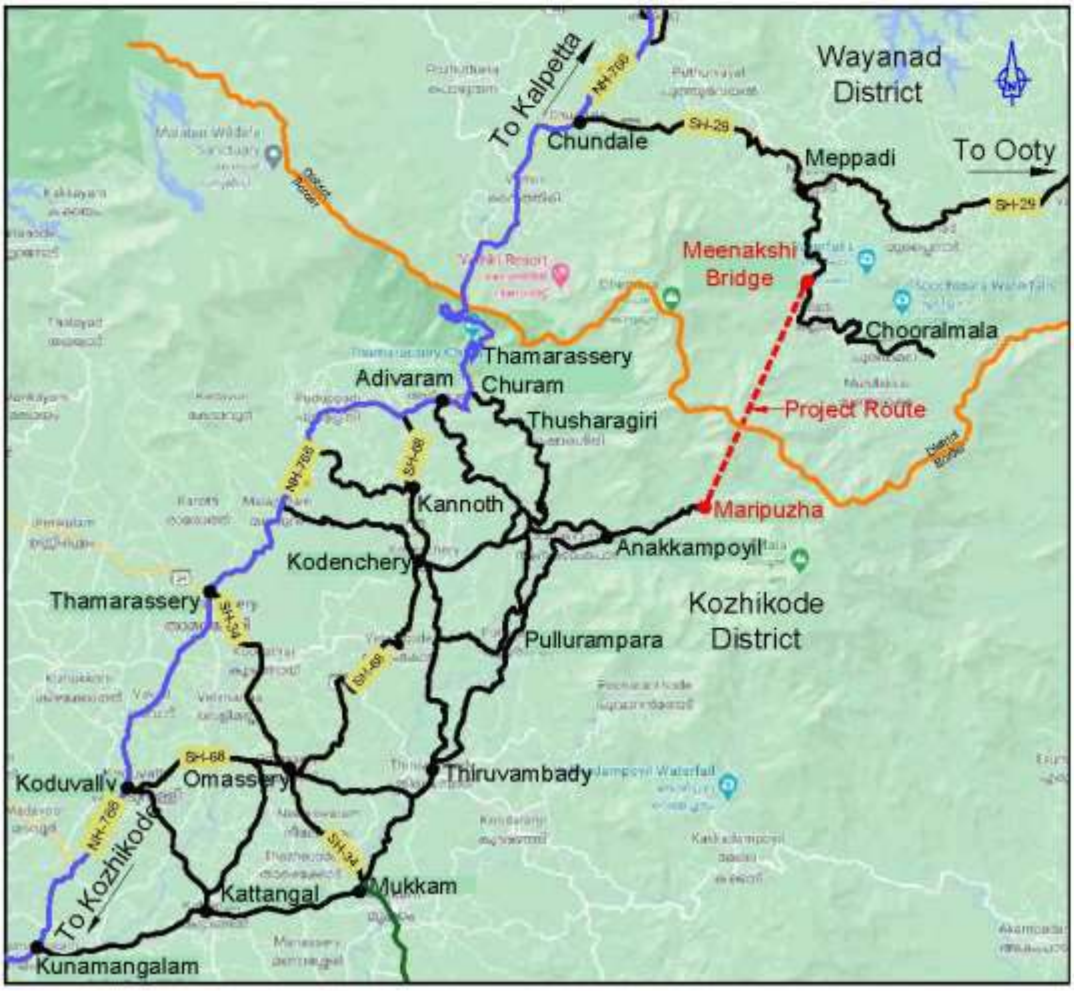


Figure 0-2. Map Showing the Connectivity of the Project Area

The regional setting of the project site is presented below.

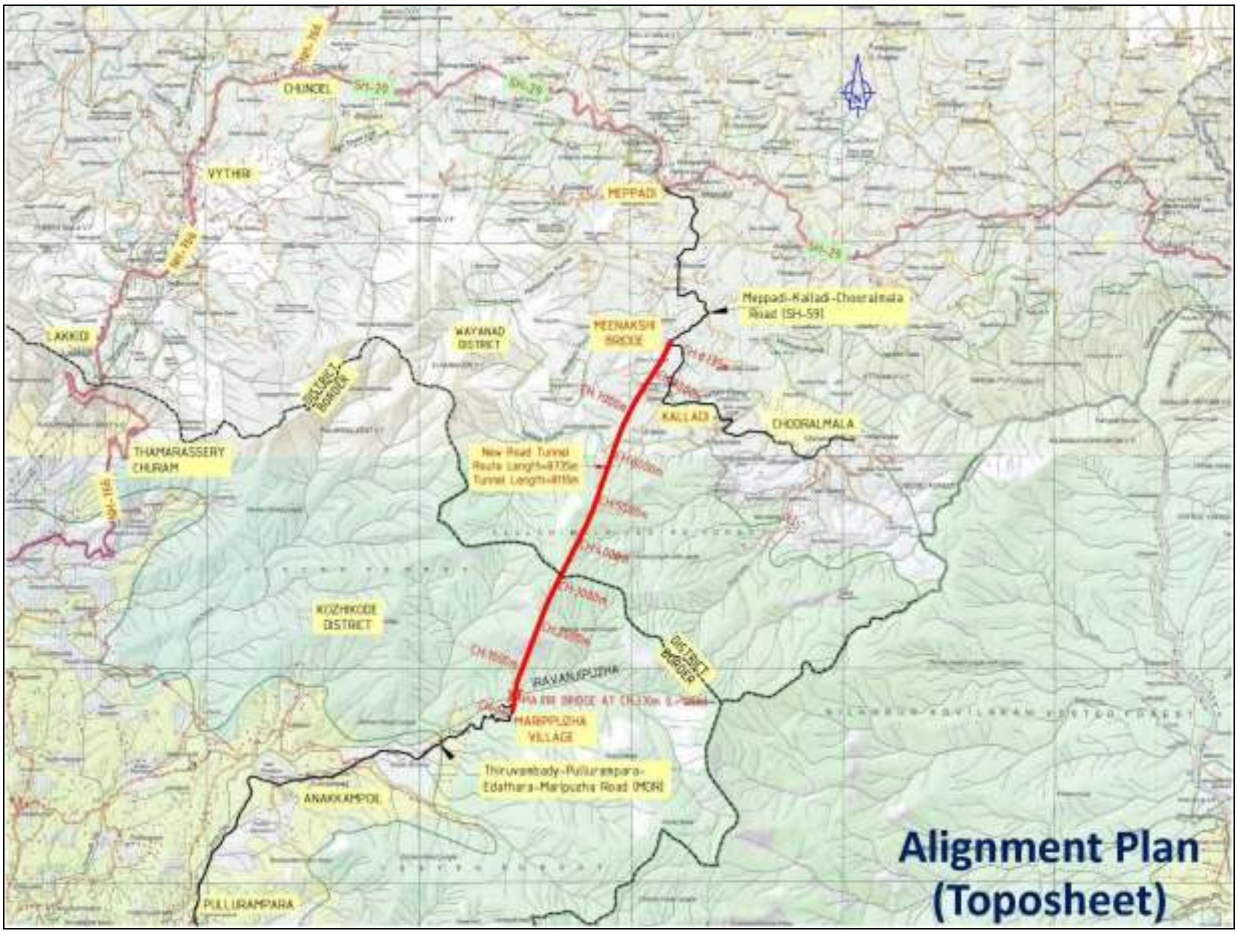


Figure 0-3. Map showing the Immediate Surrounding of the Project Area

Anakkampoyil: It is located in the hillside valley of Vellarimala, where the project alignment starts.

Aripara Falls: It is a tourist spot in Anakkampoyil near Thiruvambady Town.

Chembra Peak: It is the highest peak in the Wayanad hills and one of the highest peaks in the Western Ghats, adjoining the Nilgiri Hills and Vellarimala, it is located in the Wayanad district of Kerala, near the town of Meppadi and 8 km south of Kalpetta.

Elumbileri Check Dam: It is a weir in Wayanad district. Elumbileri Check Dam is south of Panera Peak Estate.

Soochipara Falls: It also known as Sentinel Rock Waterfalls is a three-tiered waterfall in Vellarimala, Wayanad. It is surrounded by deciduous, evergreen and montane forests.

4.4.2. Environmental Sensitivity

The major environmental sensitive areas coming within 15 km radius of the project site include Western Ghats, forests, Iruvazhinji puzha, Kalladi River, Meenakshi River etc. Environmental Sensitivity Map covering an aerial distance of 15 km is presented in **Figure 0-4** and the list of the same is presented as **Table 0.1.**

No sensitive features are directly affected due to the project.

Table 0.1. List of Environmental Sensitive Areas in the Indirect Impact Zone

Sl No	Name of the Particular	Approx. Aerial Distance (km)
Educational Institutes		
1	Marian English Medium School	5.5
2	Crescent English Medium School	8.2
3	St Josephs High School	9.4
4	St Josephs Higher Secondary School	9.3
5	SNMA LP School	9.6
6	Little Flower English Medium School	9.5
7	Govt College Kodenchery	11.5
8	Alphonsa College Thiruvambady	12.7
9	Malabar College Thiruvambady	14.1
10	Govt LP School Muthappanpuzha	1.6
11	St Marys UP School Anakkampoyil	5.0
12	Govt LP School Anakkampoyil	5.2
13	Sacred Heart Higher Secondary School	14.0
14	Thiruvambady ITI	13.9
15	Guidance Public School	14.5
16	Sacred heart UP School	13.9
17	Govt UP School Chembukadavu	7.9
18	Markaz law college	10.6
19	Govt Higher Secondary Chemprampatta	12.6
20	MEC College	14.7
21	DMA College	13.3
22	Fathima Rahim Central School	11.0
23	Little flowere school of social sciences and health	12.4
24	Markaz Public School	12.2
25	Oriental School of Hotel Management	10.5
26	Kerala veterinary and animal sciences universtity	11.9
27	Jawahar Navodaya Vidayalaya	11.8
28	Government model residential school For Boys	11.4
29	Govt LP School Lakkidi	11.0
30	St Claret Public School	9.7
31	Govt Higher secondary Vythiri	10.0
32	GLPS Amba	10.4
33	HIM UP School	10.9
34	Oriental College of Hotel Management	10.7
35	NSS Higher Secondary School	10.0
36	Co Op College	10.7
37	Creative academy arts and science college	11.2
38	HIM UP School	11.3
39	MES Women’s College	12.1
40	RCLP School Vengapally	13.4
41	Shamzul Ulama Islamic Academy	13.8
42	Special School Kalpatta	12.7
43	LMS Pre School	13.0
44	Govt Vocational Higher Secondary School	13.1
45	MCF Public School	11.3
46	De Paul Public School	10.4
47	Hamad Sukhail Khyli School	10.3

Sl No	Name of the Particular	Approx. Aerial Distance (km)
48	KristuRaja Public School	11.3
49	Govt UP School Perumthatta	8.7
50	APJ Salps School	7.1
51	Govt ITI Kalpatta	14.2
52	WMO English Academy Muttil	12.6
53	WOVHSS Muttil	12.4
54	WOUP School Muttil	12.3
55	Centre for Computer Science and Information Technology	13.5
56	AAWK Technical Institute	14.1
57	DM WIMS College	5.4
58	Wayanad Mount View College	7.2
59	Govt LP School Uppupra	7.3
60	GLPS Puttad	8.2
61	Lakhya CA Campus	12.8
62	Global Institute of Hotel Management Studies	14.0
63	GHSS Kakkavayal	14.0
64	Govt LP School Kallupadi	12.5
65	Mandad School	12.0
66	AUP School Pakkam Vazhavatta	10.3
67	GHS Thrikkaipetta	9.0
68	Sreelakshmi Vidhyanikthan Thrikkaipetta	8.2
69	Govt Upper Primary School	9.8
70	Govt LPS& HSS Meppadi	4.4
71	WMO English School	3.6
72	St joseph LP School	3.5
73	St Josephs Girls High School	3.4
74	Mount Tabor English School	3.5
75	Regional Education Centre	3.5
76	Govt Polytechnic College	0.9
77	GUPS Cottanad	5.9
78	GHSS Meppadi	4.2
79	CMS Higher Secondary School	3.6
80	Rippon GHS School	4.6
81	Govt Higher Secondary School Vaduvanchal	10.7
82	Auxilium School Vaduvanchal	10.7
83	College of Agriculture Ambalavayal Wayanad	13.7
84	Darwin College Ambalavayal	14.0
85	Nilgiri Matriculation School	14.8
86	Erumad School	13.7
87	Govt High School Mannthivayal	13.2
88	Govt Primary School	14.8
89	Govt LP School Puthumala	1.4
90	Crescent English Medium School	3.5
91	GVHSS Vellarimala	3.9
92	GLP School Mundakkai	3.9
93	Blooming buds pre school	13.9
94	ST Sebastian s HSS	13.7
95	Fathimabi Memorial HSS Koombara	14.8
96	GLP School Kakkadampoyil	12.9
97	Infant Jesus Public School	12.9

Sl No	Name of the Particular	Approx. Aerial Distance (km)
98	Sukumaramenon Memorial School	12.2
Hospitals		
1	Aster Wayanad	5.75
2	Moopainad Central Hospital	4.29
3	Dr Shahids Clinic	4.62
4	Govt Homeo Dispensary	3.51
5	Punarjani Ayurveda Cooperative Hospital	3.58
6	Community Health Centre Meppadi	4.08
7	Jyothi Thanal Dialysis Centre	4.01
8	Leo Hospital	10.66
9	Swami Vivekananda Medical Mission Hospital	13.56
10	Amrita Kripa Charitable Hospital	13.86
11	Govt Gerneral Hospital	13.36
12	K J Medical Trust Hospital	13.29
13	District Ayurveda Hospital	12.11
14	Fatima Matha Mission Hospital	12.4
15	DM WIMS Urban Health Centre	11.92
16	Ahalia foundation Eye Hospital	10.12
17	Govt General Hospital	10.11
18	ESI Dispensary	10.27
19	Santhigiri Ayurveda and Sidha Hospital	10.18
20	Nirmala Ayurvedic Hospital	9.59
21	NS Hospital	10.27
22	Medical Relief Centre	9.54
23	Jeevess Ayurvedic Hospital	12.75
24	Good Shepherd Hospital	12.86
25	Veterinary Hospital Vythiri	10.6
26	Arafa Dental Studio	10
27	Vythiri Clinic	10.6
28	Government Hospital Vythiri	10
29	Vythiri Ayurvedic Hospital	11.2
30	Govt Health Centre	11.31
31	Truecare Health Centre	11.15
32	Karuna Hospital	11.08
33	VIMS Hospital	14.27
34	Govt Ayurvedic Hospital	9.93
35	Primary Health Centre	10.4
36	Holy Cross Hospital	10.93
37	Vimala Hospital	7
38	Nellipoyil Govt Homeo Dispensary	6.89
39	Sidha Clinic Thiruvambady	13.53
40	Govt Homeo Dispensary Thiruvambady	13.48
41	Thirunethra Eye Hospital	13.84
42	TKS Hospital	13.98
43	Lisa Hospital	13.87
44	Govt PHC Thiruvambady	14.4
45	Primary Health Centre Koodaranji	12.61
46	Primary Health Centre	13.3
47	ACS Hospital Kakkadampoyil	8.17
48	Govt Hospital Kurubalangode	18.92

Sl No	Name of the Particular	Approx. Aerial Distance (km)
49	Paliative Clinic Nettikulam	17.1
50	PHC Nettikulam	18.2
51	Vijay Clinic	17.37
52	Mark Hospital	18.15
53	Govt health centre Munderi	15.07
54	Wentworth Estate Hospital	16.17
55	S N Medical Centre Ayurveda and Allopathy	14.44
56	Pain and Palliative care centre Erumad	15.06
57	Mukalel Medicare	14.22
58	St Martin Hospital	14.34
59	Vaduvanchal Medical Centre	11.07
60	Vaduvanchal Health Centre	10.87
61	Sreedhar Memorial Hospital	9.33
62	Brahmakalpa Ayurveda Hospital	8.27
Religious Properties		
1	St Sebastians Church Muthappanpuzha	1.5
2	St Thomas Church Karimbu	2.9
3	St Marys Church Anakkampoyil	4.8
4	Church of God In India Mundoor	5.2
5	Koorottupara Church	7.0
6	St Marys Malanakar Catholic Church	6.9
7	IPC Zion Church Pathipara	6.2
8	St Joseph Church Manjumala	6.0
9	Povathinchuvadu Devi Kshethram	6.8
10	Sree Dhramashastha Temple	7.9
11	Chembily Bhagavathy temple Palakkal	9.8
12	Kanalad Sree Bhagavathy Temple	10.7
13	Lakkidi Sree Kariyathan Bhagavathy temple	11.0
14	Sree Durga Devi Temple	11.7
15	Jumaa Mazjid Anakkampoyil	4.6
16	Sunni Mazjid Kandappan	4.3
17	Nooramthode Nusrath Mazjid	8.9
18	Koonthalam Ther Juma Mazjid	9.6
19	Kaithapoyil New Juma Mazjid	11.8
20	Maruthilavu Juma Mazjid	8.9
21	Adivaram Mazjid	10.6
22	St Moses Church	11.3
23	Sree Dharmashastha Temple	10.5
24	Juma Mazjid Old Temple	10.1
25	St Marys Church Anakkampoyil	10.6
26	Vaidyar Mala Subramanya Swami Temple	11.1
27	Swayambhu Mariyamman Temple	11.1
28	St Joseph Church Vyhtiri	11.5
29	HIM Convent Chapel	11.3
30	Juma Mazjid Thalipuzha	11.1
31	Juma Mazjid Vythiri	11.2
32	Juma Mazjid Vythiri	11.2
33	Salafi Juma Mazjid	11.0
34	Juma Mazjid	12.5
35	Peringoda Juma Mazjid	13.6

Sl No	Name of the Particular	Approx. Aerial Distance (km)
36	Pozhuthana Mazjid	15.1
37	Sreedevi Temple	10.4
38	St Peters Marthoma Church	10.2
39	St Judes Church	9.9
40	Sree Aiyappa Bhajana Madam	8.0
41	Odathode Mazjid	8.0
42	Kannanchath Mazjid	9.6
43	Juma Mazjid Perumthatta	8.7
44	Pentecostal Mission church Kalpatta	9.9
45	Mudiyur Sree Maha Vishnu Temple	10.2
46	Ayappa Maha Khethram	10.3
47	Sacred Heart Church	11.1
48	Aarogya Matha Church	13.3
49	St Sebastians Church Edapetty	13.2
50	Ananthaswamy Jain Temple	14.5
51	St John Paul II Church	9.1
52	Meppadi Juma Mazjid	3.9
53	Juma Mazjid	3.6
54	Meppadi juma Mazjid	3.4
55	Jamathe Islami Mazjid	3.6
56	St Joseph Shrine	4.0
57	Thazhe Araipetta Juma Mazjid	4.0
58	Chamundeshwari Devi Temple	6.1
59	St Marys Church Nedumbala	7.3
60	Malakkad Temple	14.5
61	Muttil Juma Mazjid	13.8
62	Mazjidul Hudha Kakkavayal	14.7
63	Sunni Juma Mazjid Ambalavayal	15.4
64	Juma mazjid Ambalavayal	14.3
65	Salafi Mazid Ambalavayal	13.9
66	Aiyappa Temple Ambalavayal	13.8
67	Devikunnu Temple	14.7
68	Sree Eruthukolly Pampumkavu Shiva Temple	14.4
69	Neelima Devi Temple	10.7
70	St George Church Vaduvanchal	11.0
71	St Marys Malankara Catholic Church	10.6
72	Heavely Worship Centre	12.1
73	Assemblies of God Church	10.7
74	CSI Christ Church	9.9
75	St George Orthodox Church	11.0
76	St Thomas Church Onneyar	11.7
77	Our lady of perpetual Succour Church	12.0
78	Salafi Mazjid Erumad	15.0
79	St Sebastians church Panamchira	14.2
80	Fathima Matha Church Kaiyunni	14.5
81	St Marys Church Chulliyode	14.0
82	Pentecostal mission church Kayunni	14.5
83	AG Church Chulliyode	14.7
84	CSI Church Cherambady	15.8
85	Carmel Shalom Church	15.9

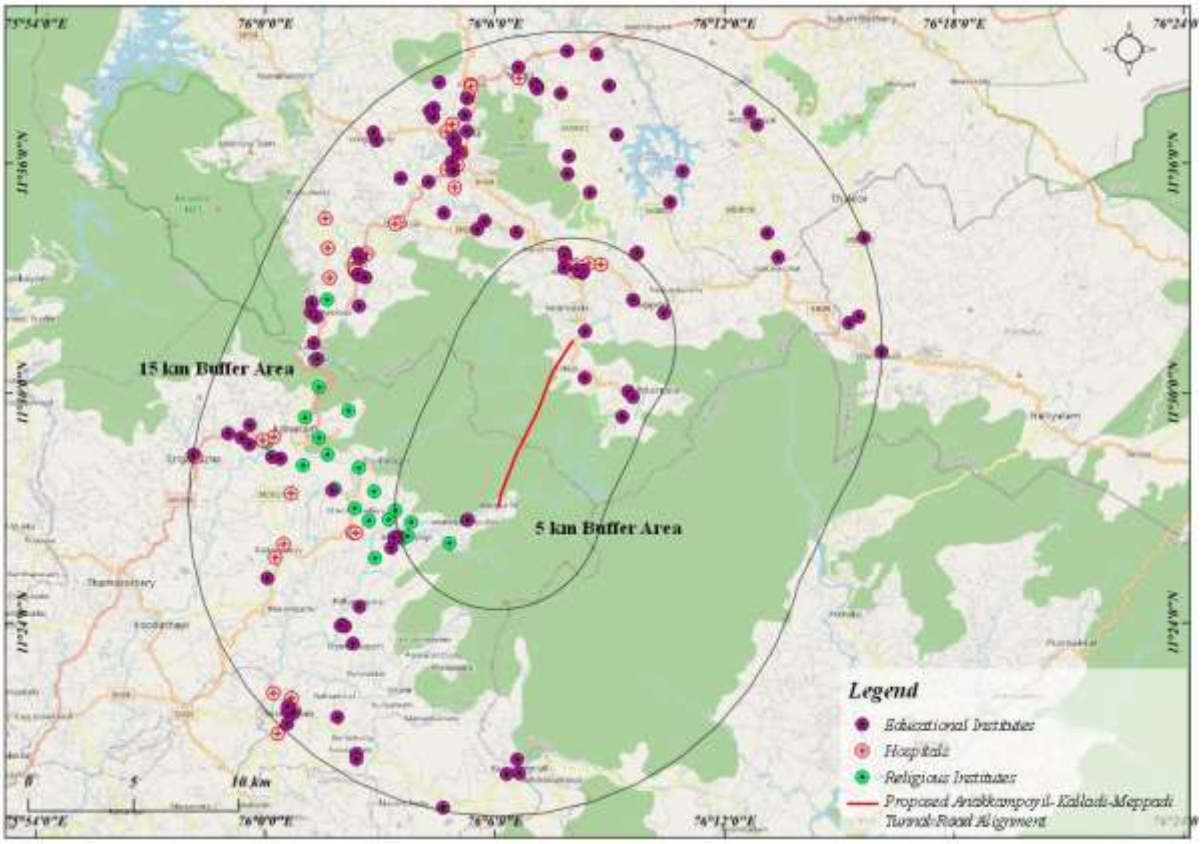


Figure 0-4. Map Showing the Environmental Sensitive Features within the Study Area

4.4.3. Geography and Topography

Geographically the project tunnel is passing through Kozhikode and Wayanad districts of Kerala. Kozhikode district is located between latitudes 11° 08' N and 11° 50' N and longitudes 75° 30'E and 76° 8'E. The district is bordered by the districts of Kannur and Mahé (Puducherry) to the north, Wayanad to the east, and Malappuram to the south. The Arabian Sea lies to the west and Western Ghats stretches towards east. Topographically, the region is part of mountainous terrain.

Wayanad lies between north latitude 11° 27' and 15° 58' and east longitude 75° 47' and 70° 27'. It is bounded on the east by Nilgiris and Mysore district of Tamil Nadu and Karnataka respectively, on the north by Coorg district of Karnataka, on the south by Malappuram district and on the west by Kozhikode and Kannur district.

The Kozhikode district is divisible into three physiographic regions from West to East viz., i) the coastal plain, ii) the midland region and iii) the hilly terrain. The coastal plain is very narrow, 5-10 km wide, gently sloping with a maximum height of about 10 m in the East. The midland region is quite wide with elevations ranging from 30-300 m. The region is characterized by an undulating topography with numerous narrow ridges, moderately sloping spurs, intervening valleys, flat and domal hills and broad valley floors, all alternating with laterite capped hummocks and narrow alluvial strips. The hilly region to the East is again very narrow. Its elevation ranges from 300-600 m. The terrain is characterized by steep to very steep hill ranges.

Topographically Wayanad district is in the high land region forming part of the Western Ghats. Located at higher altitude, the district hosts a plateau. The mountainous region has height ranging from 700 to 2061 meters above mean sea level.

The proposed alignment mainly passes through hilly terrain**.**

4.4.4. Geology and Mineralogy

Kozhikode district can be divided into three geological belts: i) a linear NW-SE trending gneissic belt, along the middle extending from North to South ii) a charnockite belt occupying large areas in the Northeast and South, extending to the adjacent districts and also occurring as pockets within the gneissic terrain. iii) a narrow coastal belt.

Charnokite and associated gneisses with enclaves and linear bands of of Magnetite – Quartzite constitutes the oldest rocks in Kozhikode district. It has a very wide distribution, especially in the Northeast and South with variations to biotite-hypersthene gneiss, biotite-hornblende-hypersthene gneiss and hornblende-hypersthene gneiss. Hornblende-biotite gneiss of the Migmatite Complex extends from North to South and is well foliated. Garnetiferrous quartzo-feldspathic gneiss, another member of the Migmatite Complex, occurs as lenses within charnockite with gradual transformational boundaries in the East. NW-SE trending dolerite dykes traverse these older rocks. These dykes are 10-20 m wide. A pebble bed occurs on the coast and along the banks of the Beypore River.

The pebble bed is associated with grit and clay and is lateritised. It comprises well rounded pebbles of quartz, granite, quartzite and granulite. It is considered to be of Pleistocene origin. Sporadic laterite cappings are recorded from the Charnockite country to the Southwest. Quarternary deposits are of marine and fluvial origin. Periyar Formation is a fluvial deposit comprising an admixture of sand, silt and clay. Guruvayur Formation is a strand line deposit of palaeo-marine origin and mostly comprises medium to fine sand. Kadapuram Formation represents contemporary marine deposits, constituting the present beach and barrier beach.

Wayanad district can be broadly divided into four geological domains viz (1) The Wayanad group in the North, (2) The Charnockite group in the south and central part (3) The Peninsular Gneissic Complex in the North and central part, (4) The Migmatite Complex in the south-central part.

Wayanad group of Supracrustal rocks include Kyanite-fuchsite-muscovite-quartz schist, amphibotite bands, quartz sericite schist/quartz mica schist and meta ultra mafites, representing upper amphibolite to lower granulite facies metamorphism, Garmet-Sillimanite –Biotite gneiss with or without graphite, Hornblende-biotite schist and gneiss ± garnet, These rocks are found as linear bands in the north. Charnockite group of comprises charnockite forming the Hilly Terrain in the south and south east. Pyroxene granulie and bonded magnetite quartzite occur as narrow band within Charnockite. Peninsular gneissic complex, represented by hornblende-biotite gneiss and pink granite gneiss, occupies a major part of the district. Migmatite complex is represented by biotite-hornblende gneiss, occurring over a large area in the south-central part. The other member of this group, namely quarnetiferous quartzo feldspathic ± sillimanite occurs as narrow bands within charnockites. Migmatite complex is represented by biotite – hornblende gneiess occurring over a large area in the south central part. The other member of this group, namely garnetiferous quartzo feldspathic ± sillimanite occurs as narrow bands within older charnockites. In the east, large bodies of intrusive pink granite occur near Kalpetta and Sulthan Bathery. Pegmatite veins are also associated with granites. Dolerite and gabbro are intrusive in to the older rocks. Large lenticular bodies of gabbro anorthosites occur north east of Mananthavady and a large body of diorite occurs near the northern boundary of the district. Geological map of the district is presented below.

Figure 0-5 reveals geological characteristics of the project district and project area.

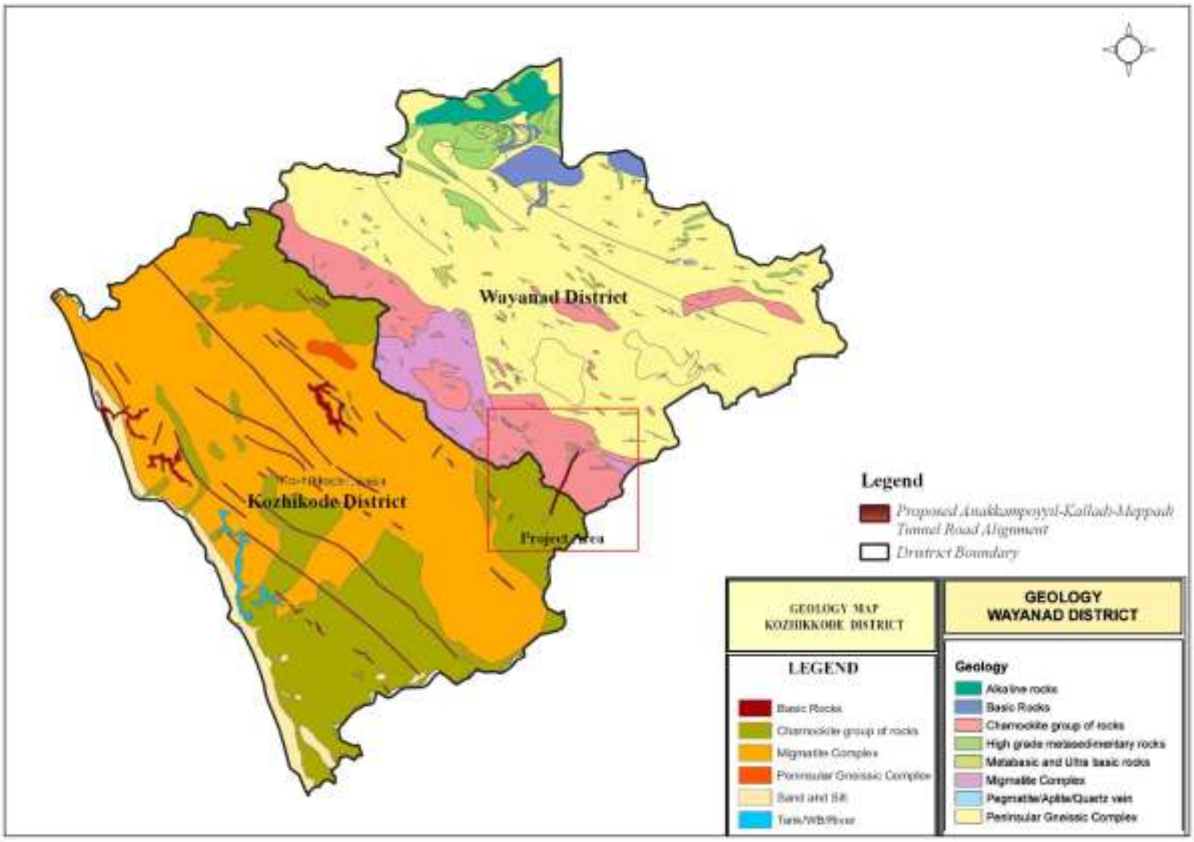


Figure 0-5. Map of the Project Area Showing Geological Features of the Project Districts*

The project area divided into four major geological units.

- Archaean charnockite, belonging to the Charnockite Group, has a very wide distribution of litho-units such as biotite-hypersthene gneiss and biotite-hornblende-hypersthene gneiss. Pyroxene granulites occur as narrow bands within charnockites.
- Hornblende-biotite-gneiss and of the Peninsular Gneissic Complex.
- Migmatite complex is represented by biotite – hornblende gneiess.

Geological features along the project alignment is presented in **Figure 0-6.**

* Source: Natural Resource Data Book for Kozhikode and Wayanad districts by Kerala State Landuse Board.

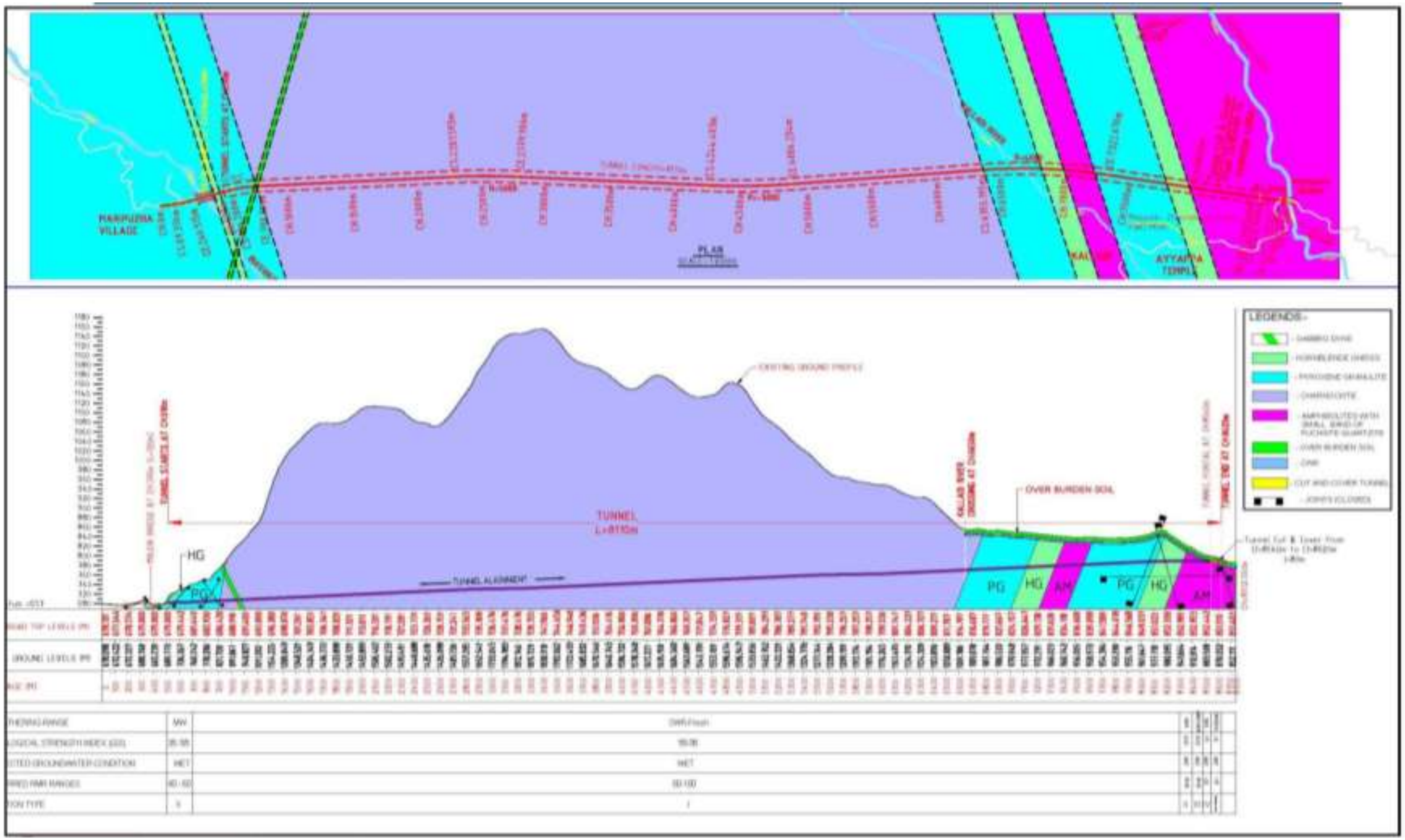


Figure 0-6. Map Showing Geological Features along the Project Alignment*

*Source: Vol I: Main Report

Clay, limeshell, magnetic iron ore, ilmenite and building stones are the economic minerals seen in Kozhikode district. Lime shell is exploited from the Kadalundi and the Korapuzha rivers. Magnetic iron ores occur at a number of places such as Nanmanda, Cheekilode, Kanniparamba, Naduvallur and Alampara. Limeshell occurs in the backwaters between Kozhikode and Vadakara. Large quantity of limeshell is reported from the lower reaches of Beypore, Korapuzha, Murat and Agalapuzha river beds. Beach sands along a small stretch between Beypore and Kallayi rivers contain good concentration of ilmenite. Primary clay (China clay) occurs at a number of places in the midland region.

In respect of economic minerals, quartz reef, containing minute quantities of gold occur in Wayanad district.

Seismicity and Volcanic Activity: Seismicity / Effect due to earthquake has been accounted for by considering the seismic load in longitudinal and transverse direction. For the purpose of determining the seismic forces the country is divided into four zones (Zone II – Zone V) based on the intensity of earthquakes that a particular area may be subjected to, with Zone V comprising of areas which have been subjected to severe earthquakes & Zone-II comprising areas least liable to earthquakes. The seismic loads are calculated using Response Spectrum method as per Modified clause of IRC 6: 2010. The seismic force depends upon several factors like zone factor, Period of vibration, Soil type etc. The seismic load in longitudinal and transverse direction is found out separately. The live load effect is not considered in the longitudinal direction where as 50% of live load is taken in transverse direction. As per the seismic zone classification of India, the project districts fall in zone III, i.e. Moderate active category. (The project area is shown in the circle marked in the Figure). The Project site falls in Zone III of seismic map (**Figure 0-7**) and relevant provisions in IRC-6:2017 have been adopted in the design.

Figure 0-7. Seismic Zone Classification of India

According to the seismic zonation map of India, whole of Kerala State falls within Zone III, where earthquakes of magnitude up to 5.7 in Richter Scale and Modified Mercalli intensity up to VII can occur (Rastogi, 2001). The study area being part of the Western Ghats and the Wayanad plateau, tremors are a possibility and need to be reckoned with during and after construction of the tunnel. Seismic records maintained by NCESS, Thiruvananthapuram for the period 2000-2016 indicate that 8 tremors with magnitude ranging from 2.0 to 3.0 occurred in the adjoining areas, mostly in parts of Kozhikode and Malappuram districts , and one in the Kannur-Wayanad border (12/1/2003; magnitude 2.6).

4.4.5. Soil Characteristics

The soils of the district are classified into sandy, laterite and hilly or forest soil. The sandy soil occurs all along the western side of Vadakara, Quilandi and Kozhikode taluk. The laterite soil occurs east of the sandy track which covers in major part of the district.

The soils of the Wayanad plateau includes poorly drained alluvial soils having sandy loam to sandy clay loam texture to well drained soils developed from gneissic materials having clay loam to clay texture. The soils in the central Sahyadri highlands Physiographic region have well to excessively drained soils developed from gneissic rock. The texture ranges from clay loam to clay texture with varying ranges of gravel content. The soils of the Mountainous region are very deep excessively drained forest soils developed from gneissic material with clay loam texture.

1) Loamy soil:-Major part of the district

2) Laterite soil:-Valleys in the middle portion of the district.

They are formed by the Weathering of acidic rocks under alternate wet and dry tropical conditions and are generally developed in regions of heavy rainfall and high Temperature Porous and well drained, their capacity for retaining water and fertilisers is somewhat poor. Laterite soils are usually of low fertility. Those found in the hills are gritty and shallow land deficient in essential plant foods. Those which occur in the plains are deeper and of finer texture containing fair quantity of organic matter but very deficient in phosphate, potash and lime. Though laterite soils are of low natural fertility they respond well to cultivation and judicious application of fertilisers.

These soils mainly occur in the midlands at elevation 20 to100 above M.S. L as a Trip between the coastal belt and hilly midup land. All these laterite soils are acidic with low water holding capacity, soil erosion and reduced effectively soil volume. The laterite soil is generally suitable for most of the dry land crops. It is mainly cultivated with coconut, arecanut banana, tapioca, vegetables, yams, pepper, pineapple, fruit tree etc.

As per the soil map by KSLUB, the project area falls in Soil Mapping Units of KL 21 of Kozhikode district and KL 19 and KL 20 of Wayanad district. Details of KL-19, KL-20 and KL-21 are as follows.

Soil Mapping Unit	Description of Major Soil	Classification	
		Major Soil	Inclusions
KL-19	Very deep, well drained, clayey soils on moderately sloping high hills with thin vegetations, with moderate erosion; associated with rock outcrops.	Clay, mixed, Ustic Palehumults Rock land	Fine –loamy, mixed, Ustic,Humitropepts Fine- loamy, mixed, Ustic Palehumults

Soil Mapping Unit	Description of Major Soil	Classification	
		Major Soil	Inclusions
KL-20	Deep, somewhat excessively drained, gravelly clay soils with, moderate surface gravelliness on steeply sloping high hills with thick vegetation, with moderate erosion ; associated with very deep, well drained, clayey soils on gently slopes	Clayey- skeletal, mixed, Ustic Haplohumults Clayey, mixed, Ustic Palehumults	Rock land , Fine, mixed, Ustic-Humitropepts
KL-21	Moderately deep, somewhat excessively drained gravelly clay soils with coherent material at 75 to 100 cm on moderately sloping medium hills with thick vegetation, with moderate erosion; Associated with moderately shallow, somewhat excessively drained gravelly clay soils with moderate surface gravelliness and coherent material at 50 to 75 cm on very steep slopes, severely eroded.	Clayey-skeletal, mixed, Ustic Haplohumults Clayey-skeletal, Kaolinitic, Typic Kanhaplustults	Rock land Fine, Mixed Ustic Humitropepts

Figure 0-8 gives the details of soil types found along the project tunnel alignment.

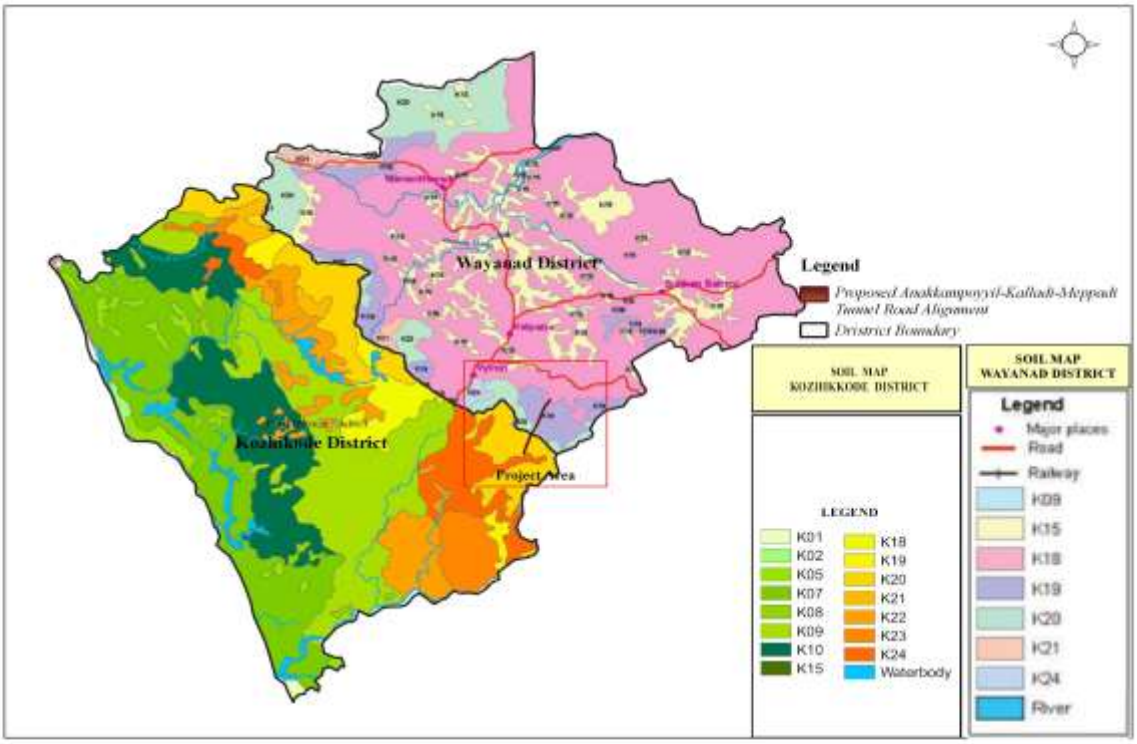


Figure 0-8. Map of the Project Area Showing Soil Characteristics*

In order to have a better understanding of the soil characteristics of the project area, soil samples were taken and analysed for all-important parameters at two locations. The Sample 1 was drawn at near rural residential area and Sample 2 was drawn at Anakkampoyil rural agricultural land (plantation), respectively.

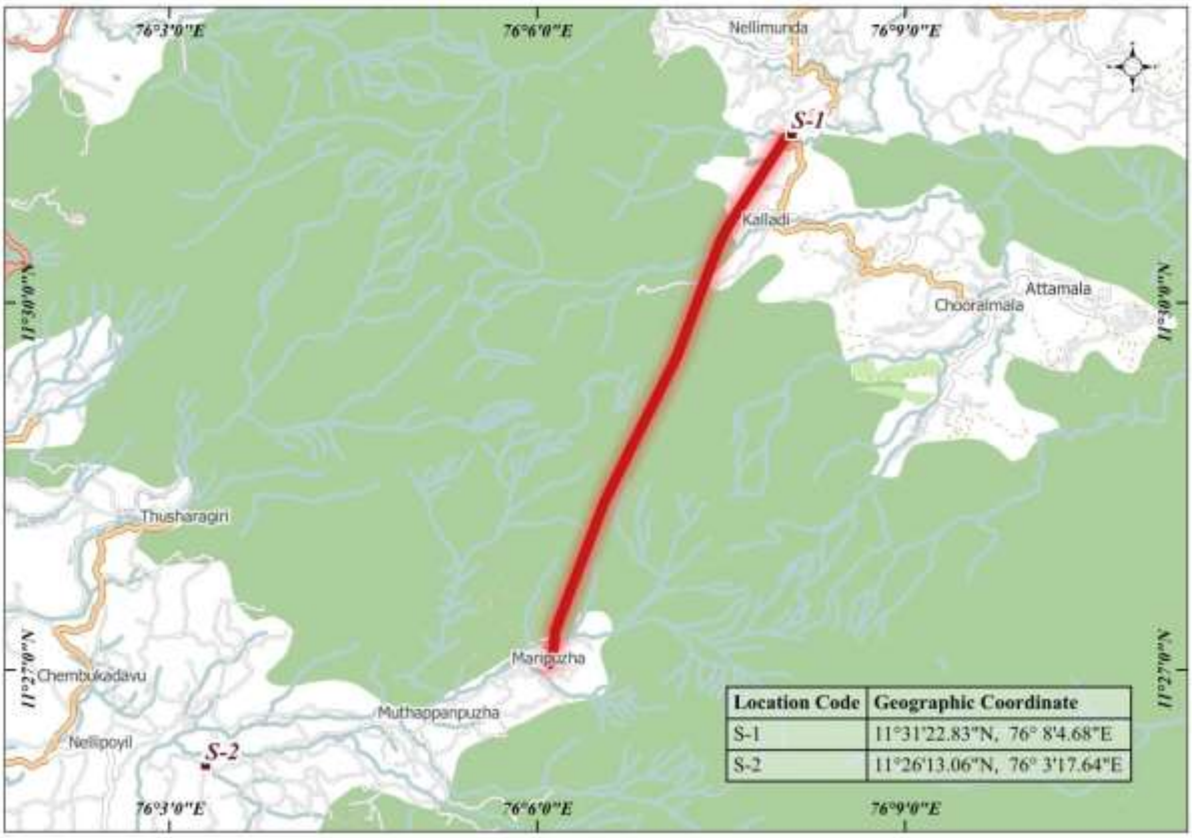


Figure 0-9. Map showing the Soil Sampling Locations

Analysis results of the soil samples collected during the monitoring are presented in **Table 0.2.**

* Source: Natural Resource Data Bank for Kozhikode and Wayanad districts by Kerala State Landuse Board.

Table 0.2. Soil Quality along the Project Road

Sl. No	Test Parameters	Unit	Anakkampoyil				Kalladi			
			SEASON 1	SEASON 2	SEASON 3	SEASON 4	SEASON 1	SEASON 2	SEASON 3	SEASON 4
1	Water Holding Capacity	%	46	28.4	44.8	27.5	45.6	38	46.6	37
2	Permeability (k)	cm/s	2.421*10-2	2.410*10-2	2.405*10-2	2.405*10-2	2.650*10-2	2.40*10-2	2.55*10-2	2.409*10-2
3	Porosity	%	50.98	52.54	30.6	27	43.5	36	41.1	35
4	Electrical Conductivity	mS/m	65	52	6.9	1.6	65	52	12.9	10.3
5	pH	---	6.21	6.85	5.17	5.17	5.78	5.46	5.81	5.39
6	Organic Matter	%	1.26	1.57	2.33	0.41	1	2.5	0.9	2.3
7	Soil Texture									
	Sand	%	63.62	66.04	88.3	91.16	89.8	92.1	89.3	91.06
	Silt	%	0.06	0	0.02	0.01	0.01	0.01	nil	0.01
	Clay	%	36.73	39.67	11.68	8.83	10.19	7.89	10.7	8.93
	Texture	%	Sandy Clay Loam	Sandy Clay	loamy sand	sand	loamy sand	sand	loamy sand	sand

Source: Baseline Environmental Monitoring done by Cochin Test House during August 2022 to August 2023

As per the monitoring result, the sandy clay loamy textured soil was found to be predominant in the project area. pH of the soil varied from 5.17 and 6.85 there by indicating that soil is acidic in nature. Organic Matter of the soil ranges from 0.4 to 2.5%.

4.4.6. Land Use

The land use profile of the project districts (Kozhikode and Wayanad) is as follows.

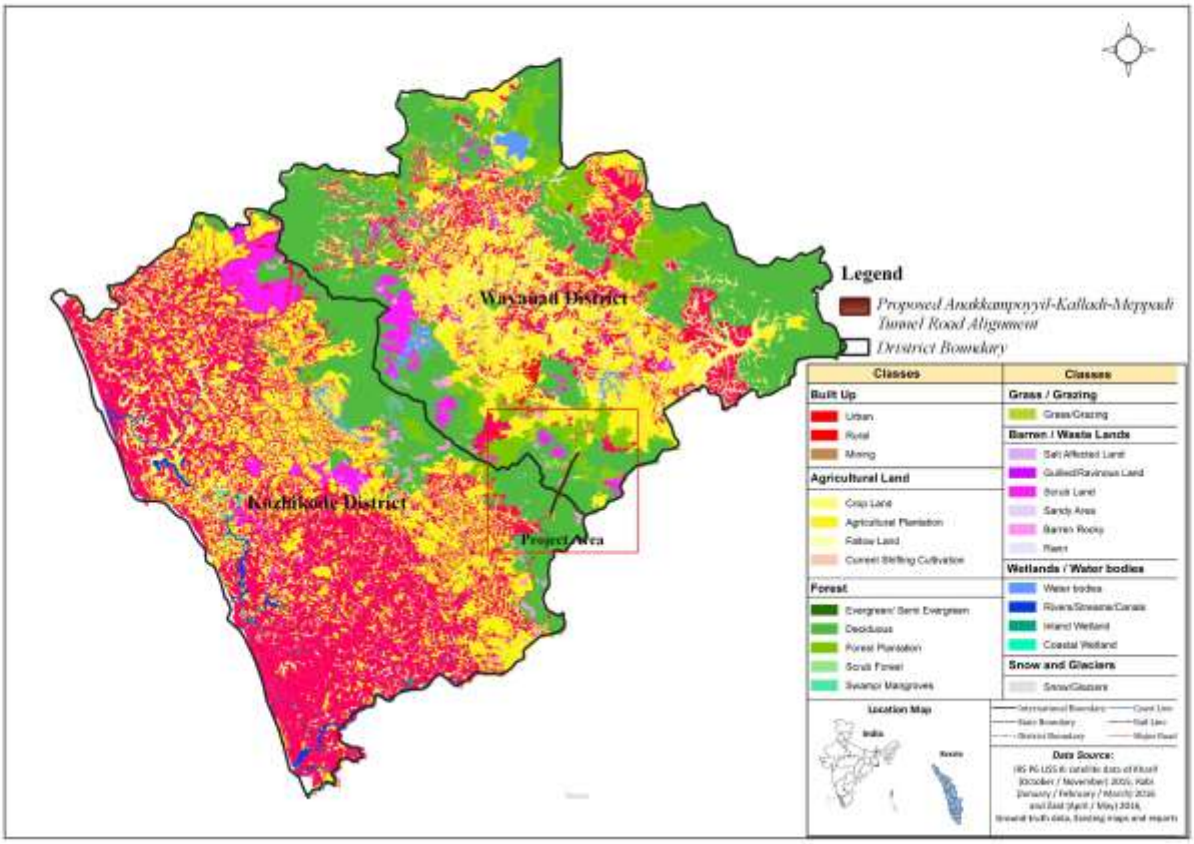


Figure 0-10. Landuse Pattern in the Project Districts

Table 0.3. Landuse Pattern of Project Districts*

Landuse Level 1	Landuse Level 2	Kozhikode		Wayanad	
		Area in Sq. km	%	Area in Sq. km	%
Agriculture	Crop land	103.54	4.42%	211.6	9.92%
	Current Shifting cultivation				
	Fallow	13.64	0.58%	0.85	0.04%
	Plantation	1375.86	58.67%	847.89	39.77%
Barren/uncultivable/ Wastelands	Barren Rocky	4.09	0.17%	3.21	0.15%
	Gullied / Ravinous Land				
	Rann				

*Source: https://bhuvan-app1.nrsc.gov.in/2dresources/thematic/LULC503/MAP/KL.pdf

Landuse Level 1	Landuse Level 2	Kozhikode		Wayanad	
		Area in Sq. km	%	Area in Sq. km	%
	Salt Affected Land				
	Sandy Area	0.19	0.01%		0.00%
	Scrub Land	23.14	0.99%	15.66	0.73%
Builtup	Mining	4.69	0.20%	1.85	0.09%
	Rural	298.92	12.75%	102.57	4.81%
	Urban	13.39	0.57%	3.25	0.15%
Forest	Deciduous	304.24	12.97%	85.61	4.02%
	Evergreen/Semi evergreen	103.84	4.43%	600.47	28.16%
	Forest Plantation	9.57	0.41%	204.03	9.57%
	Scrub Forest	14.66	0.63%	21.85	1.02%
	Swamp / Mangroves				
Grass / Grazing	Grass / Grazing	0.01	0.00%	8.63	0.40%
Wet lands / Water bodies	Inland Wetland	13.84	0.59%	0.09	0.00%
	Coastal Wetland	3.13	0.13%		0.00%
	River/Stream/Canals	45.12	1.92%	10.71	0.50%
	Water bodies	13.15	0.56%	13.74	0.64%
Total Area		2345.02	100 %	2132.01	100%

4.4.6.1. Land Use Profile of IIZ (15 km radii) of the Project Alignment

The landuse and land cover analysis provided the basic landscape of the study area. A remote sensing and GIS based analysis was performed to analyse the landuse/ land cover (LULC) pattern of the area. The details of the satellite image used for the analysis are given below.

Table 0.4. Details of the Satellite Image used for the LULC Analysis

Satellite	Sensor	Path / Row	Resolution	Bands used	Date of Acquisition
Resourcesat 2	LISS IV	17-32/188-711	5.6 m	Green	15th March 2020
				Red	
				Green	

The major part of the study area is dominated by mixed crop with Plantation crops (41806.156 ha) covering an area of 44%. Evergreen/semi evergreen forest in 26660.571 ha (28%) forms the second major category, which is followed by Deciduous forest (dry/moist) with 11727.602 ha covering about 12% of the area. Details of the same are presented in **Table 0.5** and **Annexure 10**.

Table 0.5. Details of Landuse / Land Cover Pattern of 15 km Buffer Zone of the Project Alignment

Sl No.	Land use/ Land cover	Area (Ha)	%
1	Built-up land	1135.517	1.20
2	Deciduous forest (dry/moist)	11727.6	12.39
3	Evergreen/semi evergreen forest	26660.57	28.17
4	Forest plantation	385.345	0.41
5	Grass land	316.206	0.33
6	Land with scrub	2941.712	3.11
7	Paddy fields	3958.738	4.18
8	Plantation crops	41806.16	44.18

Sl No.	Land use/ Land cover	Area (Ha)	%
9	Quarry	17.831	0.02
10	Rock exposure	1741.82	1.84
11	Underutilized/degraded notified forest	3483.698	3.68
12	Water bodies	455.805	0.48
Total area		**94631**	**100.00**

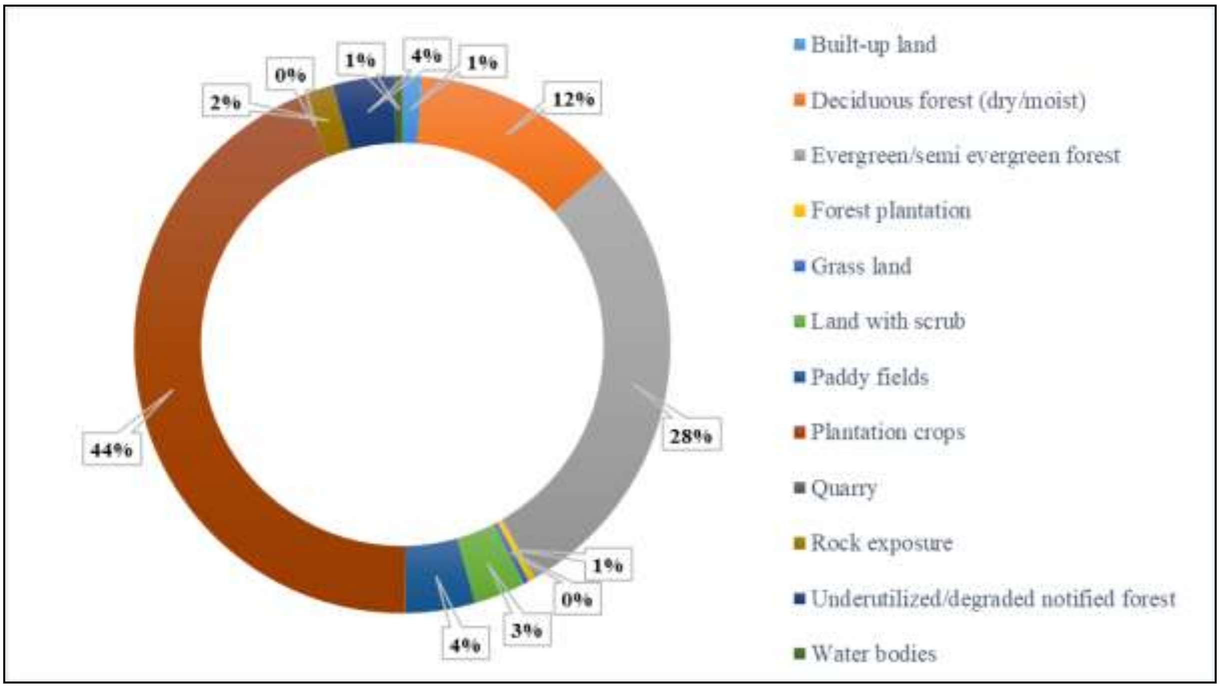


Figure 0-11. Percentage Distribution of LULC Categories in the 15 km radii of the Project Alignment

4.4.6.2. Land Use Profile of DIZ (500 m radii) of the Project Alignment

The land use pattern predominantly found along the project tunnel road is forestland followed by rural settlement and water bodies. The terrain is predominantly hilly. Land use profile along the project road is shown in **Figure 0-10**. Broad description of existing land use pattern along the project road is presented in **Table 4.6**.

Table 0.6. Broad Details of Existing Land use Pattern along Project Tunnel Road

Chainage		Broad land use
From	To	
0+000	0+500	Mostly rural settlement and agricultural land. Nallah crosses at km 0+150, Iruvazhanjippuzha crosses at km 0+350
0+500	1+000	Open area upto km 0+800. Forest land starts at km 0+800
1+000	5+150	Forest land
5+150	6+400	Non forest land charasterised by thick vegetation.
6+400	8+500	Forest land, Kalladi river crosses at km 6+660
8+500	8+700	Rural settlemet, Meenakshi river crosses at km 8+700 (at the end point)

4.4.7. Landslide / Landslip Problems

Soil erosion, landslide or landslip problems are reported from the project area (within 10 km radii of the project area. As per the District Disaster Management Plan for Wayanad and Kozhikode districts, areas near to the proposed tunnel road is marked as high or moderately (see **Figure 0-12**). Thiruvambadi gram panchayath is one of the major panchayaths with high percentage of highly unstable and critical areas. In Thiruvambadi GP, 35.67 % of the total area falls under moderately unstable areas and 26.54 % o[M A3]f the area falls under highly unstable area. 0.96 % of the area is identified as critical. The liquid limit of the soil ranges from 30-39. The soil nature ranges from semi plastic to non-plastic. Friction angle ranges from 21.04 to 40.3. silt+clay content varies from 28 to 39%. Cohesion ranges from 3.1 to 7 Kn/m^2. The stability analysis shows that chances of failure exist in all these areas. The altitude joints play an important role in slope failures in the area. The thickness of the overburden ranges 2 to 3m. The overburden slide or flow down at the interface of overburden and underlaying rock.*

The plantation village of Puthumala is approximately 0.85 km away from the proposed tunnel road, where a massive destructive landslide occurred during monsoon season of 2019.

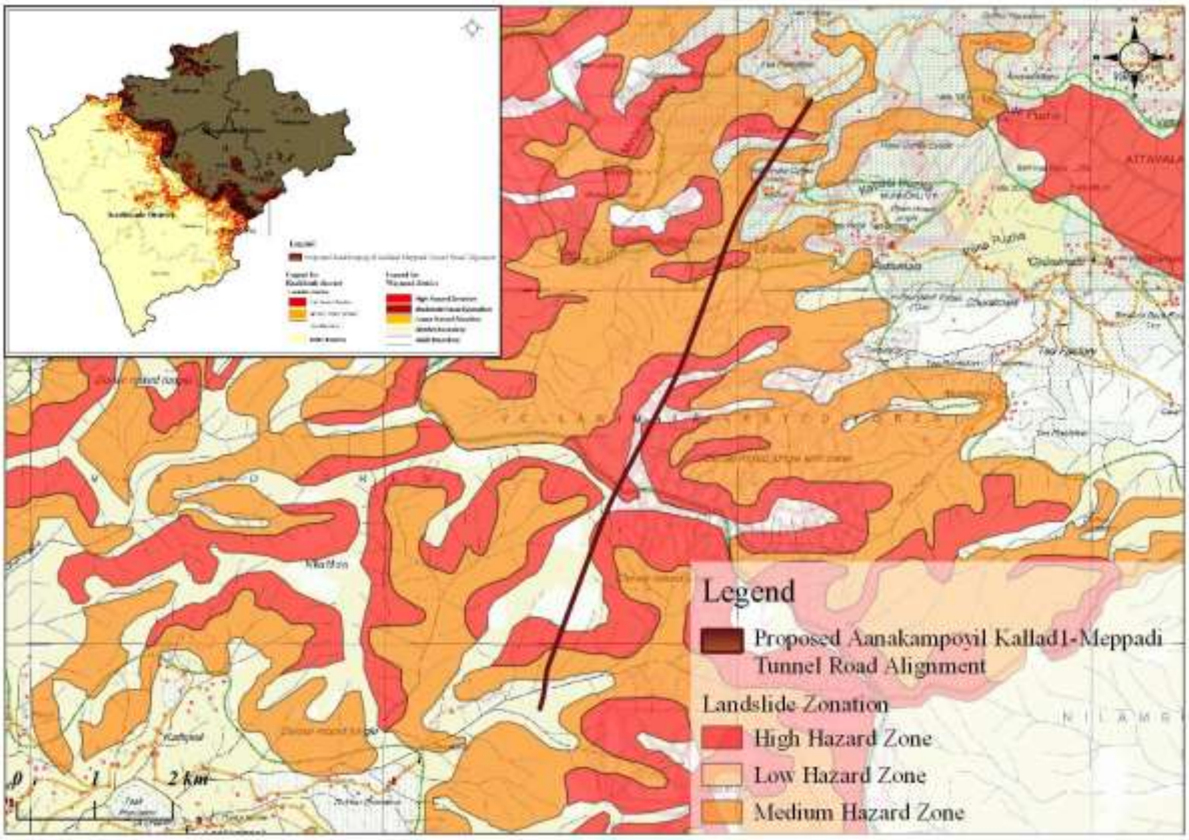


Figure 0-12. Map showing the Landslide Prone Areas in the Project Area†

4.4.8. Agriculture

The economy of Kozhikode District of Kerala is based on agriculture, horticulture and plantation-based activities. Homestead farming is also significant in the district. Different varieties of crops

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**Source: Report on "Landslide Susceptibility Assessment and Preparedness Strategies, Thiruvambadi Grama Panchayath, Kozhikode district, Kerala" by KSDMA, 2019*

†Source: District Disaster Management Plan for Kozhikode and Wayanad districts by KSDMA

including annuals and perennials are grown in these small holdings. In most of the homesteads in midland and highland region, medicinal trees such as *Terminalia bellerica, Oroxylym indicum, Stereospermum colais Phyllanthus emblica, Wrightia tinctoria* etc. are common with shrubs such as *Helicteres isora, Hemidesmus indicus, Sida spp., Pseudarthria viscida, Desmodium gangeticum, Curculigo orchioides, Glycosmis pentaphylla, Gymnema sylvestre, Tinospora cordifolia, Curcuma spp., Zingiber spp. and Costus speciosus* etc.

The main crops raised are Paddy, Pulses, Ginger, Pepper etc. Coconut, Tapioca, Areca nut, Cashew nut, Banana, Rubber and Betel vine are important source of income in the rural areas. Also, fruits like Jack, Mango, Banana, Plantain, Pineapple, Papaya and vegetables like; Drumstick, Turmeric, Ginger, Tapioca, Bitterguard are grown. Plantations of coconuts are common in the project area whereas rubber and cashew are also planted that play important role in the economic support of the farmers of Kozhikode District.

Wayanad's economy is driven by a diverse system of agro-plantations, cash crops and rice cultivation. At the same time, the region and its inhabitants also have rich traditional farming practices and Wayanad is also home to several indigenous tribal communities. Small farmers largely practice 'homestead farming' where many crops, plants and trees are grown together in small land holdings and cultivated intensely. The major cash crops such as coffee, tea, rubber, cocoa and pepper are cultivated here. The fertile soil also supports cultivation of spices like cardamom, turmeric and ginger.

Figure 0-13. Agriculture Pattern in the Project Area

4.5. Water Environment

4.5.1. Hydrology

Kozhikode district is drained by six rivers of which one is medium nature and all others are minor ones namely, Chaliyar, Kuttiyadi, Mahe, Kadalundi, Kallayi and Korapuzha.

The Chaliyar River is a medium river and originates at a height of 2066 m AMSL in Ilambalari hills of Western Ghats of Gudallur district, Tamil Nadu. It is a sixth order stream with a length of 169 km. At its upper reaches, it is formed by Punnurpuzha, Pandiyur, Karimpuzha, Cherupuzha, Kanhirampuzha, Kurumbanpuzha, Vathatpurampuzha & Iruvanjipuzha. At its lower reaches near Cheruvannur, it is flowing as a broad river developing inlets. Of these tributaries, Iruvanjipuzha /

Iruvazhanjippuzha crosses the project tunnel road near to the starting location (km 0+320). A stream passes over the tunnel at km 0+950.

The Kuttiadi River originates at a height of 1334 m AMSL on the western slopes of Wayanad plateau. It has a length of 75 km and flows through Badagara and Quilandy taluks. The Mahe River originates at a height of 910 m AMSL at Vanchimagate hills of Wayanad and flows in the northeastern corner of the district. The Kadalundi River formed by the union of Olipuzha and Veliyarpuzha has a length of 130 km. It enters the district at near its mouth of flow with only 14 km length in the district. The Kallayi River has a length of 22 km and it originates at Cherukulathur, drains the district and joining the sea near Kozhikode. The Korapuzha is a small river with a length of 40 km formed by the union of Agalapuzha and Punnurpuzha. It drains into the Arabian Sea at Elathur.

There is only one major irrigation project in the district namely the Kuttiyadi irrigation project across the Kuttiyadi River. The Kuttiyadi irrigation project (KIP) partially completed in 1972 comprises a main dam 35.5m high across Kuttiyadi at Peruvannamuzhi form a reservoir of storage capacity 113.28 MCM for regulating the yield from the catchment below the Kuttiyadi hydel dam and the tail waters of Kuttiyadi power station. Besides the major irrigation schemes, the district is irrigated by number of minor irrigation schemes, lift irrigation schemes, community irrigation schemes, wells and tanks.

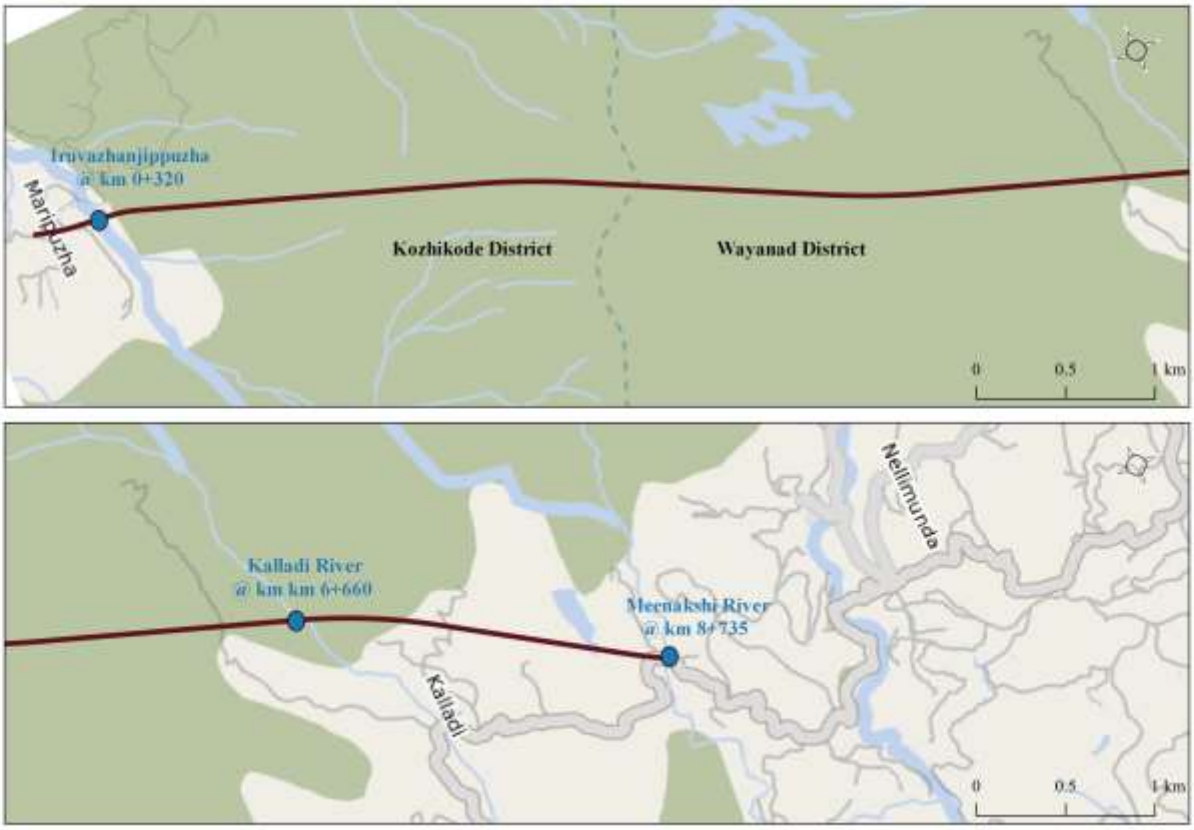


Figure 0-14. Map showing the Major Water Bodies abut/cross the Project Tunnel Road

The main river of Wayanad district is Kabani river, one of the East flowing rivers of Kerala.The three tributaries of Kabani river are Panamaram, Mananthavady and Thirunelly. The total drainage of the Kabani river in the district is 1974 sq. km. The other important rivers are Mahe and Chaliyar. The Mahe river or Mayyazhipuzha originates from the Western slopes of the dense forests of

Mananthavady Taluk. The Chaliyar or Beypore river originates from the Elembileri Hills of Sulthan Batheri Taluk.

Kalladi and Meenakshi rivers, tributaries of Iruvanjipuzha crosses the project tunnel road at km 6+660 and km 8+735 (alignment in Wayanad district).

4.5.2. Groundwater Availability

Kozhikode district: Groundwater occurs in the weathered and fractured portions of crystalline formations and alluvial formations in the district. Phreatic conditions exist in weathered formation and are mostly developed by dug wells for domestic and irrigation purposes. Semi-confined to confined conditions exist in deep fractures where storage and movement of groundwater is mainly controlled by the fracture system. Deep bore wells with high yield are located along fractures / lineaments.

Groundwater occurs under phreatic condition in weathered crystallines and under confined to semi-confined conditions in deeper crystalline formations. Dug wells are the suitable abstraction structures in this area. The depth to water level varies from 0.73 (Tamarasseri) to 16.11 m bgl (Kozhikode) during pre monsoon (April, 2011) and from 0.26 to 10.62 m bgl during post monsoon (November, 2011). The yield of dug wells in phreatic formations ranges between 5 and 10 m^3 /day with pumping duration ranging from less than 1 to 4 hours in a day. The open dug wells are used for domestic purposes and their yield reduces during drought periods.

Wayanad district: All the four blocks in the district are having similar hydrogeological conditions. The major water bearing formations in the district are weathered/fractured crystallines, alluvium and valley fills. Alluvium and valley fills are seen along the river courses and broad valleys. The alluvial aquifers are better represented in Kalpetta and Sulthan Bathery blocks and considerable thickness of this formation are seen in and around Muttil, Kainatti, and Varadur and in different parts of Panamaram Watershed. In these formations groundwater occurs under phreatic condition. Dug wells are suitable abstraction structures for this formation with depth range varying from 3.5 to 7.8 mbgl. The depth to water level varies from 2.6 to 3.7 mbgl during pre monsoon (April) and from 0.70 to 2.60 during post monsoon (November). The yield of dug wells in this formation ranges from less than 500 LPH to about 10,000 LPH with pumping duration ranging from less than 1 to 4 hours in a day.

The methodology used for the resources assessment is based on Groundwater Resource Estimation Methodology 1997 (GEC-’97). Existing gross groundwater draft for irrigation in Kalpetta, Mananthawady and Sultan’s Battery Blocks is 2.25, 1.42 and.2.85 MCM and that for domestic & industrial use is 12.15, 14.08 and 14.92 MCM respectively. All the three blocks are falling in safe category where the stage of ground water development is 16.63% for Kalpetta, 17.94% for Mananthavady and 17.22% for Sulthanbathery.

4.5.3. Surface and Ground Water Quality

Based on reconnaissance, the type of water bodies and their relative importance with the project site; surface water samples were collected from three locations in proximity to the study area. Water quality monitoring locatsions are presented in **Figure 4.15.**

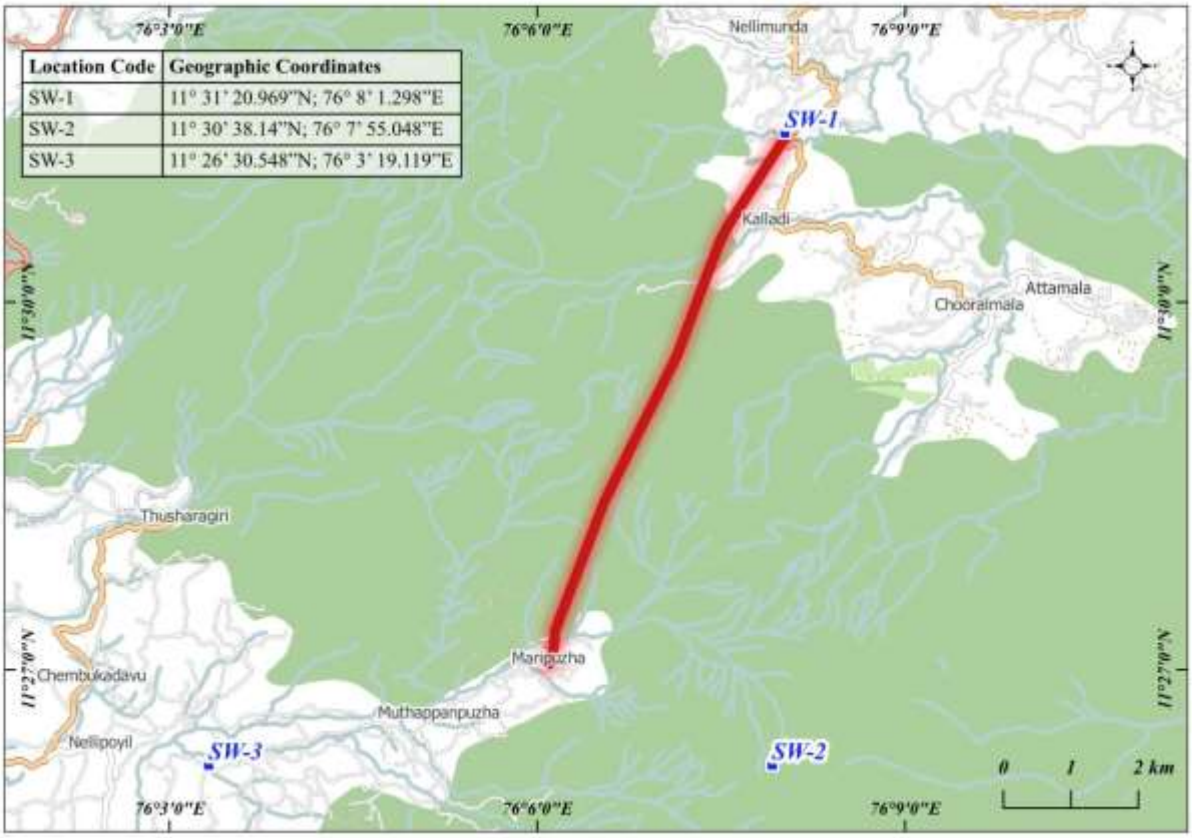


Figure 0-15. Map showing the Surface Water Sampling Locations

The water quality of the sampling locations have been presented in **Table 4.7**.

Table 0.7. Surface Water Quality Analysis Results

Source: Baseline Environmental Monitoring done by Cochin Test House during August 2022 - August 2023

Sl.No	Parameters	Unit	Method	River-Meenakshi				River Kalladi				River Iravazhinji				Tolerance Limit CPCB Class B
				12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	
1	Colour	Colour Unit	IS : 3025 [Pt.04]	2	2	2.0	2.0	2	2	2.0	2.0	2	2	2.0	2.0	-
2	Odour		IS : 3025 [Pt.05]	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
3	Turbidity	NTU	IS : 3025 [Pt.10]	2.2	3.2	2.4	3.6	0.8	1.1	0.9	1.2	BDL(MDL-0.8)	1.1	BDL[MDL-0.8]	1.2	-
4	pH@25°C	---	IS : 3025 [Pt.11]	5.82	6.58	5.88	6.55	5.92	6.72	5.86	6.66	6.18	6.56	6.03	6.62	6.5 to 8.5
5	Iron as Fe	mg/l	IS : 3025 [Pt.53]	0.50	0.20	0.71	0.3	BDL(MDL0.08)	BDL(MDL0.08)	BDL[MDL-0.08]	BDL[MDL-0.08]	BDL[MDL-0.08]	BDL[MDL-0.08]	BDL[MDL-0.08]	BDL[MDL-0.08]	-
6	Chloride as Cl	mg/l	IS : 3025 [Pt.32]	11.8	12.56	11.33	12.44	6.8	8.2	6.89	8.13	8.8	9.15	8.37	9.09	-
7	Fluoride as F	mg/l	APHA : 23rd Ed.	BDL [MDL-0.1]	BDL [MDL-0.1]	BDL[MDL-0.1]	BDL [MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	-

Sl.No	Parameters	Unit	Method	River-Meenakshi				River Kalladi				River Iravazhinji				Tolerance Limit CPCB Class B
				12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	
			4500 F^- D													
8	Total Dissolved Solids	mg/l	IS : 3025 [Pt.16]	40	36	42	33	21	21	20	19	24	21	22	20	-
9	Sulphate as SO_4	mg/l	APHA : 23rd Ed. 4500 SO_4^{2-} E	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	-
10	Alkalinity as $CaCO_3$	mg/l	IS : 3025 [Pt.23]	22.80	15.50	22.5	15.27	12.5	9.6	12.37	9.4	10.35	9.38	10.12	9.4	-
11	Nitrate as NO_3	µs/cm	IS : 3025 [Pt.34]	BDL [MDL-0.1]	BDL [MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	-
12	Conductivity	mg/l	IS : 3025 [Pt.14]	82.0	65.0	86	61	44	39	42	36	45	38	46	37	-
13	Sodium as Na	mg/l	IS : 3025 [Pt.45]	3.2	7.8	3.8	7.7	BDL[MDL-1.0]	2.2	BDL[MDL-1.0]	2.2	BDL[MDL-1.0]	1.8	BDL[MDL-1.0]	2.1	-
14	Potassium as K	mg/l	IS : 3025	BDL (MDL-	BDL[MDL-1.0]	BDL[MDL-1.0]	2.0	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[M	BDL[M	BDL[MDL-	BDL[M	BDL[M	BDL[M	-

Sl.No	Parameters	Unit	Method	River-Meenakshi				River Kalladi				River Iravazhinji				Tolerance Limit CPCB Class B
				12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	
			[Pt.45]	1.0)						DL-1.0]	DL-1.0]	1.0]	DL-1.0]	DL-1.0]	DL-1.0]	
15	Mercury as Hg	mg/l	CTH/CH/SOP/416	BDL [MDL – 0.001]	BDL [MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	-
16	Arsenic As	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.005]	BDL [MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	-
17	Lead as Pb	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.010]	BDL [MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	-
18	Copper as Cu	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	0.013	BDL[MDL – 0.01]	0.015	BDL[MDL – 0.01]	0.018	-
19	Chromium as Cr	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	-
20	Zinc as Zn	mg/l	IS : 3025 [Pt.02]	0.02	BDL[MDL – 0.010]	0.015	BDL[MDL – 0.010]	0.06	0.019	0.05	0.024	0.06	0.026	0.052	0.026	-
21	Selenium as Se	mg/l	IS : 3025 [Pt.02	BDL[MDL – 0.001]	BDL [MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	-

Sl.No	**Parameters**	**Unit**	**Method**	**River-Meenakshi**				**River Kalladi**				**River Iravazhinji**				**Tolerance Limit CPCB Class B**
				12-08.2022	**25-11-2022**	**28-03-2023**	**30.05.2023**	**12-08.2022**	**25-11-2022**	**28-03-2023**	**30.05.2023**	**12-08.2022**	**25-11-2022**	**28-03-2023**	**30.05.2023**	
			]													
22	Nickel as Ni	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.010]	BDL [MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	-
23	Cadmium as Cd	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.001]	BDL [MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	
24	Manganese as Mn	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.010]	BDL [MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	-
25	Total Suspended Solids	mg/l	IS : 3025 [Pt.16]	BDL[MDL-2.0]	BDL [MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	-
26	Anionic Surface Active Agent as MBAS	ºC	IS : 13428 Annex K	BDL[MDL-0.18]	BDL [MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	-
27	BOD	mg/l	IS : 3025 [Pt.44]	2.6	2.2	2.9	2.1	2.2	BDL(MDL2.0)	2.1	BDL[MDL-2.0]	2.5	BDL[MDL-0.18]	2.7	BDL[MDL-2.0]	3mg/l
28	Magnesium Hardness	mg/l	IS : 3025 [Pt.46]	11.4	6.2	11	6.0	7.2	3.2	7.0	3	5.2	4.8	5.0	5.0	-

Sl.No	Parameters	Unit	Method	River-Meenakshi				River Kalladi				River Iravazhinji				Tolerance Limit CPCB Class B
				12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	
29	Dissolved Oxygen [DO]	mg/l	IS : 3025 [Pt.38]	6.3	6.1	6.27	6.2	6.3	6.5	6.37	6.4	6.4	6.4	6.37	6.5	5mg/l or more
30	Oil & Grease	mg/l	IS : 3025 [Pt.39]	BDL [MDL-4.0]	BDL [MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	-
31	Salinity	mg/l	CTH/CH/SOP/522	19.2	20.65	18.68	20.51	12.0	13.6	11.36	13.4	14	15.2	13.81	14.98	-
32	Temperature	mg/l	IS : 3025 [Pt.09]	27.1	27.1	27.2	27.2	27	26.8	26.6	26.6	27	27	27.1	27.1	-
33	Total Nitrogen	mg/l	IS : 3025 [Pt.34]	BDL[MDL-1.0]	BDL [MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	4.0
34	Total Phosphorous	mg/l	APHA : 23rd Ed. 4500 – P[C]	BDL[MDL-0.2]	BDL[MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	3.0
35	Total Kjeldhal Nitrogen	mg/l	IS : 3025 [Pt.34]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	-
36	Ammonia	MPN/	IS :	BDL[M	BDL[MD	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	-

Sl.No	Parameters	Unit	Method	River-Meenakshi				River Kalladi				River Iravazhinji				Tolerance Limit CPCB Class B
				12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	
		100 ml	3025 [Pt.34]	DL-1.0]	L-1.0]	[MDL-1.0]	[MDL-1.0]	[MDL-1.0]	[MDL-1.0]	[MDL-1.0]	[MDL-1.0]	[MDL-1.0]	[MDL-1.0]	[MDL-1.0]	[MDL-1.0]	
37	Coliforms	MPN/ 100 ml	IS : 1622 - 1981	240	140	300	170	1600	70	900	80	300	80	500	70	500 or less
38	Faecal Coliforms	MPN/100 ml	IS : 1622 - 1981	<2	33	<2	40	30	<2	50	<2	<2	<2	<2	<2	-

From the analysis, it is observed that the monitoring parameters of water samples were well within the the standards (Water quality criteria of CPCB , CLASS B) except for pH and DO. As per the standard, tolerence limit for pH is 6.5 – 8.5. But the pH for all the samples analysed were observed below the status, shows the surface water sources in the project area is slightly acidic. Chloride concentration of the samples is very low as per the limit. Salinity of the samples varies from 11 to 21 mg/l. Presence of flouuride is below the detectable level. Concentration of Total Dissolved Solids (TDS) in the samples ranges from 19 mg/l to 40 mg/l. Concentration of sulphate, total Nitrogen and nitrate is observed below detectable level. Alkalinity, Calcium (Ca) ,Magnesium concentration are all within limits. Concentration of Sodium ranges from 2.2 to 7.8 mg/l and of Pottassium is 2.0 mg/l for River Minakshi and BDL for the other samples. From the analysis, it is noted that heavy metal content (Mercury, Arsenic, Lead, Copper, Chromium, Zinc, Selenium, Nickel, Cadmium, Manganese) is below the detectable level. DO values for all the samples are above the tolerance limit. Limit for BOD (by CPCB Water quality criteria class B) is 3 mg/l and the highest value observed is 2.95 mg/l (Minakshi River). It is noted that presence of coliform is observed. Faecal Coliform concentration for the samples is ranges from <2 to 50 MPN/100ml.

Figure 0-16. Map showing the Ground Water Sampling Locations

Table 0.8. Ground Water Quality Analysis Results

Sl.No	Parameters	Unit	Method	Well Kalladi				Well Anakkampoyal				IS 10500 - 2012	
				12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	Requirement (AcceptableLimit)	Permissible Limit in the Absence of Alternative Sources
1	Colour	Colour Unit	IS : 3025 [Pt.04]	2	2	2.0	2.0	2	2	2.0	2.0	5	15
2	Odour		IS : 3025 [Pt.05]	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
3	Turbidity	NTU	IS : 3025 [Pt.10]	BDL(MDL-0.8)	4.3	0.8	4.1	BDL(MDL-0.8)	9.9	BDL[MDL-0.8]	10.3	1	5
4	pH@25°C	---	IS : 3025 [Pt.11]	6.98	6.28	7.26	6.25	5.82	5.7	5.76	5.68	6.5-8.5	No Relaxation
5	Iron as Fe	mg/l	IS : 3025 [Pt.53]	BDL(MDL0.08)	0.25	BDL[MDL-0.08]	0.29	BDL[MDL-0.08]	1.56	BDL[MDL-0.08]	1.76	0.3	No Relaxation
6	Chloride as Cl	mg/l	IS : 3025 [Pt.32]	18.2	14.6	18.48	14.8	8.0	12.5	7.88	12.44	250	1000
7	Fluoride as F	mg/l	APHA : 23rd Ed. 4500 F^- D	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	BDL[MDL-0.1]	1.0	1.5
8	Total Dissolved Solids	mg/l	IS : 3025 [Pt.16]	145	70	141	72	18	26	17	28	500	2000
9	Sulphate as SO_4	mg/l	APHA : 23rd Ed. 4500 SO_4^{2-}E	3.0	8.65	2.8	8.77	BDL[MDL-1.0]	0.92	BDL[MDL-1.0]	1.07	200	400
10	Alkalinity as $CaCO_3$	mg/l	IS : 3025 [Pt.23]	82.9	32.9	84.37	32.9	8.2	13.1	7.87	12.9	200	600
11	Nitrate as NO_3	µs/cm	IS : 3025 [Pt.34]	BDL[MDL-0.1]	2.0	BDL[MDL-0.1]	2.19	BDL[MDL-0.1]	0.92	BDL[MDL-0.1]	0.98	45	No Relaxation

Sl.No	Parameters	Unit	Method	Well Kalladi				Well Anakkampoyal				IS 10500 - 2012	
				12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	Requirement (AcceptableLimit)	Permissible Limit in the Absence of Alternative Sources
12	Conductivity	mg/l	IS : 3025 [Pt.14]	219	136	223	133	37	52	36	51	-	-
13	Sodium as Na	mg/l	IS : 3025 [Pt.45]	14.0	8.8	17.0	8.5	BDL[MDL-1.0]	2.0	BDL[MDL-1.0]	3.5	-	-
14	Potassium as K	mg/l	IS : 3025 [Pt.45]	4.9	2.6	5.1	2.9	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	-	-
15	Mercury as Hg	mg/l	CTH/CH/SOP/416	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	0.001	No Relaxation
16	Arsenic As	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	BDL[MDL – 0.005]	0.01	No Relaxation
17	Lead as Pb	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	0.01	No Relaxation
18	Copper as Cu	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	BDL[MDL – 0.01]	0.015	BDL[MDL – 0.01]	BDL[MDL – 0.01]	0.05	1.5
19	Chromium as Cr	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	0.05	No Relaxation
20	Zinc as Zn	mg/l	IS : 3025 [Pt.02]	0.06	0.04	0.052	BDL[MDL – 0.010]	0.01	0.046	0.012	0.042	5	15
21	Selenium as Se	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	0.01	No relaxation
22	Nickel as Ni	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	0.02	No

Sl.No	Parameters	Unit	Method	Well Kalladi				Well Anakkampoyal				IS 10500 - 2012	
				12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	Requirement (AcceptableLimit)	Permissible Limit in the Absence of Alternative Sources
													relaxation
23	Cadmium as Cd	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	BDL[MDL – 0.001]	0.003	No Relaxation
24	Manganese as Mn	mg/l	IS : 3025 [Pt.02]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	BDL[MDL – 0.010]	0.038	BDL[MDL – 0.010]	0.015	BDL[MDL – 0.010]	0.012	0.1	0.3
25	Total Suspended Solids	mg/l	IS : 3025 [Pt.16]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	1.8	BDL[MDL-2.0]	2.2	-	-
26	Anionic Surface Active Agent as MBAS	ºC	IS : 13428 Annex K	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	BDL[MDL-0.18]	0.2	1.0
27	BOD	mg/l	IS : 3025 [Pt.44]	2.2	BDL(MDL2.0)	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-2.0]	BDL[MDL-0.18]	BDL[MDL-2.0]	BDL[MDL-2.0]	-	-
28	Magnesium Hardness	mg/l	IS : 3025 [Pt.46]	28.2	16	27.5	15	2.8	5.2	3	5	30	100
29	Dissolved Oxygen [DO]	mg/l	IS : 3025 [Pt.38]	6.31	6.38	6.27	6.4	6.5	6.5	6.37	6.2	-	-
30	Oil & Grease	mg/l	IS : 3025 [Pt.39]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	BDL[MDL-4.0]	-	-
31	Salinity	mg/l	CTH/CH/SOP/522	31.2	24.6	30.46	24.4	13.1	20.8	12.99	20.51	-	-
32	Temperature	mg/l	IS : 3025 [Pt.09]	27	26.9	26.6	27.0	26.6	27.1	26.9	26.9	-	-

Sl.No	Parameters	Unit	Method	Well Kalladi				Well Anakkampoyal				IS 10500 - 2012	
				12-08.2022	25-11-2022	28-03-2023	30.05.2023	12-08.2022	25-11-2022	28-03-2023	30.05.2023	Requirement (AcceptableLimit)	Permissible Limit in the Absence of Alternative Sources
33	Total Nitrogen	mg/l	IS : 3025 [Pt.34]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	BDL[MDL-1.0]	-	-
34	Total Phosphorous	mg/l	APHA : 23rd Ed. 4500 – P[C]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL[MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	BDL [MDL-0.2]	-	-
35	Total Kjeldhal Nitrogen	mg/l	IS : 3025 [Pt.34]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL[MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	-	-
36	Ammonia	MPN/ 100 ml	IS : 3025 [Pt.34]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL[MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	BDL [MDL-1.0]	0.5	No Relaxation
37	Coliforms	MPN/ 100 ml	IS : 1622 - 1981	<2	34	<2	40	300	70	50	27	-	-
38	Faecal Coliforms	MPN/100 ml	IS : 1622 - 1981	<2	<2	<2	<2	<2	<2	<2	<2	-	-

Source: Baseline Environmental Monitoring done by Cochi Tesh House during August 2022 to August 2023

It has been inferred from the monitoring results that all important potability parameters of water are falling within the limit for all ground water samples. The pH value of the samples ranges from 5.7 to 7.3. Turbidity of the sample from BDL to 10.3 NTU. Chloride content ranges from 7.88 to 18.48 mg/lit. Parameters like TDS, Sulphates, Alkalinity, Nitrate, metal contentents, heavy metal contents very less compared to the standards.

4.6. Air Environment

4.6.1. Climate & Meteorology

The climate of project districts is tropical. There is significant rainfall in most months of the year. The short dry season has little effect on the overall climate. This climate is considered to be "Am[*]" according to the Köppen-Geiger climate classification. The climate condition can be divided into four seasons.

- Winter – January to February
- Hot weather – March to May
- South west Monsoon – June to September
- North east Monsoon – October to November

4.6.1.1. Rainfall

Kozhikode district receives the annual average rainfall of 5190 mm and more than 60 per cent of it occurs during the period of South-West monsoon. The rainfall during July is very heavy and the project district receives 60 per cent of the annual rainfall during this season.

Wayanad experiences salubrious climate with mean rainfall of 2786 mm. Lakkidi, Vythiri and Meppady are the high rainfall experiencing areas. The SW and NE monsoons contribute rainfall in the area with 80 % of the rainfall from SW monsoon. The month of June experiences abundant rainfall and is the wettest month. The months of July, August and October also receive heavy rainfall.

The rainfall information for the five years from (2014-2018) is given in **Table 0.9.**

Table 0.9. Summary of the Rain Fall Data of the Project Districts[†]

Year	Kozhikode District					Wayanad District				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
Jan	0.0	0.0	0.0	7.7	7.7	0.0	0.1	3.3	14.5	0.0
Feb	0.0	0.0	0.0	0.1	0.9	4.2	0.0	0.0	0.0	11.2
Mar	0.8	35.3	32.4	21.3	36.9	10.1	45.8	13.0	49.7	78.6
Apr	90.7	90.5	5.7	68.1	79.0	142.0	138.9	20.1	60.9	105.6
May	254.4	189.5	260.1	251.8	563.0	202.0	203.3	112.8	182.8	267.4
Jun	508.2	667.9	916.4	822.5	1081.8	539.4	829.8	411.2	343.2	814.4
Jul	1068.2	780.5	604.2	662.9	1037.4	1060.8	304.3	337.7	419.6	1089.0
Aug	879.0	256.9	268.5	544.6	836.0	642.0	226.1	242.5	435.0	1053.5

[*] Am in Kopen-Geiger Climate Classificaiton ndicates – Tropical Monsoon

[†]*Source: Customised Rainfall Information System, IMD, Pune*

Year	Kozhikode District					Wayanad District				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
Sep	318.3	290.1	98.2	491.6	29.3	317.4	232.5	82.4	454.2	111.4
Oct	331.6	351.3	42.5	216.2	267.8	251.2	154.1	58.6	118.5	242.5
Nov	105.6	199.3	8.9	46.1	57.5	32.8	113.4	12.1	37.5	44.6
Dec	9.3	8.8	23.2	9.1	35.0	57.7	34.4	34.1	9.1	13.9

4.6.1.2. Temperature

During December to March, no rain shall be received and from October onwards, the temperature gradually increases to reach the maximum in May, which is the hottest month of the year. The maximum temperature in the month of May comes to 36°C. The maximum temperature recorded at Kozhikode was 38.1° C during the month of November 2000 and lowest temperature was 13.8° C recorded on the January 1969.

The temperatures of Wayanad district are highest on average in April, at around 25.6°C (78.1°F). In December, the average temperature is 21.7°C (71.1°F). It is the lowest average temperature of the whole year.

Table 0.10. Monthlywise Temperature Data of the Project Districts*

Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kozhikode district												
Avg. (°C)	27	27.75	28.85	29.05	28.75	27.7	26.8	26.7	27.3	27.75	27.5	27
Min. (°C)	20.6	21.8	23.5	23.5	23	22.5	22.1	22.3	22.8	22.6	21.8	20.5
Max. (°C)	33.4	33.7	34.2	34.6	34.5	32.9	31.5	31.1	31.8	32.9	33.2	33.5
Wayanad district												
Avg. (°C)	21.9	23.3	24.9	25.6	25.1	22.8	21.8	22.2	22.6	23	22.5	21.7
Min. (°C)	16.7	17.9	19.5	20.8	20.8	19.7	19.3	19.4	19.2	19.4	18.6	17
Max. (°C)	27.2	28.8	30.4	30.4	29.4	25.9	24.4	25.1	26	26.6	26.5	26.5

4.6.1.3. Humidity

The relative humidity of the project districts ranges from 74 to 92 % during morning hours and from 64 to 89% in evening hours. The monsoon months record high humidity.

4.6.2. Ambient Air Quality

Ambient air quality of the project area is generally good due to the absence of air polluting industries or allied urban activities throughout its stretch. This is further enhanced by the presence of forest areas, open lands and agricultural lands. Vehicles are the only source of emission of gases like NO_x, SO_x, etc., but this is expected to come down, as the smooth traffic flow upon project completion will lead to reduction in emissions.

The baseline status of the ambient air quality was established through a scientifically designed network of Ambient Air Quality Monitoring (AAQM) stations selected at 2 representative locations based on land use and wind direction.

Source: IMD, Pune

The parameters measured during the monitoring along with their frequency of sampling are given in **Table 0.11**.

Table 0.11. Ambient Air Quality Parameters and Frequency of Sampling

Parameters	Sampling Frequency
Particulate Matter 2.5 , $PM_{2.5}$	One continuous sampling for 24 hr throughout one season except monsoon
Particulate Matter 10, PM_{10}	
Sulphur dioxide, SO_2	
Oxides of Nitrogen, NO_x	
Carbon Monoxide, CO	Hourly sample for 24 hours throughout one season except monsoon

Analysis techniques used for different air quality parameters are presented in **Table 0.12**.

Table 0.12. Techniques Used for the Analysis of Ambient Air Quality Parameters

Sl. No	Parameter	Technique	Technical Protocol	Minimum Detectable Limit
1	Particulate Matter of Size less than 10µm (PM_{10})	Gravimetric Method	IS:5182 Part -23	10 µg/m^3
2	Particulate Matter of Size less than 2.5µm ($PM_{2.5}$)	Gravimetric Method	CTH/CH/SOP/462	4 µg/m^3
3	Sulphur Dioxide (SO_2)	Improved West and Gaeke	IS:5182 Part -02	4 µg/m^3
4	Nitrogen Dioxide (NO_2)	Modified Jacob and Hochheiser	IS:5182 Part -06	6 µg/m^3
5	Carbon Monoxide (CO)	CO Meter	CTH/CH/SOP/473	0.012 mg/m^3

The prime objective of the baseline air quality study is to establish the existing ambient air quality of the study area. This will be useful for assessing the conformity to standards of the ambient air quality during the construction and operation phase of the project.

The important sources of air pollution in the region are vehicular traffic and domestic fuel burning activities.

Details of sampling locations are presented in **Figure 0-17** and the monitoring results are presented in Error! Reference source not found. along with the revised CPCB ambient air quality standards.

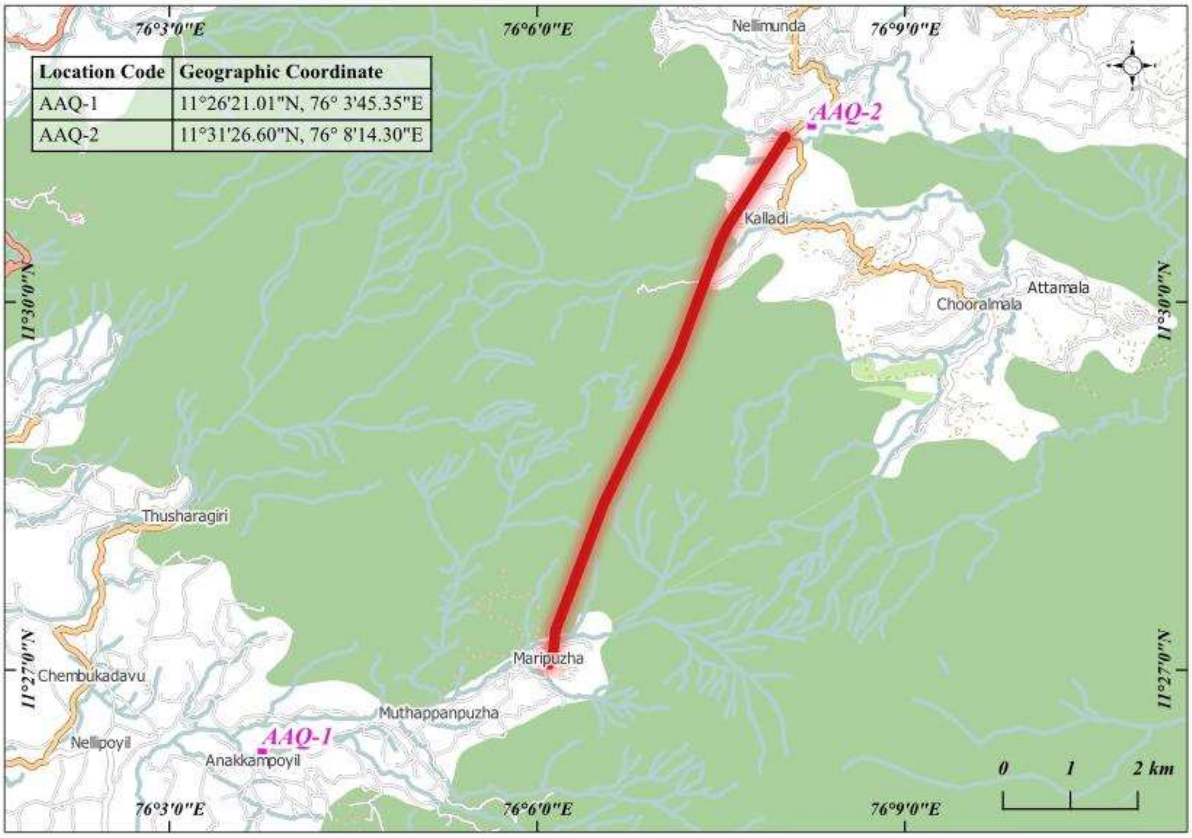


Figure 0-17. Map showing the Ambient Air Quality Monitoring Locations

Figure 0-18. Ambient Air Quality Monitoring Conducted

Table 0.13. Ambient Air Quality along the Project Road

Source: Baseline Environmental Monitoring done by Cochin test House during August 2022 to August 2023

Sampling Season	Duration	Location	Particulate Matter of Size less than 10µm(PM_{10})		Particulate Matter of Size less than 2.5µm($PM_{2.5}$)		Sulphur Dioxide (SO_2)		Oxides of Nitrogen (NO_x)		Carbon Monoxide (CO)	
		Unit	**µg/m³**		**µg/m³**		**µg/m³**		**µg/m³**		**mg/ m³**	
		Intervals	**I**		**I**		**I**		**I**		**I**	
			Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
I	**August 2022 To October 2022**	**AQ 1**	14.9	42.38	9.78	18.2	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-6.0)	BDL(MDL-6.0)	0.4	0.47
		AQ 2	15.09	51.8	8.05	24.47	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-6.0)	BDL(MDL-6.0)	0.4	0.47
II	**November 2022 To January 2023**	**AQ 1**	24.4	59.2	11.78	23.46	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-6.0)	BDL(MDL-6.0)	0.42	0.48
		AQ 2	25.4	64.32	13.1	25.6	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-6.0)	BDL(MDL-6.0)	0.43	0.48
III	**February 2023 To April 2023**	**AQ 1**	23.5	61.9	10.2	27.8	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-6.0)	BDL(MDL-6.0)	0.4	0.49
		AQ 2	22.5	70.3	10	28.7	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-6.0)	BDL(MDL-6.0)	0.41	0.49

IV	**May 2023 To July 2023**	**AQ 1**	19	31	9.6	16.24	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-6.0)	BDL(MDL-6.0)	0.4	0.47
		AQ 2	14.2	30.4	9.1	16.2	BDL(MDL-4.0)	BDL(MDL-4.0)	BDL(MDL-6.0)	BDL(MDL-6.0)	0.41	0.48
		NAAQ Standards	**Eco Sensitive Areas**		**100**		**60**		**80**		**80**	
			Other Area		**100**		**60**		**80**		**80**	

It is observed from the results all the parameteres monitored are well within the NAAQ standards. The concentration of SO_2 and NO_2 is observed below detectable level (4 µg/m^3 and 6 µg/m^3). CO concentration are well within the permissible level.

4.7. Noise Environment

4.7.1. Ambient Noise Quality

Noise in general is unwanted / undesired sound, which is composed of many frequency components of various loudness distributed over the audible frequency range. Various noise scales have been introduced to describe, in a single number, the response of an average human to a complex sound made up of various frequencies at different loudness levels. The most common and universally accepted scale is the A weighted Scale which is measured as dB (A). This is more suitable for the audible range of sound, 20 to 20,000 Hz. The scale has been designed to weigh various components of noise according to the response of a human ear. The impact of noise sources on surrounding community depends on:

- Characteristics of noise sources (instantaneous, intermittent or continuous in nature). It can be observed that steady noise is not as annoying as one, which is continuously varying in loudness;
- The time of day at which noise occurs, for example high noise levels at night in residential areas are not acceptable because of sleep disturbance; and
- The location of the noise source, with respect to noise sensitive land use, which determines the loudness and period of exposure.

The environmental impact of noise can have several effects varying from Noise Induced Hearing Loss (NIHL) to annoyance depending on loudness of noise. The assessment of noise is carried out considering various factors like potential damage to hearing, physiological responses, annoyance and general community responses.

It is possible to describe important features of noise for noise levels measured over 24 hours using statistical methods. These features of noise are the parameters used for describing the noise levels at a particular location. Standards for permissible noise levels at various zones are set based on these parameters. The notations used for various noise level parameters are described below.

- L_{eq} - Equivalent sound pressure level - the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
- $L_{eq\ (1\ hr)}$ - The equivalent noise level for a specific one - hour period.
- $L_{eq\ (24\ hr)}$ – The equivalent noise level during a 24-hour period.
- L_{day} - The equivalent noise level from 6:00 hours to 22.00 hours.
- L_{night} - The equivalent noise level from 22:00 hours to 6.00 hours.
- L_{dn} - It is similar to a 24 hr equivalent noise level except that during nighttime (10 pm to 6 am) a 10 dB(A) weighting penalty is added to the instantaneous sound level before computing the 24 hr average. This nighttime penalty is added to account for the fact that noise during

- night when people usually sleep is judged as more annoying than the same noise during the daytime.

A noise monitoring survey was conducted August 2022 to July 2023 at two representative locations based on the land use of the area with the objective of assessing baseline noise levels, which can be later used to assess the impact of the total noise generated by the proposed project activities. Noise level monitoring was carried out continuously for 24 hours with one-hour interval at each location during the study period, using a Luthron sound level meter capable of measuring the Sound Pressure Level (SPL) in dB(A). Hourly L_{eq} values were computed by the noise integrating sound level meter and statistical analysis was done for measured noise levels at four locations in the study area. The L_{eq} day and L_{eq} night calculated for various locations in the project area. Summary of AmbientNoise quality monitoring data are presented in the **Table 0.14**. The values are compared with the standards prescribed by CPCB for various zones.

Figure 0-19. Noise Monitoring Conducted

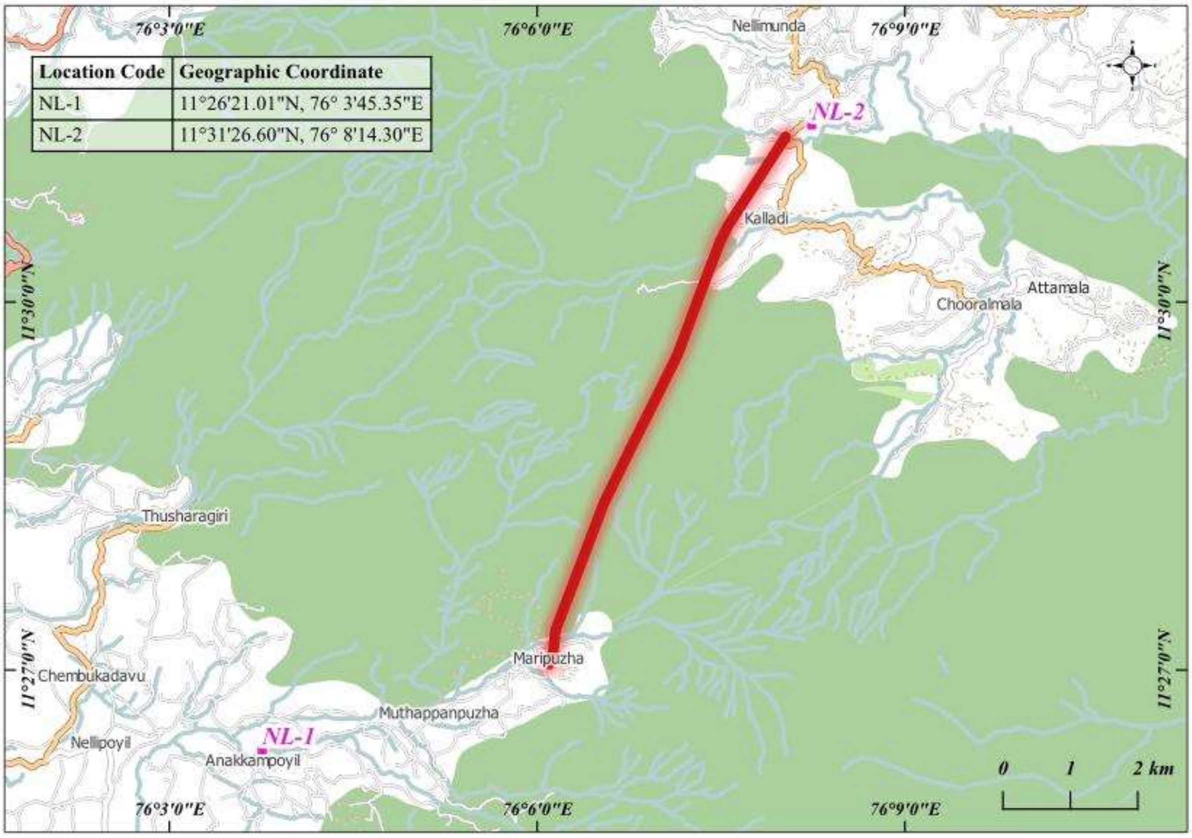


Figure 0-20. Map showing the Noise Monitoring Locations

The monitoring locations represents residential area. NL-2 is situated close to the Govt. Polytechnic College, Meppadi. Noise level for daytime and nighttime in all the locations are within the prescribed limits of CPCB standards. The increase in noise level is due to vehicular traffic, honking at junctions, and public activities.

Table 0.14. Summary of Ambient Noise Level along the Project Area

	Location code	Noise Level Values dB(A)		*CPCB Standard Leq dB(A)	
		L_{Day}	L_{Night}	Day	Night
Season 1	N 1	56.9	49.7	55	45
	N 2	50.5	44.5		
Season 2	N 1	54.5	48.9		
	N 2	55.9	52.3		
Season 3	N 1	53.0	48.0		
	N 2	55.6	52.7		
Season 4	N 1	56.8	49.8		
	N 2	54.9	49.7		

Source: Baseline Environmental Monitoring done by Cochin Test House during August 2022 to August 2023

Table 0.15. Hourly Ambient Noise Level along the Project Area

Sl. No.	Hourly Interval	Season 1		Season 2		Season 3		Season 4	
		Hourly Leq Values at		Hourly Leq Values at		Hourly Leq Values at		Hourly Leq Values at	
		N 1	N 2	N 1	N 2	N 1	N 2	N 1	N 2
1	07.00 AM – 08.00 AM	53	47.2	53.2	52.2	78	53.1	52.9	53.0
2	08.00 AM – 09.00 AM	55.6	49	54.9	54.3	54.5	54.5	55.8	55.8
3	09.00 AM – 10.00 AM	56.9	51.2	54.7	51.9	54.2	57.3	57.1	57.0
4	10.00 AM – 11.00 AM	60.8	49.5	55.5	52.5	53.9	56.5	60.8	60.8
5	11.00 AM – 12.00 AM	58.3	51.8	59.6	53.3	52.5	55.4	56.9	58.5
6	12.00 AM – 01.00 PM	56.5	49	53.9	56.8	55.9	57.1	56.3	52.0
7	01.00 PM – 02.00 PM	57.4	52	53.1	53.5	55.0	57.1	57.2	51.4
8	02.00 PM – 03.00 PM	58.1	50.4	54	57.5	50.0	56.8	58.1	51.6
9	03.00 PM – 04.00 PM	58.1	50.6	53.2	60.4	54.8	56.0	58.1	52.0
10	04.00 PM – 05.00 PM	56.7	48.9	53.8	62.2	52.8	55.9	56.6	51.0
11	05.00 PM – 06.00 PM	57	46.3	54.7	53.4	51.6	56.4	57.0	50.8
12	06.00 PM – 07.00 PM	57	50.3	54.5	51.7	51.5	56.0	57.0	49.6
13	07.00 PM – 08.00 PM	54.3	53.5	52.7	51.8	51.7	54.0	54.9	55.3
14	08.00 PM – 09.00 PM	53	51.1	51.3	52.6	50.9	52.0	52.8	52.8

15	09.00 PM – 10.00 PM	51.9	50.9	49.8	51.1	50.6	50.9	51.9	51.9
16	10.00 PM – 11.00 PM	51	44.6	49.3	52	48.4	50.8	51.0	51.0
17	11.00 PM – 12.00 PM	51.1	44.7	48	51.4	47.7	49.3	50.0	50.0
18	12.00 PM – 01.00 AM	49.7	44.4	47.4	50.9	47.6	56.5	49.7	49.7
19	01.00 AM – 02.00 AM	46.6	44.4	48.7	52.1	48.1	57.4	46.6	46.6
20	02.00 AM – 03.00 AM	46.5	44.3	49	51.4	47.8	51.2	46.6	46.6
21	03.00 AM – 04.00 AM	47.2	44.1	49	51.2	48.3	47.9	47.2	47.2
22	04.00 AM – 05.00 AM	47.6	44.8	49.1	52.5	47.6	48.7	47.6	47.6
23	05.00 AM – 06.00 AM	49.9	44.9	49.1	55.2	47.7	49.4	49.9	49.3
24	06.00 AM – 07.00 AM	53.4	44.5	49.9	52.3	48.9	50.8	53.7	53.7

The day equivalent noise level recorded were compared with Ambient Noise Standards and were observed that the values are well below the permissible limit specified for residential areas.

4.8. Biological Environment

4.8.1. Protected Natural Habitats

The project area is located in Western Ghats, a UNESCO World Heritage Site* and is one of the 36 hotspots of biological diversity in the world. It contains a very large proportion of the country's flora and fauna, many of which are only found in India and nowhere else in the world. According to UNESCO, the Western Ghats are older than the Himalayas. It is an area stretching up to 1,600 km has at least 325 globally threatened species, which comprises 229 plant species, 31 mammal species, 15 bird species, 43 amphibian species, 5 reptile species and 1 fish species. Of these globally threatened species, 129 are classified as Vulnerable, 145 as Endangered and 51 as Critically Endangered.

Part of Nilgiri Biosphere Reserve, the first biosphere reserve in India established in the year 1986, falls within the 10 km radii of the project alignment. Nilgiri Biosphere Reserve is also an International Biosphere Reserve in the Western Ghats. It is the largest protected forest area in India, spreading across Tamil Nadu, Karnataka and Kerala. It includes the Aralam, Mudumalai, Mukurthi, Nagarhole, Bandipur and Silent Valley national parks, as well as the Wayanad, Karimpuzha, and Sathyamangalam wildlife sanctuaries.[M A4]

* Source: https://whc.unesco.org/en/list/1342

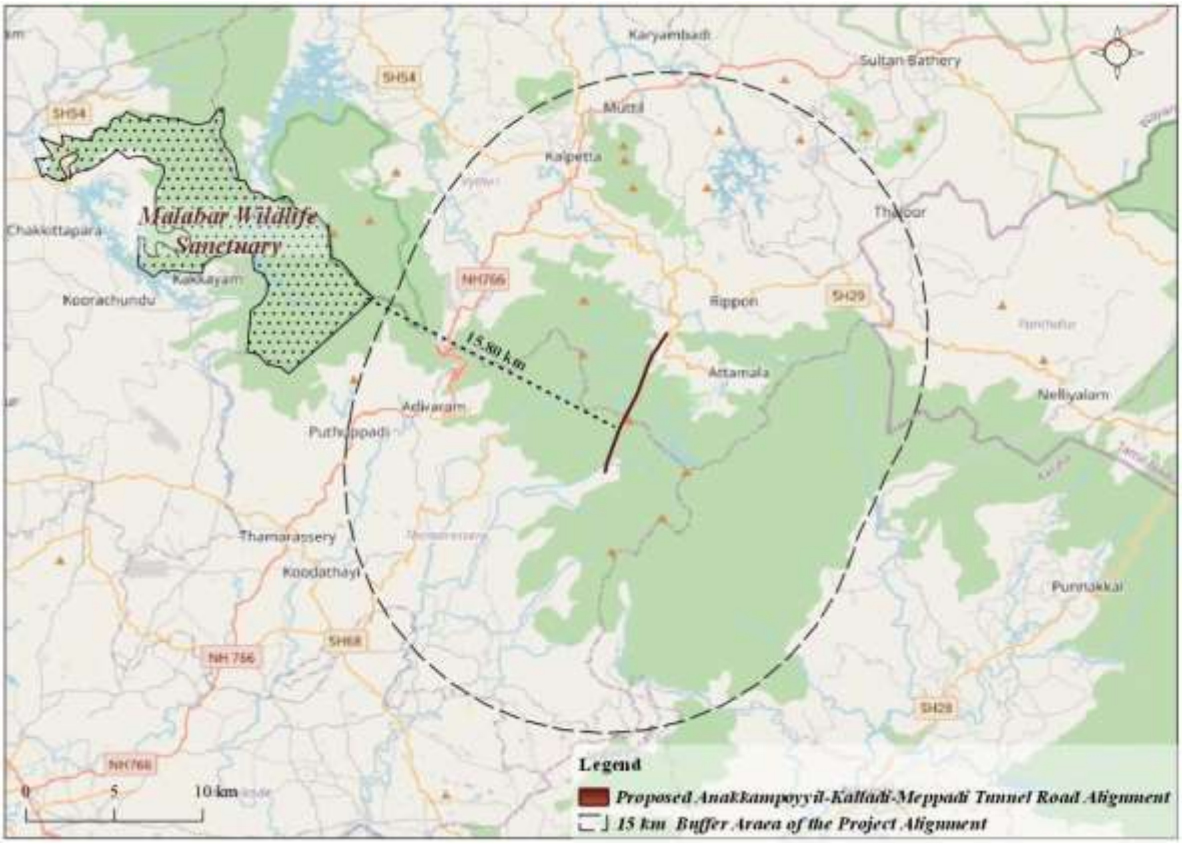


Figure 0-21. Map showing the Malabar Wildlife Sanctuary to the Proposed Project Alignment

No other protected natural habitats (National Parks / Wildlife Sanctuary / other protected areas under Wildlife (Protection) Act, 1972) is situated within 15 km radius of the project tunnel road. The project alignment does not pass through CRZ area. Nearest protected area (under Wildlife (Protection) Act, 1972) to the project, alignment is Malabar Wildlife Sanctuary, which is located 15.80 km away (aerial distance) from the proposed alignment. Map showing the proximity of Malabar Wildlife Sanctuary to the project alignment is presented in **Figure 0-21**[K5]**.**

4.8.2. Wildlife Habitat outside Protected Areas

The project area is part of Western Ghat, a hotspot for biodiversity and is home to 5,000 species of flora and fauna. A variety of large wild animals and various types of birds seen in the forest area.

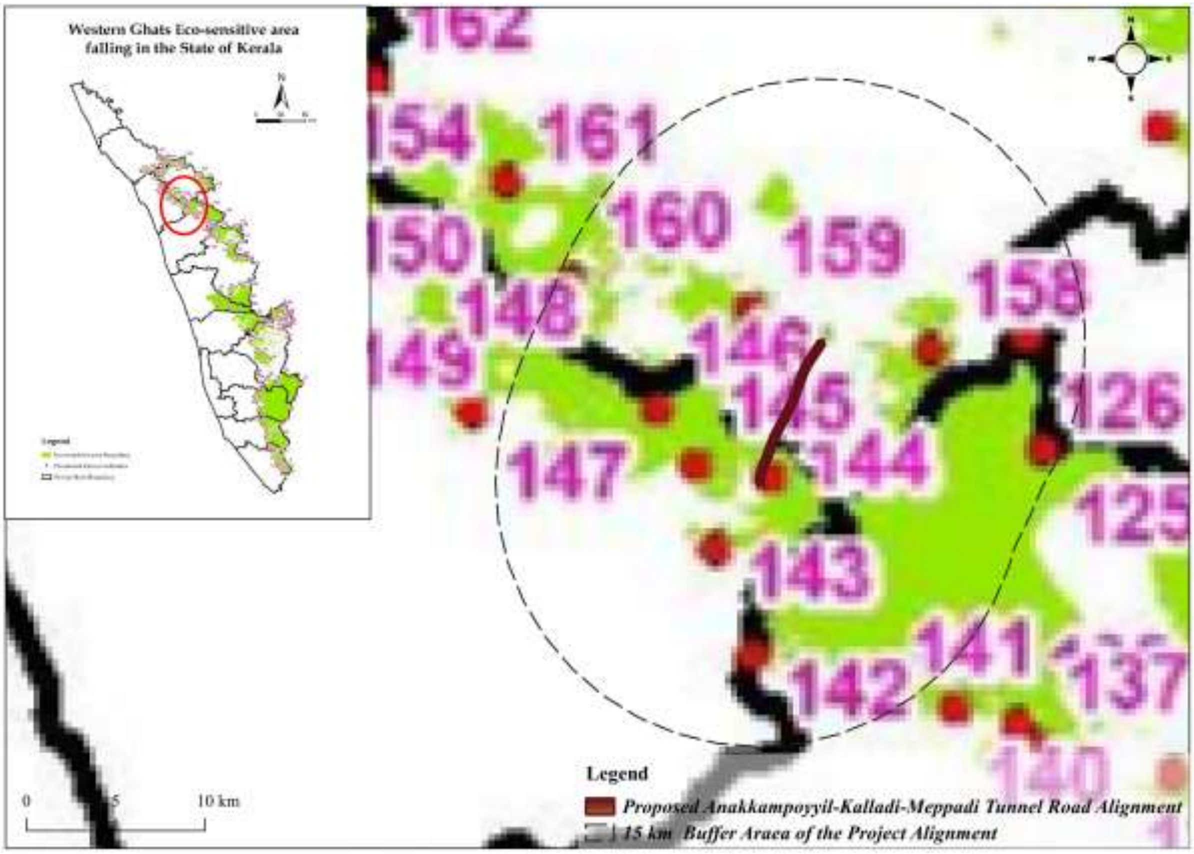


Figure 0-22. Map showing the Eco Sensitive Area of Western Ghat and the Project Alignment[*]

The project area lies in the Ecologically Sensitive Area (ESA) of Western Ghat as recommended by High Level Working Group Report on Western Ghats. As per the Cadastral level details of ESA Villages (accessed through Kerala Biodiversity Website), Sy Nos. 53pt, and 260 of Vellarimala Village of Vythiri Taluk, Wayanad district[†] and Old Sy Nos. 163 of Kodenchery Village and Thiruvambadi Village of Thamarassery Taluk, Kozhikode district[‡] falls in the list of Ecologically Sensitive Area of Western Ghat and the project alignment passes through the mentioned Sy. Nos. Alignment overlaid on the Eco-Sensitive Area Map of Wester Ghat is presented in **Figure 0-22**.

4.8.3. Presence of Forest

As per Champion and Seth (1968) and Chandrasekharan (1960) the natural vegetation of the project districts is falling into following types: (i) Moist deciduous forests and (ii) Semi-Evergreen Forests. Apart from these two vegetation types, certain edaphic types such as reed brakes, moist bamboo brakes, secondary evergreen forests, sholas, riparian vegetation, marshy grasslands, grasslands and plantations are also present in the state as well in the Kozhikode district[K6].

As per the India State Forest Report (ISFR) of Kerala, the type of forests present in the project forest divisions are West Coast tropical evergreen forests, Cane brakes, West Coast Semi-Evergreen Forests, Bamboo brakes, Tropical Moist Deciduous Forests, Southern Secondary moist deciduous Forests,

[*] Source: https://www.keralabiodiversity.org/images/esa/gps_point_%20map.pdf
[†] Source: https://www.keralabiodiversity.org/images/esamap/Wayanad.pdf
[‡] Source: https://www.keralabiodiversity.org/images/esamap/Kozhikkod.pdf

Reed brakes. The project region has West Coast Tropical Evergreen Forests. As per the Forest Survey of India (FSI), the Kozhikode district has more percentage of forest area (61.28%) in comparison with Kerala state (54.42%). In the context of the Wayanad District, the overall percentage of the total forest cover is slightly more than the state i.e. 74.19%. Summary of the forest area of the State and project districts are presented in **Table 0.16.**

Table 0.16. Details of Forest Cover in the Project District and Kerala State (in Sq. km)

District/ State	Geographical Area	Very Dense	Moderately Dense	Open Forest	Total Forest	% of the Total Area
Kozhikode	2,345	70.81	409.89	956.27	1,436.97	61.28
Wayanad	2,130	188.99	1,221.00	170.23	1,580.22	74.19
Kerala	**38,852**	**1,934.83**	**9,508.24**	**9,701.22**	**21,144.97**	**54.42**

There are 20 forest patches coming within the 10 km buffer of the project alignment. Out of 10 km buffer zone of the project alignment 242.80 Sq km (Area is extracted from forest demarcated in the SoI Toposheet). Details of the forests coming within 10 km buffer of the project alignment is given in **Table 0.17.** Map showing the forest patches coming within the 10 km buffer zone of the project alignment is presented in **Figure 0-23.**

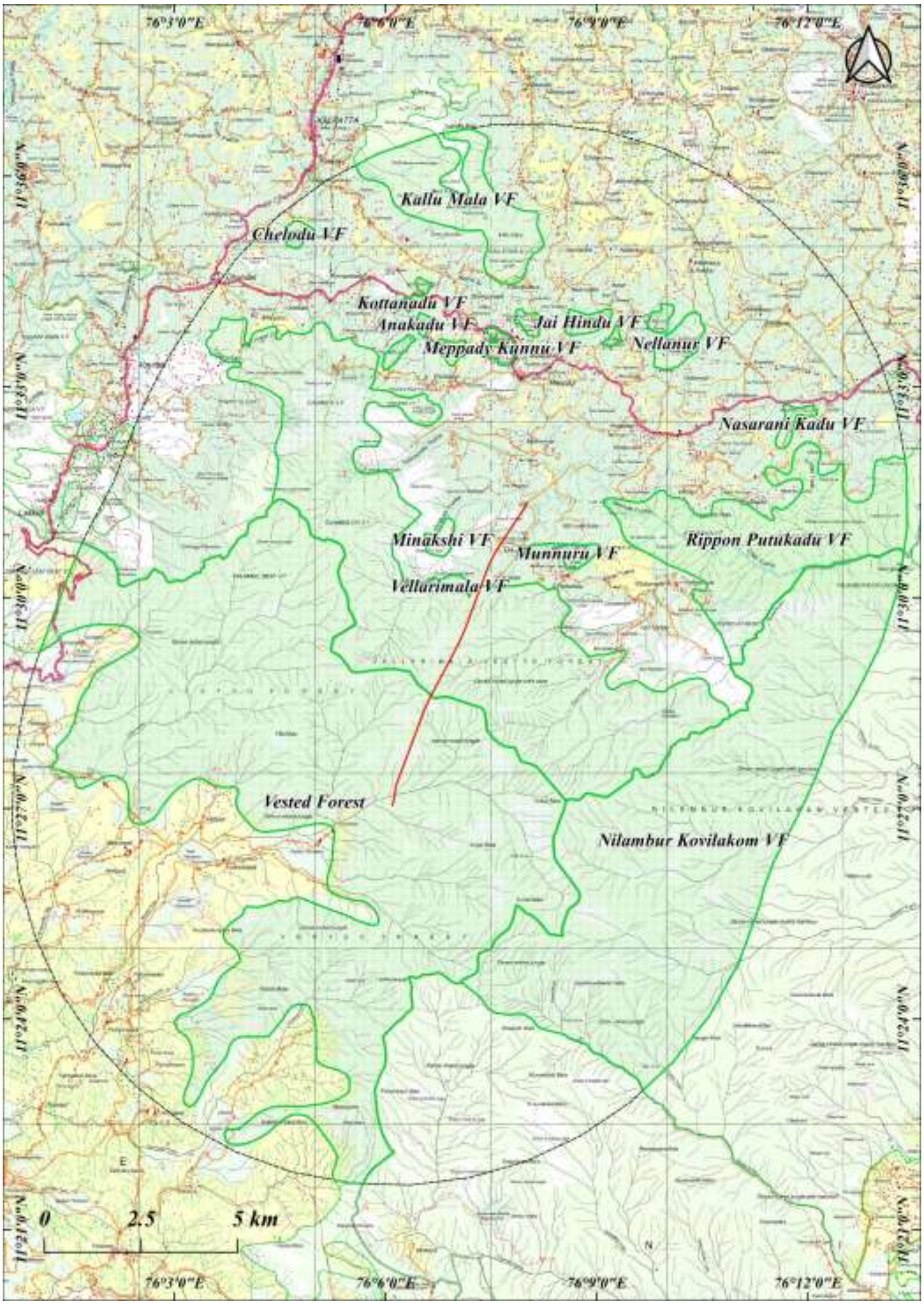


Figure 0-23. Map showing the Forest Areas within 10 km Buffer of the Project Tunnel Road*

* *Source: SOI Toposheet*

Table 0.17. Details of Forest Cover in the 10 km Buffer of the Projec Alignment (in Sq. km)*

Sl No	Name of the Forest	Area in (Sq.km)
1	Nilambur Kovilakom VF	59.33
2	Vested Forest	103.59
3	Kallu Mala VF	8.11
4	Rippon Putukadu VF	18.05
5	Kottanadu VF	0.11
6	Kottanadu VF	0.16
7	Anakadu VF	0.19
8	Chembra (Erumakolli) VF	0.34
9	Meppady Kunnu VF	0.46
10	Puzamula VF	0.30
11	Vellarimala VF	47.64
12	Minakshi VF	0.49
13	Munnuru VF	0.72
14	Nasarani Kadu VF	0.47
15	Nellanur VF	1.17
16	Koleri VF	0.33
17	Jai Hindu VF	0.13
18	Jai Hindu VF	0.54
19	Meppadi Kunnu VF	0.30
20	Chelodu VF	0.36
Total Area (Sq. km)		**242.80**

Around 5.76 km of the project alignment passes through forestland. Approximately, 17.263 Ha of forest land is to be utilised for the project, out of which 16.269 Ha forest land is for underground usage and 0.994 Ha forest land is for overground usage.

Table 0.18. Details of Forest Area Crosses/Abuts the Project Road

<table>
<tr><th>Sl. No.</th><th>District</th><th>Village</th><th>Forest Area (ha)</th><th>Forest Area village wise (ha)</th></tr>
<tr><td>1</td><td>Kozhikode</td><td>Thiruvambadi</td><td rowspan="2">7.956</td><td>0.052</td></tr>
<tr><td>2</td><td></td><td>Kodencherry /Nellipoyil</td><td>7.903</td></tr>
<tr><td>3</td><td>Wayanad</td><td>Muppainad/ Vellarimala</td><td rowspan="2">9.307</td><td>5.104</td></tr>
<tr><td>4</td><td></td><td>Meppadi/ Kottapadi</td><td>4.203</td></tr>
<tr><td>5</td><td>Total</td><td></td><td>17.263</td><td>17.263</td></tr>
</table>

Total Area for Overground Usage	**9940 Sq. m**	**0.994 Ha**
Total Area for Underground Usage	**16269 Sq.m**	**16.269 Ha**
Total Area	**17263 Sq.m**	**17.263 Ha**

* *Source: SOI Toposheet*

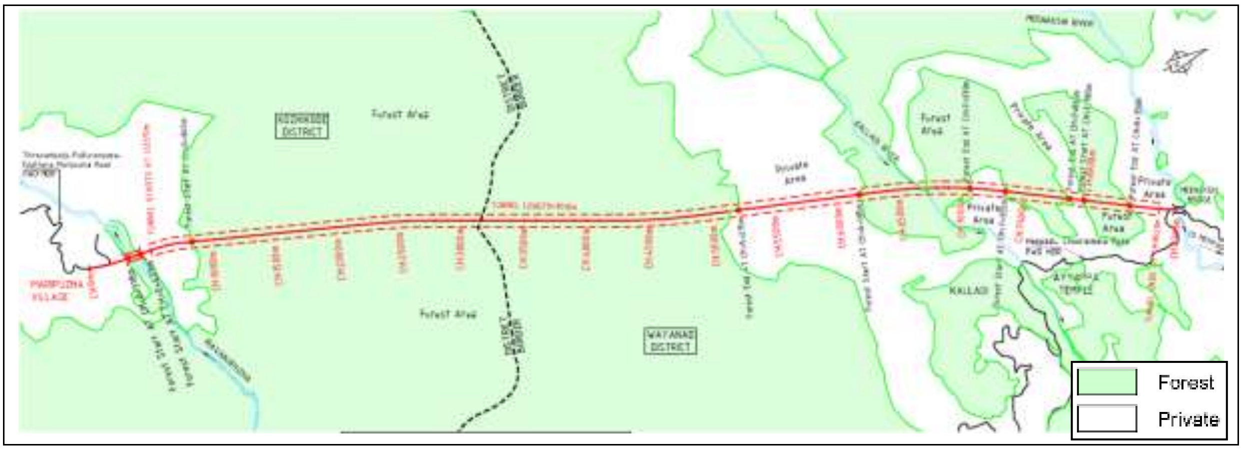


Figure 0-24. Map showing the Forest Area Crosses/Abuts the Project Tunnel Road

4.8.4. Terrestrial Vegetation

Vegetation cover of the project environment (lying along the proposed tunnel-road alignment in 15 km on either side) is constituted by a combination of tropical wet evergreen, semi-evergreen and moist deciduous forests; montane grasslands; evergreen riparian belts of Iruvazhanjipuzha and sparse vegetation of the rocky slopes, apart from tea, coffee, cardamom, teak and eucalyptus plantations and agri-horticultural farms. The forestland involved in the tunnel-road alignment lies within Thamarassery and Meppadi Ranges of Kozhikode and Wayanad South Forest Divisions respectively. The natural forests and grasslands of the region together constitute a cloud forest (montane rain forest), which typically supports high epiphytic [M A7]growth, especially of orchids. The following forms a brief description of the vegetation types encountered in the stretch.

Southern tropical wet evergreen forest: Evergreen forests extending from lower to higher elevations of the area exhibit variation in physiognomy and species composition with respect to change in altitude, and is characterised by striking species diversity contained in different strata. Occurrence of epiphytes including orchids, mosses and lichens increase with altitude while woody climbers (lianas) decline. The multiplicity of species co-existing in complex biological equilibrium offers this type of forests with the highest ecological status, namely ‘climatic climax’. Evergreen forests occupy different ecological niches depending on the local factors of elevation, slope and soil conditions. Notable tree elements of the forest stretch include *Aglaia elaeagnoidea*, *A. lawii, Antidesma bunius, A. montanum, Cinnamomum malabatrum, Diospyros bourdillonii, D. buxifolia, D. candolleana, D. paniculata, Drypetes oblongifolia, Flacourtia montana, Garcinia cowa, G. gummi-gutta, G. morella, Gomphandra coriacea, Holigarna arnottiana, Holoptelea integrifolia, Hopea parviflora, Hydnocarpus pentandrus, Litsea coriacea, Mangifera indica, Mesua ferrea, Monoon fragrans, Nothopegia racemosa, Persea macrantha, Pterosperum reticulatum, Scolopia crenata, Streblus asper, Symplocos acuminata, Syzygium cuminii, S. laetum* and *Vateria indica*. The shrubby vegetation is represented by *Aeschynanthus perrottettii, Blachia umbellata, Casearia ovata, Cinnamomum heyneanum, Eugenia argentia, E. roxburghii, Glycosmis mauritiana, G. pentaphylla, Isonandra lanceolata, Justicia betonica, Leea indica, Maesa indica, Memecylon gracile, Memecylon grande, Nothapodytes nimmoniana, Polyalthia malabarica, Pogostemon mollis, Psychotria flavida, Strobilanthes ciliatus* and *Thottea siliquosa*. Among climbers, *Ancistrocladus heyneanus, Artabotrys zeylanicus, Desmos chinensis* var. *lawii, Millettia rubiginosa, Piper argyrophyllum, P.*

hymenophyllum, *Salacia fruticosa* and *Strychnos minor* are noteworthy. Important herbs include *Epithema carnosum* and *Gymnostachyum febrifugum* var. *febrifugum*.

Southern moist deciduous forest: The forest type is constituted by both evergreen and deciduous elements although evergreen components predominate. It has been found to occur adjacent or within disturbed tracts of evergreen forests. Major trees of the forest system are *Alstonia scholaris, Aporusa lyndelyana, Bombax ceiba, Briedelia retusa, Butea monosperma, Cassia fistula, Dalbergia lanceolaria, Ficus benghalensis, F. callosa, F. tsjahela, Grewia tiliifolia, Haldinia cordifolia, Mallotus philippensis, M. tetracoccus, Mangifera indica, Mitragyna parvifolia, Olea dioica, Pajanelia longifolia, Phyllanthus emblica, Pongamia pinnata, Pterocarpus marsupium, Schleichera oliosa, Scleropyrum pendandrum, Sterculia guttata, S. urens, Strycnos nux-vomica, Syzygium cuminii, Terminalia elliptica, T. paniculata, Xylia xylocarpa* and *Zanthoxylum rhetsa*. Shrubs include *Allophyllus serratus, Briedelia stipularis, Canthium rheedei, Catunaregam spinosa, Cippadessa baccifera, Desmodium triquetrum, Helicteres isora* and *Polyalthia korintii* apart from a few thickets of bamboos (*Bambusa bambos* and *Dendrocalamus strictus*) and reeds (*Ochlandra travancorica*). Notable climbers are *Ampellocissus latifolia, Calycopteris floribunda, Cayratia trifoliata, Croton caudatus, Dalbergia volubilis, Gnetum ula, Ichnocarpus frutescens* and *Mucuna gigantea*.

Grasslands: Commonly found grasses in the system are *Allopteropsis cimmicina, Aristida setacea, Arundinella leptochloa, A. mesophylla, Chrysopogon aciculatus, C. hackelii, Cymbopogon citratus, C. flexuosus, Digitaria bicornis, D. ciliaris, Eulalia trispicata, Garnotia tenella, Heteropogon contortus, Ischaemum barbatum, I. indicum, Oplismenus burmanni, Panicum brevifolium, Pennisetum polystachyon, Perotis indica, Setaria intermedia* and *S. pumila*. The sedges (members of Cyperaceae), *Scleria lithosperma* and *Fimbristylis dichotoma*, are frequently found. Occurrence of ground orchids such as *Brachychorithis iantha* and *Habeneria* spp. is noteworthy.

Riparian vegetation: Riparian vegetation occurring all along the banks of rivers and streams is chiefly composed of evergreen trees and shrubs with a mix of few deciduous elements. Life forms in this community are peculiar in having inherent capacity to withstand periodic inundation during monsoon floods. The banks of Iruvazhanjipuzha (a tributary of Chaliyar River) mainly house trees such as *Aporosa cardiosperma, Artocarpus hirsutus, Diospyros bourdillonii, Elaeocarpus tuberculatus, E. serratus, Flacourtia montana, Holigarna arnottiana, Hopea parviflora, Humboldtia vahliana, Lophopetalum wightianum, Madhuca neeriifolia, Mesua ferrea, Nothopegia racemosa, Persea macrantha, Pongamia pinnatta, Syzygium occidentale, Vateria indica,* etc. Notable shrubs and herbs include *Glycosmis pentaphylla, Homonoia riparia, Ochlandra travancorica, Leea indica, Pogostemon mollis, Psychotria flavida, Strobilanthes ciliatus* and *Thottea siliquosa.* Frequently encountered climbers are *Entada rheedei, Fagraea ceilanica, Gnetum ula* and *Salacia fruticosa*. River bed is characterized by *Homonoia riparia, Lagenandra ovata* and *Rotula aquatica*.

Vegetation of the rocky slopes: Rocky slopes show sparse occurrence of trees with stunted growth, among which *Bombax ceiba, Careya arborea, Cochlospermum religiosum, Hymenodictyon obovatum* and *Streblus asper* are notable. Shrubs and climbers include *Calycopteris floribunda, Canthium angustifolium, C. coromandelicum, Catunaregam spinosa, Helicteres isora, Smilax zeylanica, Ziziphus oenoplia* and *Z. rugosa*. Notable herbs and grasses are *Eulalia trispicata, Ischaemum barbatum* and *Kalanchoe pinnata*. The vegetation on the whole resembles a scrub jungle.

Plantations: Forest plantations of the area are constituted mainly by Teak (*Tectona grandis*) and Eucalyptus (*Eucalyptus* sp.), of which the latter is located towards Meppadi end. Commercial plantations are of Tea, Coffee and Cardamom. Rubber plantations mainly occupy small/medium land holdings in Anakkampoil area. Mixed farms associated with farm houses and homesteads are found in both Anakkaompoil and Meppadi areas.

4.8.4.1. Floral Composition and Diversity

The following forms a brief account of the terrestrial floral composition and diversity of the project area and surroundings, covering flowering plants (angiosperms) and lower groups of plants (gymnosperms, pteridophytes and bryophytes).

4.8.4.2. Angiosperms[dj8]

Angiosperm composition of the project area and surroundings (study area) was analysed through random survey covering all prominent seasons in the proposed stretch of tunnel-road alignment (500 m on either side of the tunnel-road alignment) and its peripheral areas (covering 15 km on either side) and available authentic secondary information. The plants were identified, enumerated and checklist of the component species prepared. Authentic documents on floral composition and diversity of the region such as State and District Floras (Gamble, 1915-36; Manilal and Sivarajan, 1982; Sreekumar and Nair, 1991; Ratheesh Narayanan, 2010), checklists (Nayar et al, 2006, 2014; Sasidharan, 2004), and other related publications (Shaju, 2010; Ratheesh Narayanan et al., 2013) have been used in authenticating the present enumeration. The flora is composed mainly of forest plants with a sizeable number of evergreen elements; cultivated plants of forest plantations, agri-horticultural fields and homesteads; and alien weeds invaded in the domesticated and wilderness areas. Checklist of trees, shrubs, climbers and herbs, found in the project environment is presented in **Annexure 13**

The terrain

Biodiversity survey

Terminalia paniculata

Litsea coreacea

Pteropspermum rubiginosum

Tabernaemontana alternifolia

Ensete superbum

Madhuca neriifolia

A total of 451 species of flowering plants were recorded from the project environment, which include 160 trees, 105 shrubs, 61 climbers and 125 herbs. As indicted earlier, the area harbours notable number of epiphytes, mostly orchids like *Acampe praemorsa*, *Dendrobium crepidatum*, *D. ovatum*, *D. wightii*, *Luisia tristis*, *Rhynchostylis retusa*, etc. *Dendrophthoe falcata*, *Helixanthera wallichiana*, *Macrosolon capitellatus*, *M. parasiticus*, *Helicanthus elastica* and *Cassytha filiformis* are some of the parasitic plants.

Table-4.19 shows cultivated species of the region, including food crops, cash crops, timber and soft wood trees. Apart from these, several vegetable and fruit crops and ornamental plants are cultivated in the homesteads. Cultivation of different varieties of banana and several species of tubers including wild relatives of yam (*Dioscorea oppositifolia*), such as *D. pentaphylla* and *D. wallichii* often consumed by the native people is exceptionally noteworthy.

Table4.19: Cultivated species of the project environment

Sl. No.	Botanical name	Local /common name	Family
1.	*Ailanthus excelsa* Roxb.	Perumaram	Simaroubaceae
2.	*Ailanthus triphysa* (Dennst.) Alston	Matti	Simaroubaceae
3.	*Alpinia calcarata* (Andrews) Rosc.	Kolinchi	Zingiberaceae
4.	*Alpinia galanga* (L.) Willd.	Kolinchi, Galang	Zingiberaceae
5.	*Amorphophallus paeonifolius* (Dennst) Niolson var. *campanulatus*	Chena, Elephant foot yam	Araceae
6.	*Amaranthus tricolor* L.	Thanducheera, Amaranth	Amaranthaceae
7.	*Anacardium occidentale* L.	Kasumavu, Cashew nut tree	Anacardiaceae
8.	*Annona muricata* L.	Mullatha, Soursop	Annonaceae
9.	*Annona reticulata* L.	Atha, Bullock's heart	Annonaceae
10.	*Annona squamosa* L.	Seethappazham, Custard apple	Annonaceae
11.	*Areca catechu* L.	Kamuku, Arecanut	Arecaceae
12.	*Artocarpus heterophyllus* Lam.	Plavu, Jackfruit tree	Moraceae
13.	*Artocarpus altilis* (Parkinson) Fosberg	Seemaplavu, Breadfruit tree	Moraceae
14.	*Caesalpinia sappan* L.	Chappangam, Sappan wood	Fabaceae
15.	*Camellia sinensis* (L.) Kuntze	Theyila, Tea plant	Theaceae
16.	*Capsicum annuum* L.	Kappamulaku, Chilly	Solanaceae
17.	*Capsicum frutescens* L.	Kantharimulaku, Bird chilly	Solanaceae
18.	*Carica papaya* L.	Oma, Pappaya	Caricaceae
19.	*Cinnamomum verum* Presl	Karuva, Cinnamon	Lauraceae
20.	*Citrus maxima* (Burm.f.) Merr.	Kabilinarakam, Bumblimos	Rutaceae
21.	*Cocos nucifera* L.	Thengu, Coconut tree	Arecaceae
22.	*Coffea arabica* L.	Kappi, Coffee	Rubiaceae
23.	*Colocasia esculenta* (L.) Schott	Chembu, Taro	Araceae
24.	*Curcuma longa* L.	Manjal, Turmeric	Zingiberaceae
25.	*Dioscorea esculenta* L.	Nanakizhangu	Dioscoreaceae
26.	*Dioscorea oppositifolia* (Lour.) Burkill	Kachil, Yam	Dioscoreaceae
27.	*Elaeis guineensis* Jacq.	Ennappana, Oil palm	Arecaceae
28.	*Elettaria cardamomoum* (L.)	Elam, Cardamomum	Zingeberaceae

	Maton		
29.	*Eucalyptus* sp.	Yukali, Eucalyptus	Myrtaceae
30.	*Garcinia gummi-gutta* (L.) Robs.	Kodampuli, Malabar gamboge	Clusiaceae
31.	*Garcinia mangostana* L.	Mangosteen	Clusiaceae
32.	*Grevillea robusta* Cunn ex R. Br.	Silver oak	Proteaceae
33.	*Hevea brasiliensis* (Willd ex A. Juss.) Muell.-Arg.	Rubber	Euphorbiaceae
34.	*Litchi chinensis* Sonner.	Litchi	Sapindaceae
35.	*Mangifera indica* L.	Mavu, Mango	Anacardiaceae
36.	*Manihot esculenta* Crantz.	Maracheeni, Cassava	Euphorbiaceae
37.	*Manilkara zapota* (L.) P. Royen	Sappota, Chiku	Sapotaceae
38.	*Maranta arundinacea* L.	Koova, Arrow-root	Marantaceae
39.	*Moringa oleifera* Lam.	Muringa, Drumstick tree	Moringaceae
40.	*Murraya koenigii* (L.) Spreng.	Kariveppu, Curry bush	Rutaceae
41.	*Musa paradisiaca* L.	Vazha, Plantain	Musaceae
42.	*Myristica fragrans* Houtt.	Jathi, Nut-meg	Myrtaceae
43.	*Oryza sativa* L.	Nellu, Rice	Poaceae
44.	*Nephelium lappaceum* L.	Rambutan	Sapindaceae
45.	*Passiflora edulis* Sims	Passion fruit	Passifloraceae
46.	*Persea americana* Mill.	Butter-fruit, Avocado	Lauraceae
47.	*Phyllanthus acidus* (L.) Skeels	Arinelli, Star gooseberry	Euphorbiaceae
48.	*Phyllanthus emblica* L.	Nelli, Indian goosberry	Euphorbiaceae
49.	*Pimenta dioica* (L.) Merr.	Sarvasugandhi, All-spice tree	Myrtaceae
50.	*Piper nigrum* L.	Kurumulaku, Pepper	Piperaceae
51.	*Psidium guajava* L.	Pera, Guava	Myrtaceae
52.	*Punica granatum* L.	Mathalam, Pomegranate	Lythraceae
53.	*Syzygium aromaticum* (L.) Merr. & Perry	Grampu, Clove	Myrtaceae
54.	*Theobroma cacao* L.	Cocoa	Sterculiaceae
55.	*Tamarindus indica* L.	Valanpuli, Tamarind	Fabaceae
56.	*Tectona grandis* L.f.	Thekku, Teak	Verbenaceae
57.	*Vanilla planifolia* Andr.	Vanilla	Orchidaceae
58.	*Zingiber officinale* Rosc.	Inchi, Ginger	Zingiberaceae

Endemic flowering plants: Different forest types of the project environment (study area) harbours a significant number of endemic species. Some species in nature have restricted distribution, often confined to a particular habitat/geographical area; such taxa are called *endemics* and the phenomenon, *endemism*. Endemic species are of great interest to phyto-geographers as some such taxa may be very ancient in origin (palaeo-endemics), while others may be comparatively new (neo-endemics), indicating the movement of landmass and evolution. The endemics make phyto-geographical regions and the component flora unique. The Western Ghats is one of the global biodiversity hotspots and one of the three hotspots in India, in the context of floristic composition and concentration of endemic taxa. Nayar (1997) estimated that out of the 4,000 species of flowering plants of Western Ghats, 1,500 are endemics. In Kerala, Nayar (1997) estimated 1,272 endemics out of a total of 3,800 species of flowering plants, accounting for 33.47% endemism.

Random floral survey and collation of authentic secondary information resulted in the enumeration of 104 endemic flowering plants from the project environment **(Annexure 14),** including 12 exclusive endemic species to the State of Kerala (distribution restricted within the geographical boundary of Kerala), viz. *Aglaia malabarica*, *Biophytum congestiflorum, Bulbophyllum silentvalliensis, Dendrobium anilii, Impatiens johnsiana, I. minae, Isachne henryi, Memecylon wayanadense, Miliusa wayanadica, Orophea sivarajanii, Sonerila cannanorensis* and *S. keralensis*.

Hopea parviflora

Ixora brachiata

Atrocarpus hirsutus

Holigarna arnottiana

Humboltia vahliana

Homonoia riparia

Rare category plants: As per IUCN (International Union for Conservation of Nature and Natural Resources) classification, rare species are the ones that are uncommon, but not necessarily at risk (of extinction). The list of rare category flowering plants found in the project environment are summarised in **Table-4.20.** Out of the 91 angiosperms figuring in the IUCN Red List of Threatened Species, three (*Aglaia malabarica*, *Impatiens johnsiana* and *Impatiens minae*) are 'Critically Endangered'; seven species (*Cinnamomum heyneanum, Cynometra travancorica, Eugenia argentia, Humboldtia vahliana, Myristica beddomei, Psychotria globicephal* and *Tectona grandis*) are 'Endangered'; 15 species (*Aporosa cardiosperma, Aralia malabarica, Dalbergia latifolia, Drypetes wightii, Epithema carnosum* var. *hispida, Hydnocarpus pentandrus, Lasianthus jackianus, Magnolia nilagirica, Memecylon grande, Myristica malabarica, Pterosperum reticulatum, Strobilanthes ciliatus, Syzygium occidentale, Tarenna nilagirica* and *Vateria indica*) are 'Vulnerable'; six species (*Aglaia barberi, Elaeocarpus munroi, Ensete superbum, Litsea bourdillonii, Litsea coriacea* and *Polyalththia malabarica*) are 'Near Threatened', and the remaining ones figure in the 'Least Concern' category.

Table-4.20: List of rare category plants found in the project environment

Sl. No.	Scientific name	Family	IUCN Red list Status
1.	*Abelmoschus angulosus* Wall ex Wight & Arn.	Malvaceae	Least Concern
2.	*Abelmoschus moschatus* Medik.	Malvaceae	Least Concern
3.	*Acalypha fruticosa* Forssk.	Euphorbiaceae	Least Concern
4.	*Acacia caesia* Wight & Arn.	Fabaceae: Mimosoideae	Least Concern
5.	*Actinodaphne wightiana* (Kuntze) Noltie	Lauraceae	Least Concern
6.	*Aglaia barberi* Gamble	Meliaceae	Near Threatened
7.	*Aglaia elaeagnoidea* (A. Juss.)	Meliaceae	Least Concern

	Benth.		
8.	*Aglaia lawii* (Wight) Saldanha	Meliaceae	Least Concern
9.	*Aglaia malabarica* Sasidh.	Meliaceae	Critically Endangered
10.	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Least Concern
11.	*Antidesma montanum* Blume	Euphorbiaceae	Least Concern
12.	*Aporosa cardiosperma* (Gaertn.) Merr.	Euphorbiaceae	Vulnerable
13.	*Aralia malabarica* Bedd.	Araliaceae	Vulnerable
14.	*Baliospermum solanifolium* (Burm.) Suresh	Euphorbiaceae	Least Concern
15.	*Bischofia javanica* Blume	Euphorbiaceae	Least Concern
16.	*Caesalpinia bonduc* L.	Fabaceae: Caesalpinioideae	Least Concern
17.	*Cardiospermum halicacabum* L.	Sapindaceae	Least Concern
18.	*Catunaregam spinosa* (Taunb.) Triveng.	Rubiaceae	Least Concern
19.	*Cinnamomum heyneanum* Nees	Lauraceae	Endangered
20.	*Cinnamomum malabatrum* (Burm.f.) Blume	Lauraceae	Least Concern
21.	*Cippadessa baccifera* (Roth) Miq.	Meliaceae	Least Concern
22.	*Cuscuta reflexa* Roxb.	Convolvulaceae	Least Concern
23.	*Cynometra travancorica* Bedd.	Fabaceae: Caesalpinioideae	Endangered
24.	*Dalbergia latifolia* Roxb.	Fabaceae: Papiliooideae	Vulnerable
25.	*Dalbergia volubilis* Roxb.	Fabaceae: Papilionoideae	Least Concern
26.	*Dioscorea wallichii* Hook.f.	Dioscoreaceae	Least Concern
27.	*Drypetes wightii* (Hook.f.) Pax & Hoffm.	Euphorbiaceae	Vulnerable
28.	*Elaeocarpus munronii* (Wight) Mast.	Elaeocarpaceae	Near Threatened
29.	*Ensete superbum* (Roxb.) Cheesman.	Musaceae	Near Threatened
30.	*Epithema carnosum* Benth. var. *hispida*	Gesneriaceae	Vulnerable
31.	*Eugenia argentia* Bedd.	Myrtaceae	Endangered
32.	*Ficus drupacea* Thunb.	Moraceae	Least Concern
33.	*Ficus exasperata* Vahl.	Moraceae	Least Concern
34.	*Ficus hispida* L.f.	Moraceae	Least Concern
35.	*Ficus racemosa* L.	Moraceae	Least Concern
36.	*Fimbristylis dichotoma* (L.) Vahl	Cyperaceae	Least Concern
37.	*Flacourtia indica* (Burm.f) Merr.	Flacoutiaceae	Least Concern
38.	*Garcinia gummi-gutta* (L.)	Clusiaceae	Least Concern

	Robs.		
39.	*Garcinia morella* (Gaertn.) Desv.	Clusiaceae	Least Concern
40.	*Glycosmis pentaphylla* (Retz.) DC.	Rutaceae	Least Concern
41.	*Gmelina arborea* Roxb.	Verbenaceae	Least Concern
42.	*Hedyotis diffusa* Willd.	Rubiaceae	Least Concern
43.	*Homonoia riparia* Lour.	Euphorbiaceae	Least Concern
44.	*Hopea parviflora* Bedd.	Dipterocarpaceae	Least Concern
45.	*Humboldtia vahliana* Wight	Fabaceae	Endangered
46.	*Hydnocarpus pentandrus* (Buch.-Ham.) Oken	Flacoutiaceae	Vulnerable
47.	*Impatiens chinensis* L.	Balsaminaceae	Least Concern
48.	*Impatiens johnsiana* Ratheesh, Sunil & Anil	Balsaminaceae	Critically Endangered
49.	*Impatiens minae* Ratheesh, Anil Kumar & Sivad.	Balsaminaceae	Critically Endangered
50.	*Ischaemum indicum* (Houtt.) Merr. ssp. *indicum* var. *indicum*	Poaceae	Least Concern
51.	*Isonandra lanceolata* Wight	Sapotaceae	Least Concern
52.	*Justicia adhatoda* L.	Acanthaceae	Least Concern
53.	*Kyllinga nemoralis* (J.R. Forst. & G. Forst.) Dandy ex Hutch. & Dalz.	Cyperaceae	Least Concern
54.	*Knema attenuata* (Hook.f. & Thoms.) Warb.	Myristicaceae	Least Concern
55.	*Lagenandra ovata* (L.) Thw.	Araceae	Least Concern
56.	*Lagenandra toxicaria* Dalz.	Araceae	Least Concern
57.	*Lagerstroemia microcarpa* Wight	Lythraceae	Least Concern
58.	*Lasianthus jackianus* Wight	Rubiaceae	Vulnerable
59.	*Litsea bourdillonii* Gamble	Lauraceae	Near Threatened
60.	*Litsea coriacea* (Heyne ex Meisn.) Hook.f.	Lauraceae	Near Threatened
61.	*Lophopetalum wightianum* Arn.	Celastraceae	Least Concern
62.	*Ludwigia hyssopifolia* (G. Don.) Exell.	Onagraceae	Least Concern
63.	*Maesa indica* (Roxb.) Sweet	Myrsinaceae	Least Concern
64.	*Magnolia nilagirica* (Zenk) Figlar	Magnoliaceae	Vulnerable
65.	*Mallotus philippensis* (Lam.) Muell.-Arg.	Euphorbiaceae	Least Concern
66.	*Melicope lunu-ankenda* (Gaertn.) Hartley	Rutaceae	Least Concern
67.	*Memecylon grande* Retz.	Melastimataceae	Vulnerable
68.	*Moringa oleifera* Lam,	Moringaceae	Least Concern
69.	*Myristica beddomei* King	Myristicaceae	Endangered
70.	*Myristica malabarica* Lam.	Myristicaceae	Vulnerable

71.	*Oplismenus compositus* (L.) P. Beauv.	Poaceae	Least Concern
72.	*Pajanelia longifolia* (Willd.) K. Schum.	Bignoniaceae	Least Concern
73.	*Panicum repens* L.	Poaceae	Least Concern
74.	*Polygonum plebeium* R. Br.	Polygonaceae	Least Concern
75.	*Polyalththia malabarica* (Budd.) I.M. Turner	Annonaceae	Near Threatened
76.	*Psychotria globicephala* Gamble	Rubiaceae	Endangered
77.	*Pterosperum reticulatum* Wight & Arn.	Sterculiaceae	Vulnerable
78.	*Rotula aquatica* Lour.	Boraginaceae	Least Concern
79.	*Schleichera oliosa* (Lour.) Oken	Sapindsceae	Least Concern
80.	*Scleria lithosperma* (L.) Sw.	Cyperaceae	Least Concern
81.	*Strobilanthes ciliatus* Nees	Acanthaceae	Vulnerable
82.	*Symplocos acuminata* (Blume) Miq.	Symplocaceae	Least Concern
83.	*Syzygium occidentale* (Bourd.) Gandhi	Myrtaceae	Vulnerable
84.	*Tamarindus indica* L.	Fabaceae: Caesalpinioideae	Least Concern
85.	*Tarenna nilagirica* (Bedd.) Bremek.	Rubiaceae	Vulnerable
86.	*Tectona grandis* L.f.	Verbenaceae	Endangered
87.	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Least Concern
88.	*Terminalia chebula* Retz.	Combretaceae	Least Concern
89.	*Tetrameles nudiflora* R. Br.	Datiscaceae	Least Concern
90.	*Vateria indica* L.	Dipterocarpaceae	Vulnerable
91.	*Waltheria indica* L.	Sterculiaceae	Least Concern

Myristica malabarica

Vateria indica

Strobilanthes ciliatus

Knema attenuata

Weeds: Nineteen species of weeds have also been recorded, which are found in the crop lands, plantations, homesteads and degraded forest areas. Table-4.21 presents the list of weeds of the region. Spread of the invasive tree species *Senna spectabilis* (Manjakkonna) in the forestland, especially in Meppadi area, is significant.

Table-4.21: List of weeds found in the project environment

Sl. No.	Scientific name	Local / vernacular name	Family
1.	*Ageratum conyzoides* L.	Murianpacha	Asteraceae
2.	*Ageratum houstonianum* Mill.	Kaliyammanpathiri	Asteraceae
3.	*Caesalpinia mimosoides* Lam.	Kalthottavadi	Fabaceae
4.	*Chromolaena odorata* (L.) King & Robins.	Communistupacha	Asteraceae
5.	*Conyza canadensis* (L.) Cronq.		Asteraceae
6.	*Corchorus trilocularis* L.	Arenukam	Tiliaceae
7.	*Cyrtococcum oxyphyllum* (Steud.) Stapf		Poaceae
8.	*Eleutheranthera ruderalis* (Sw.) Sch.		Asteraceae
9.	*Lantana camara* L.	Poochedi	Verbenaceae
10.	*Mikania micrantha* Kunth	Dritharashtrapacha	Asteraceae
11.	*Mimosa diplotricha* C. Wight ex Sanvelle	Anathottavadi	Asteraceae
12.	*Oplismenus compositus* (L.) P. Beauv.		Poaceae
13.	*Panicum notatum* Retz.		Poaceae
14.	*Senna spectabilis* (DC.) H.S. Irvin & Barneby	Manjakkonna	Fabaceae
15.	*Tridax procumbens* L.	Muriyanpacha	Asteraceae
16.	*Triumfetta pilosa* Roth	Erumachappu	Tiliaceae
17.	*Triumfetta rhomboidea* Jacq.	Oorpam	Tiliaceae
18.	*Vernonia albicans* DC.	Puvankuranthal	Asteraceae
19.	*Waltheria indica* L.		Sterculiaceae

Gymnosperms

Gymnosperms are the group of vascular plants which reproduces by means of exposed seeds (borne in cones and are not enclosed by an ovary), unlike angiosperms whose seeds are enclosed by mature ovaries or fruits. Gymnosperms were dominant in the Mesozoic era and have been gradually displaced by more recently evolved angiosperms. The two gymnosperms naturally occurring in the project environment are *Cycas circinalis* (Kanamaram) of family Cycadaceae and *Gnetum ula* (Karuthodal) of Gnetaceae; the two species are frequently found towards lower elevations of the project environment. *Cycas revoluta* and *Zamia* sp. are cultivated as ornamental plants in the home gardens.

Cycas circinalis

Gnetum ula

Pteridophytes

Pteridophytes are a unique group of vascular plants which play significant roles in the ecosystem as gap fillers, soil binders, and supporting other biota by providing congenial microhabitats. The proposed project area and surroundings were surveyed through random search covering almost all possible habitat locations. Noted Pteridologist Dr. K.P. Rajesh (Aranyakam Nature Foundation) led the survey, assisted by Dr. B. Mufeed. The pteridophyte species observed in the area during the present survey are listed in Table-4.22. The global status of pteridophytes have not been assessed yet. However, based on the available information, the status of observed species is summarised in the Table. Further, based on the frequency of occurrence and sightings in the area, a qualitative abundance assessment was made and presented as rare, common and occasional in addition to endemic status. The survey resulted in recording 58 species of pteridophytes. Among these, three are endemic to the Western Ghats (Manickam and Irudayraj, 1992; Nayar and Geevarghese, 1993; Fraser-

Jenkins *et al.*, 2017, 2018, 2021). Eight of the species recorded are rarely distributed in the area.

Table-4.22: List of Pteridophytes found in the Anakkampoyil-Meppadi area

Sl.	Name of the species	Family	Remarks
1.	*Asplenium decrescens* Kunze	Aspleniaceae	Occasional in the area
2.	*Asplenium erectum* Bory ex Willd.	Aspleniaceae	Common in the area
3.	*Asplenium formosum* Willd.	Aspleniaceae	Common in the area
4.	*Asplenium yoshinagae ssp. austroindicum* Fraser-Jenk.	Aspleniaceae	Occasional in the area
5.	*Anisocampium cumingianum* C. Presl	Athyriaceae	Occasional in the area
6.	*Athyrium hohenackerianum* (Kunze) Moore	Athyriaceae	Common in the area
7.	*Diplazium esculentum* (Retz.) Sw.	Athyriaceae	Common in the area
8.	*Blechnopsis orientalis* (L.) C. Presl	Blechnaceae	Common in the area
9.	*Blechnum appendiculatum* Willd.	Blechnaceae	Common in the area
10.	*Stenochlaena palustris* (Burm. fil.) Bedd.	Blechnaceae	Common in the area
11.	*Alsophila nilgirensis* (Holttum) R. M. Tryon	Cyatheaceae	WG Endemic; Occasional in the area
12.	*Davallodes pulchra* (D.Don) M.Kato & Tsutsumi	Davalliaceae	Occasional in the area
13.	*Hypolepis resistens* (Kunze) Hook.	Dennstaedtiaceae	Common in the area
14.	*Microlepia speluncae* (L.) Moore	Dennstaedtiaceae	Common in the area
15.	*Pteridium aquilinum* ssp. *wightianum* (Wall. ex J. Agardh) W. C. Shieh	Dennstaedtiaceae	Common in the area
16.	*Arachniodes sledgei* Fraser-Jenk.	Dryopteridaceae	Occasional in the area
17.	*Bolbitis appendiculata* (Willd.) K. Iwats.	Dryopteridaceae	Common in the area
18.	*Dryopteris cochleata* (D. Don) C. Chr.	Dryopteridaceae	Occasional in the area
19.	*Dryopteris hirtipes* (Blume) Kuntze	Dryopteridaceae	Occasional in the area
20.	*Elaphoglossum beddomei* Sledge	Dryopteridaceae	WG Endemic
21.	*Elaphoglossum nilgiricum* Krajina ex Sledge	Dryopteridaceae	WG Endemic; Rare in the area
22.	*Dicranopteris linearis* (Burm. fil.) Underw.	Gleicheniaceae	Occasional in the area

23.	*Crepidomanes campanulatum* (Roxb.) Panigrahi & Sarn. Singh	Hymenophyllaceae	Rare in the area
24.	*Hymenophyllum exsertum* Wall. ex Hook.	Hymenophyllaceae	Rare in the area
25.	*Leucostegia immersa* C.Presl	Hypodematiaceae	Rare in the area
26.	*Lindsaea ensifolia* Sw.	Lindsaeaceae	Occasional in the area
27.	*Palhinhaea cernua* (L.) Vasc. & Franco	Lycopodiaceae	Occasional in the area
28.	*Phlegmariurus phlegmaria* (L.) Holub	Lycopodiaceae	Rare in the area
29.	*Lygodium flexuosum* (L.) Sw.	Lygodiaceae	Common in the area
30.	*Angiopteris helferiana* C. Presl	Marattiaceae	Occasional in the area
31.	*Nephrolepis cordifolia* (L.) C.Presl	Nephrolepidaceae	Common in the area
32.	*Osmunda acuta* (Burm.f.) Fraser-Jenk.	Osmundaceae	Rare in the area
33.	*Drynaria quercifolia* (L.) J.Sm.	Polypodiaceae	Occasional in the area
34.	*Lepisorus nudus* (Hook.) Ching	Polypodiaceae	Common in the area
35.	*Microsorum punctatum* (L.) Copel.	Polypodiaceae	Common in the area
36.	*Pyrrosia porosa* (C. Presl) Hovenkamp	Polypodiaceae	Common in the area
37.	*Selliguea hastata* (Thunb.) Fraser-Jenk. *subsp. montana* (Sledge) Fraser-Jenk. & Ranil	Polypodiaceae	Rare in the area
38.	*Adiantum concinnum* Humb. & Bonpl. ex Willd.	Pteridaceae	Common in the area
39.	*Adiantum philippense* L.	Pteridaceae	Common in the area
40.	*Adiantum raddianum* C.Pres	Pteridaceae	Common in the area
41.	*Antrophyum plantagineum* (Cav.) Kaulf.	Pteridaceae	Rare in the area
42.	*Ceratopteris thalictroides ssp. thalictroides* (L.) Brongn.	Pteridaceae	Common in the area
43.	*Cheilanthes tenuifolia* (Burm. fil.) Sw.	Pteridaceae	Common in the area
44.	*Haplopteris elongata* (Sw.) E.H.Crane	Pteridaceae	Occasional in the area
45.	*Mickelopteris cordata* (Hook. & Grev.) Fraser-Jenk.	Pteridaceae	Occasional in the area
46.	*Pteris argyraea* Moore	Pteridaceae	Common in the area
47.	*Pteris arisanensis* Tagawa	Pteridaceae	Common in the area
48.	*Pteris pellucida* C.Presl	Pteridaceae	Common in the area

49.	*Pteris vittata ssp.* vittata L.	Pteridaceae	Common in the area
50.	*Selaginella delicatula* (Desv. ex Poir.) Alston	Selaginellaceae	Common in the area
51.	*Selaginella involvens* (Sw.) Spring	Selaginellaceae	Common in the area
52.	*Selaginella tenera* (Hook. & Grev.) Spring	Selaginellaceae	Common in the area
53.	*Tectaria coadunata* (Wall. ex Hook. & Grev.) C. Chr.	Tectariaceae	Common in the area
54.	*Tectaria wightii* (C. B. Clarke) Ching	Tectariaceae	Common in the area
55.	*Christella dentata* (Forsk.) Brownsey & Jermy	Thelypteridaceae	Common in the area
56.	*Christella meeboldii* (Rosenst.) Holttum	Thelypteridaceae	Common in the area
57.	*Christella parasitica* (L.) Lév.	Thelypteridaceae	Common in the area
58.	*Pseudocyclosorus ochthodes* (Kunze) Holttum	Thelypteridaceae	Occasional in the area

Bryophytes

Bryophytes are the second largest group of land plants after angiosperms. However, studies on bryophytes are very less compared to other groups of plants. Many botanists, teachers and students are reluctant to study the plants under this group in detail mostly because of the low direct economic importance and the difficulty in identification. These constraints made the bryophytes a tough to learn subject for most of the people. Recently, the studies on bryophytes have acquired pace in India in tune with other parts of the world. Hence the survey in the Western Ghats, especially in Kerala State has increased resulting in addition of several new taxa and new records of phytogeographical significance (Gangulee, 1969-1980; Manju and Rajesh, 2017; Daniels *et al.*, 2018; Daniels and Kariyappa 2019; Daniels and Raja, 2020; Mufeed *et al*., 2021; Manjula *et al.*, 2022). Due to lack of field studies, the assessment of this group as per the IUCN guidelines have not been attempted in India.

Observations made in the Anakkampoyil and Meppadi areas, the impact zone of the proposed tunnel road, are included in this report. The team of experts with Dr. Manju C. Nair and Dr. B. Mufeed covered the study area by walking through the entire stretch of different habitats. Stress was given to the patches near the tunnel mouth locations and nearby areas. The survey was conducted in June-July 2023. Data from previous records (Aswathy, 2019) were also used. The status of the species in the area was assessed based on the frequency of observation during the survey. The bryophytes observed in the area are given in Table-4.23 along with the status of the species in the area and also remarks on locations of occurrence.

Table-4.23: List of Bryophytes observed in the Anakkampoyil-Meppadi areas

Family	Sl. No.	Name of species	Status of occurrence in the area	Remarks
Liverworts				
Dumortieraceae	1.	*Dumortiera hirsuta* (Sw.) Nees	Rare	Common species in high altitude shola and evergreen
Calyculariaceae	2.	*Calycularia crispula* Mitt.	Rare	
Lejeuneaceae	3.	*Caudalejeunea reniloba* (Gottsche) Scheph.	Rare	
	4.	*Cololejeunea spinosa* (Horik.) Pandé & R.N. Misra	Very common	Species found near Tunnel entry
	5.	*Cololejeunea lanciloba* Steph.	Common	Species found near Tunnel entry
	6.	*Cololejeunea hasskarliana* (Lehm.) Schiffn.	Common	
	7.	*Chelolejeunea birmensis* (Steph.) Mizut.	Common	
	8.	*Cheilolejeunea serpentina* (Mitt.) Mizut.	Common	Species found near Tunnel entry
	9.	*Lopholejeunea indica* Udar & U.S. Aswathi	Common	
	10.	*Lopholejeunea abortiva* (Mitt.) Steph.	Common	Species found near Tunnel entry
	11.	*Lejeunea subfusca* (Neese) Schiffn.	Common	
	12.	*Lejeunea exilis* (Reinw., Blume & Nees) Grolle	Common	
	13.	*Lejeunea pallide-virens* S. Hatt.	Common	
	14.	*Microlejeunea ulicina* (Taylor) Steph.	Common	
Jubulaceae	15.	*Frullania nepalensis* (Spreng.) Lehm. & Lindenb.	Common	
	16.	*Frullania wallichiana* Mitt.	Rare	
Plagiochilaceae	17.	*Plagiochila sciophila* Nees ex Lindenb.	Common	
	18.	*Plagiochila wightii* Nees ex Lindenb.	Very rare	This species has been reported from India long back around 1840 from Karnataka. So, the

				present collection of the species is after 180 years.
Cephaloziaceae	19.	*Cephalozia darjeelingensis* Udar & D. Kumar	Common	
Porellaceae	20.	*Porella campylophylla subsp. tosana* (Steph.) S. Hatt.	Rare	
Mosses				
Dicranaceae	21.	*Campylopus pilifer* Brid.	Common	Common in the high-altitude grass land
Bryaceae	22.	*Bryum argenteum* Müll. Hal.	Common	Species found near Tunnel entry
	23.	*Rosulabryum wightii* (Mitt.) J.R. Spence	Common	Species found near Tunnel entry. Found only in high altitude evergreen and shola forests
	24.	*Rosulabryum billarderii* (Schwägr.) J.R. Spence	Rare	found only in high altitude evergreen and shola forests
	25.	*Rhodobryum giganteum* (Schwägr.) Paris	Common	Found only in high altitude shola forest
Polytrichaceae	26.	*Pogonatum neesii* (Müll. Hal.) Dozy	Common	Common in medium and high-altitude areas
	27.	*Atrichum subserratum* (Harv. & Hook. f.) Mitt.	Rare	
Racopilaceae	28.	*Racopilum orthocarpum* Wilson ex Mitt.	Common	
Daltoniaceae	29.	*Actinodontium rhaphidostegum* (Müll. Hal.) Bosch & Sande Lac.	Rare	Species found near Tunnel entry
Calymperaceae	30.	*Calymperes afzelii* Sw.	Very common	Found in low and high-altitude areas
	31.	*Calymperes lonchophyllum* Schwägr.	Rare	
	32.	*Syrrhopodon spiculosus* Hook. & Grev.	Common	
	33.	*Octoblepharum albidum* Hedw.	Very common	Very common species in the low and high-altitude areas.
Pottiaceae	34.	*Trichostomum tortelloides* (Broth. & Dixon) R.H. Zander	Rare	
	35.	*Hyophila involuta* (Hook.) A. Jaeger	Very common	Species found near Tunnel entry. Common in species in the low altitude areas, rare in high altitude areas.

Bartramiaceae	36.	*Philonotis falcata* (Hook.) Mitt.	Common	Species found near Tunnel entry
	37.	*Philonotis mollis* (Dozy & Molk.) Mitt.	Common	
Stereophyllaceae	38.	*Entodontopsis anceps* (Bosch & Sande Lac.) W.R. Buck & Ireland	Common	Species found near Tunnel entry
Leucobryaceae	39.	*Leucoloma taylorii (Schwägr.)* Mitt.	Common	Species found in shola area
Pterobryaceae	40.	*Pterobryopsis orientalis* (Müll. Hal.) M. Fleisch.	Common	
	41.	*Pterobryopsis acuminata* (Hook.) M. Fleisch.	Common	
	42.	*Calyptothecium wightii* (Mitt.) M. Fleisch.	Common	
	43.	*Penzigiella cordata* (Hook.) Fleisch	Rare	Earlier collected only from Silent Valley NP
Entodontaceae	44.	*Erythrodontium julaceum* (Schwägr.) Paris	Common	
Cryphaeaceae	45.	*Schoenobryum concavifolium* (Griff.) Gangulee	Very common	
Fissidentaceae	46.	*Fissidens anomalus* Mont.	Rare	Typical of shola species
	47.	*Fissidens bryoides* Hedw.	Very common	
	48.	*Fissidens crispulus* Brid.	Very common	Species found near Tunnel entry
	49.	*Fissidens pallidinervis* Mitt.	Rare	
	50.	*Fissidens ceylonensis* Dozy & Molk.	Very common	
Meteoriaceae	51.	*Cryptopapillaria fuscescens* (Hook) M. Menzel	Common	
	52.	*Meteoriopsis ancistrodes* (Renauld & Cardot) Broth.	Very common	Species found near Tunnel entry
	53.	*Floribundaria floribunda* (Dozy & Molk.) M. Fleisch.	Very common	
	54.	*Floribundaria walkerii* (Renauld & Cardot) Broth.	Very common	
Macromitriaceae	55.	*Macromitrium sulcatum* (Hook.) Brid.	Very common	Species found near Tunnel entry
Thuidiaceae	56.	*Haplocladium microphyllum*	Rare	

	57.	*Thuidium assimile* (Mitt.) A.Jaeger	Rare	
Neckeraceae	58.	*Himantocladium plumula* (Nees) M. Fleisch.	Very common	
	59.	*Pinnatella* sp.		Need further investigation for confirming the species
	60.	*Pinnatella calcutensis* M. Fleisch.	Common	
Hypopterygiaceae	61.	*Hypopterygium tamarisci* (Sw.) Brid. ex Müll. Hal.	Very common	
Trachypodaceae	62.	*Trachypodopsis serrulata* (P. Beauv.) M. Fleisch.	Very common	
Brachytheciaceae	63.	*Brachythecium formosanum* Takaki	Common	
Sematophyllaceae	64.	*Aptychella tenuiramea* (Mitt.) Tixier	Rare	
Hypnaceae	65.	*Taxiphyllum maniae* (Renauld & Paris) M. Fleisch.	Common	
	66.	*Bryocrumia malabarica* Manju *et. al.*	Rare	Endemic to Kerala, (Manju et al. 2021 described this species from Malabar WLS)

The present observations record occurrence of 66 species of bryophytes under 30 families (Table-4.23). Among these, 20 are liverworts and 46 are mosses. The area holds a good number of species and among the 30 families, Lejeuneaceae are the most represented one with 12 species followed by Fissidentaceae with five species. *Bryocrumia malabarica* Manju *et al*. endemic to Kerala reported during 2021 from Malabar Wildlife Sanctuary could be observed in the Meppadi area. Occurrence of many species together as a mix on the habitat is common in this area. It was interesting to note that some small twigs of about 50 cm long may hold more than 7 species. The species found near tunnel mouth are *Actinodontium rhaphidostegum* (Müll. Hal.) Bosch & Sande Lac., *Bryum argenteum* Müll. Hal., *Cololejeunea spinosa* (Horik.) Pandé & R.N. Misra, *Cololejeunea lanciloba* Steph., *Cheilolejeunea serpentina* (Mitt.) Mizut, *Entodontopsis anceps* (Bosch & Sande Lac.) W.R. Buck & Ireland, *Hyophila involuta* (Hook.) A. Jaeger, *Fissidens crispulus* Brid., *Lopholejeunea abortiva* (Mitt.) Steph., *Meteoriopsis ancistrodes* (Renauld & Cardot) Broth., *Rosulabryum wightii* (Mitt.) J.R. Spence, *Philonotis falcata* (Hook.) Mitt. and *Macromitrium sulcatum* (Hook.) Brid. Except for *Actinodontium rhaphidostegum*, all the species recorded from the tunnel mouth location are common or very common. *Actinodontium rhaphidostegum* is rare in the area.

4.8.5. Fauna/Wildlife

Assessment of faunal composition [dj9]including the Mammals, Birds, Reptiles, Amphibians and the Butterflies, Odonates and Grass hoppers was carried out through random sampling in the project environment. Transect method of sampling was adopted for assessment of the species under each group. The details of methods followed for each group of animals are given under description of the respective group.

Mammals

The presence/absence of mammals were assessed by direct sighting and indirect evidences such as foot print, pugmarks, burrows, skeleton, faecal materials, hairs, horn, etc. and also by the presence of dens and caves. Since most mammals are secretive or nocturnal, they are seldom seen by a casual observer. But their presence is often revealed by tracks, burrows, nests, evidence of feeding and its residues, foot prints, tail markings, faecal material or scats. In addition to the field survey, consultation with the local people was also made. The indirect sighting of fauna was photographed and identified using field guides.

Though it was planned to make a quantitative assessment of the elephants in the area using dung count method, it was not successful due to the heavy rains. A survey during the rains would have resulted in a highly biased estimate since the elephant dung would have been washed away especially because of the hilly terrain of the area. Hence, the attempt for quantitative abundance distribution estimation was abandoned. However, evidences of elephants in different habitats were visible in most of the areas. In addition, the knowledge of the Forest field staff and the public was helpful in preparing a list of mammalian species and also making a qualitative assessment of its abundance in the area, which is mentioned under the Remarks column (Table-4.24).

Table-4.24: List of mammals (excluding bats) reported from the proposed Anakkampoyil-Meppadi tunnel project area and surroundings

Sl. No.	Common name	Scientific name	IUCN status	WPA Schedule	Remarks
1.	Bonnet Macaque	*Macaca radiata*	Vulnerable	Schedule I	Common; mostly outside the forest areas
2.	Nilgiri Langur	*Semnopithecus johnii*	Vulnerable	Schedule I	Rare; seen in the shola near Aaranamala
3.	Asiatic Wild dog	*Cuon alpinus*	Endangered	Schedule I	Rare

4.	Jungle cat	*Felis chaus*	Least Concern	Schedule I	Rare
5.	Leopard	*Panthera pardus*	Vulnerable	Schedule I	Rare
6.	Tiger	*Panthera tigris*	Endangered	Schedule I	Rare
7.	Sloth Bear	*Melursus ursinus*	Vulnerable	Schedule I	Rare
8.	Asian Palm Civet	*Paradoxurus hermaphroditus*	Least Concern	Schedule I	Common
9.	Small Indian Civet	*Viverricula indica*	Least Concern	Schedule I	Common
10.	Indian chevrotain	*Moschiola indica*	Data Deficient	Schedule I	Rare
11.	Sambar deer	*Rusa unicolor*	Vulnerable	Schedule I	Common
12.	Malabar Red Muntjak	*Muntiacus Muntjak malabaricus*	Not assessed	Schedule I	Rare
13.	Asian Elephant	*Elephas maximus*	Endangered	Schedule I	Common
14.	Grey Mongoose	*Urva edwardsii*	Least Concern	Schedule I	Common
15.	Malabar Giant Squirrel	*Ratufa indica*	Least Concern	Schedule I	Rare; seen in the shola near Aaranamala
16.	Indian Pangolin	*Manis crassicaudata*	Endangered	Schedule I	Rare
17.	Wild Pig	*Sus scrofa*	Least Concern	Schedule II Part A	Common
18.	Indian Porcupine	*Hystrix indica*	Least Concern	Schedule I	Rare
19.	Travancore Flying Squirrel	*Petinomys fuscocapillus*	Data Deficient	Schedule I	Rare

Of the 19 species of mammals recorded from the area, four are ‘Endangered’, five species are ‘Vulnerable’ as per IUCN Red List of Threatened Species; seven species figure in the ‘Least Concern’ category. The species are also categorised as per WPA (Wildlife Protection Act) Schedule (Table-08).

Bats: are considered to be the second largest group of mammals followed by rodents. Around 22% of the mammal group is contributed by bats (Boyles *et al*., 2008). Even though bats play a key role in maintaining ecological services and economic benefits, they were marginalised on the negative side. Habitat loss, deforestation, changes in climatic conditions, and other anthropogenic threats including hunting for bushmeat, and killing bats out of fear are declining their population globally (Frick *et al.*, 2020). Also, because of their elusive and nocturnal behaviour, they still remain as one of the less studied groups in the tropics. It is important to understand their population dynamics globally for better conservation management. Shri Nithin Divakar, a Researcher on bats and of Aranyakam Nature Foundation compiled the information/observations on this rare groups of mammals.

Three locations along the proposed tunnel road alignment were considered for the bat sampling based on the elevation and habitat. A combination of sampling techniques which includes mist netting, harp netting and acoustic samplings were carried out to understand the diversity and perceived abundance of bats species in the area. Two transects of 1.0 km length were established in each location and sampled for at least two consecutive nights. Additionally, opportunistic acoustic samplings were counted as part of the study. Samplings were conducted during the night and early morning time (18:00 - 22:00 and 05:00 - 06:30) and roost searches were carried out in the daytime.

A five-shelved mist net of 1 X 2 mm mesh size, a customized harp net of 2 X 2 m frame size, an active android bat recorder along with a Redmi Note 11 phone and a passive acoustic recorder (SM4 Bat) were used for sampling the bats. Captured individuals were identified with the help of available literature (Bates and Harrison, 1997; Raman *et al.*, 2020) and recorded calls were referred to the bat acoustic key from Raman *et al*. (2020). Also, a thorough literature survey was conducted for the studies from these areas (Paul, 2017; Raman *et al*., 2020). Identified literature and unpublished observational records were also used to compile the species list.

Indian Fruit Bat

Leschenault's Rousette

Rufous Horseshoe Bat **Greater Short-nosed Fruit Bat**

The present survey, carried out in the proposed tunnel-road alignment and surroundings recorded a total of 11 bat species (Table-4.25). In addition to this, through the detailed literature review and observations from an ongoing study that is being carried out since the last two years, a checklist was compiled which includes a total of 20 bat species belonging to seven families and 14 genera. Of these, *Hipposideros pomona* is Endangered, *Rousettus leschenaultii* is Near Threatened, *Rhinolophus indorouxii* and *Myotis peytoni* are Data Deficient and all others fall under Least Concerned according to IUCN. Out of the 20, only one species (Indian Flying Fox) is protected under Schedule II of the Indian Wildlife Protection Act (1972). The highest number of species were recorded from the families Vespertilionidae (7) followed by Pteropodidae (4) and Rhinolophidae (4).

Table-4.25: List of bats observed/reported from the proposed project area and surroundings

Sl. No.	Common name	Scientific name	IUCN Status	WPA Schedule	Perceived Abundance
	I. Family Pteropodidae				
1.	Lesser Short-nosed Fruit Bat	*Cynopterus brachyotis* (Gray, 1871)	Least Concern		Rare
2.	Greater Short-nosed Fruit Bat	*Cynopterus sphinx* (Vahl, 1797)	Least Concern		Very common
3.	Indian Flying Fox	*Pteropus medius* (Temminck, 1825)	Least Concern	Schedule II	Common
4.	Leschenault's Rousette	*Rousettus leschenaultia*	Near Threatened		Occasional
	II. Family Rhinolophidae				
5.	Beddome's Horseshoe Bat	*Rhinolophus beddomei* K. Andersen, 1905	Least Concern		Common
6.	Blyth's Horseshoe Bat	*Rhinolophus lepidus* Blyth, 1844	Least Concern		Common
7.	Greater Rufous Horseshoe Bat	*Rhinolophus indorouxii* Chattopadhya *et al*., 2012	Data Deficient		Very common
8.	Rufous Horseshoe Bat	*Rhinolophus rouxii* Temminck, 1835	Least Concern		Very common

	III. Family Hipposideridae				
9.	Pomona Leaf-nosed Bat	*Hipposideros pomona* K. Andersen, 1918	Endangered		Common
10.	Schneider's Leaf-nosed Bat	*Hipposideros speoris* (Schneider, 1800)	Least Concern		Common
	IV. Family Emballonuridae				
11.	Black-bearded Tomb Bat	*Taphozous melanopogon* Temminck, 1841	Least Concern		Rare
	V. Family Megadermatidae				
12.	Lesser False Vampire Bat	*Megaderma spasma* (Linnaeus, 1758)	Least Concern		Very common
	VI. Family Miniopteridae				
13.	Small Long-fingered Bat	*Miniopterus pusillus* Dobson, 1876	LC		Very rare
	VII. Family Vespertilionidae				
14.	Lesser Hairy-winged Bat	*Harpiocephalus harpia* (Temminck 1840)	LC		Rare
15.	Hardwicke's Woolly Bat	*Kerivoula hardwickii* (Horsfield, 1824)	LC		Very rare
16.	Painted Woolly Bat	*Kerivoula picta* (Pallas, 1767)	NT		Occasional
17.	Peyton's Whiskered Myotis	*Myotis peytoni* Wroughton & Ryley, 1913	DD		Occasional
18.	Kelaart's Pipistrelle	*Pipistrellus ceylonicus* (Kelaart, 1852)	LC		Common
19.	Greater Asiatic Yellow House Bat	*Scotophilus heathii* (Horsfield, 1831)	LC		Rare
20.	Lesser Bamboo Bat	*Tylonycteris pachypus* (Temminck, 1840)	LC		Very rare

NB: The species 1-8, 11-12 and 18 were recorded during the present survey; others are from previous studies (Raman *et al*. 2020; Bibin 2017) carried out in this region.

Birds

The presence of birds in almost all kinds of habitat and their conspicuous nature make studies on avian taxa comparatively easier (Goodale *et al.*, 2014). Effects of loss or degradation of natural habitats on biodiversity can be most effectively understood by studying birds of the region, owing to their vulnerability to anthropogenic changes. And hence, birds are reasonably considered as one of the best ecological indicators of habitat change and biodiversity loss (Morrison, 1986; Watson *et al*., 2005). The birds play crucial roles in diverse ecosystem services like pollination, pest-control, seed dispersal, and prey-predator roles in the food chain (Sekercioglu *et al*., 2004; Wang *et al*., 2022). Abundance and richness of insects and every other vertebrate taxon including reptiles, amphibians, and fish are co-dependent on the presence of birds, and consequently represents the overall health of an ecosystem. Apart from the numerous ecological services they provide, birds are considered to have immense aesthetic values which in turn would improve ecotourism-related benefits, and the hobby of birdwatching is generally considered to improve one's mental health (Murawiec *et al.*, 2021; Tryjanowski *et al.*, 2022).

Most studies from all over the world show a very clear decline in bird species richness/ abundance in degraded or fragmented habitats (Ohno and Ishida, 1997; Patten *et al*., 2010; Sidhu *et al*., 2010). There are some exceptions in the case of human-modified landscapes like plantations where richness or abundance of birds remain unchanged or are sometimes higher than in natural habitats (Harvey and Villalobos, 2007). But to evaluate the impact of large-scale human activities like mining, constructions of roads and tunnels, etc., it is important to study the bird population in such areas to get an idea of the diversity of birds these areas support and the extent such activities would degrade the habitat quality and diversity in general. Moreover, it is the range-restricted and threatened species which will be the most vulnerable to threats from such activities.

With this background information, the proposed project site and surroundings were covered for information on birds. The study was led by Ms. C. Karthika (a Bird Researcher and Member of Aranyakam Nature Foundation) with observational input from Shri Dhruv Raj and Nithin Divakar. The proposed tunnel road (8 km) was divided into 7 transects (2 km each) in different survey locations, starting from Anakkampoyil (tunnel entry point) in Kozhikode to Meenakshikunnu (tunnel exit point) in Wayanad. Point count method was used for surveying birds along these transects. The transects (2 km) were walked and birds observed at every 200 m point marked along the transect which totals up to 10 point counts in a location. These point counts were done both in the morning (6:30 to 10:00 am) and evening (3:00 to 6:00 pm) hours. At each point, birds were observed for 15 minutes for recording birds that were seen or heard, and the number of individuals (Sutherland, 2006). Vanguard 10 x 42 binoculars and Nikon P900 camera were used for observing birds. Species identification was done with the help of field guide (Grimmet *et al.*, 2013). Data analysis was done using PAST software (version 4.12).

The survey conducted in the proposed Anakkampoyil-Meppadi tunnel road alignment and surroundings resulted in the observation of 97 species. Additionally, a checklist has been compiled of bird species recorded as part of a study that had been conducted in these areas in the past three years by Ms. Karthika. The compiled checklist reports 185 bird species belonging to 54 Families of 16 Orders (Table-4.25). Of these, five species are under threatened categories as per the IUCN Red List; Nilgiri Wood Pigeon, Great Hornbill and Broad-tailed Grassbird are Vulnerable (VU), and Banasura Chilappan and Nilgiri Sholakili are Endangered (EN). Fourteen species are endemic to Western Ghats. Twenty-nine species are under Schedule I and 155 species under Schedule II of Wildlife (Protection) Act, 1972. Highest number of species representations were from families Muscicapidae (17), Accipitridae (14), Picidae (11) and Columbidae (8).

Table-4.25: List of birds recorded from Anakkampoyil-Meppadi area

Sl. No.	Name of species	IUCN* Status	WPA** Schedule	Endemism	Present survey	Status in the study area
	Order: Galliformes					
	Family: Phasianidae					
1.	Indian Peafowl *Pavo cristatus*	Least Concern	Sch. I			Rare
2.	Red Spurfowl *Galloperdix spadicea*	Least Concern	Sch. II		✓	Rare
3.	Grey Jungle Fowl *Gallus sonneratii*	Least Concern	Sch. I		✓	Common
	Order: Columbiformes					
	Family: Columbidae					
4.	Nilgiri Wood Pigeon *Columba elphinstonii*	Vulnerable	Sch. I	Western Ghats		Rare
5.	Spotted Dove *Streptopelia chinensis*	Least Concern	Sch. II		✓	Common
6.	Asian Emerald Dove *Chalcophaps indica*	Least Concern	Sch. II		✓	Common
7.	Grey-fronted Green Pigeon *Treron affinis*	Least Concern	Sch. II		✓	Common
8.	Green Imperial Pigeon *Ducula aenea*	Least Concern	Sch. II			Rare
9.	Mountain Imperial	Least	Sch. II			Rare

	Pigeon *Ducula badia*	Concern				
10.	Malabar Imperial Pigeon *Ducula cuprea*	Least Concern	Sch II	Western Ghats	✓	Rare
11.	Yellow-footed Green Pigeon *Treron Phoenicopterus*	Least Concern	Sch. II			Very rare
	Order: Caprimulgiformes					
	Family: Apodidae					
12.	Asian Palm Swift Cypsiurus *balasiensis*	Least Concern	Sch. II			Rare
13.	Crested Treeswift *Hemiprocne coronate*	Least Concern	Sch. I			Rare
14.	Indian House Swift *Apus affinis*	Least Concern	Sch. II			Common
15.	Alpine Swift *Tachymarptis melba*	Least Concern	Sch. II			Common
16.	Indian Swiftlet *Aerodramus unicolor*	Least Concern	Sch. I			Common
17.	Brown-backed Needletail *Hirundapus giganteus*	Least Concern	Sch. II			Rare
18.	White-rumped Spinetail *Zoonavena sylvatica*	Least Concern	Sch. II			Common
	Order: Cuculiformes					
	Family: Cuculidae					
19.	Greater Coucal *Centropus sinensis*	Least Concern	Sch. II		✓	Common
20.	Asian Koel *Eudynamys scolopaceus*	Least Concern	Sch. II			Common
21.	Banded Bay Cuckoo *Cacomantis sonneratii*	Least Concern	Sch. II			Common
22.	Fork-tailed Drongo Cuckoo *Surniculus dicruroides*	Least Concern	Sch. II			Common
23.	Common Hawk Cuckoo *Hierococcyx varius*	Least Concern	Sch. II		✓	Common
24.	Grey-bellied Cuckoo *Cacomantis passerines*	Least Concern	Sch. II			Rare
	Order: Gruiformes					
	Family: Rallidae					
25.	White-breasted Waterhen *Amaurornis*	Least Concern	Sch. II			Common

	phoenicurus					
	Order: Charadriiformes					
	Family: Charadriidae					
26.	Red-wattled Lapwing *Vanellus indicus*	Least Concern	Sch. II			Very common
	Order: Pelecaniformes					
	Family: Ciconiidae					
27.	Asian Openbill *Anastomus oscitans*	Least Concern	Sch. II			Common
	Family: Ardeidae					
28.	Black-crowned Night Heron *Nycticorax nycticorax*	Least Concern	Sch. II			Rare
29.	Cattle Egret *Bubulcus ibis*	Least Concern	Sch. II			Very common
30.	Intermediate Egret *Ardea intermedia*	Least Concern	Sch. II			Common
31.	Indian Pond Heron *Ardeola grayii*	Least Concern	Sch. II		✓	Very common
	Family: Phalacrocoracidae					
32.	Little Cormorant *Microcarbo niger*	Least Concern	Sch. II		✓	Common
	Order: Accipitriformes					
	Family: Accipitridae					
33.	Oriental Honey Buzzard *Pernis ptilorhynchus*	Least Concern	Sch. II			Rare
34.	Common Buzzard *Buteo buteo*	Least Concern	Sch. I			
35.	Jerdon's Baza *Aviceda jerdoni*	Least Concern	Sch. I			Vert rare
36.	Crested Serpent Eagle *Spilornis cheela*	Least Concern	Sch. I		✓	Very common
37.	Crested Hawk Eagle *Nisaetus cirrhatus*	Least Concern	Sch. I		✓	Rare
38.	Rufous-bellied Eagle *Lophotriorchis kienerii*	Least Concern	Sch. I		✓	Rare
39.	Black Eagle *Ictinaetus malaiensis*	Least Concern	Sch. I		✓	Common
40.	Booted Eagle *Hieraaetus pennatus*	Least Concern	Sch. I		✓	Common
41.	Bonelli's Eagle *Aquila fasciata*	Least Concern	Sch. I			Very rare
42.	Crested Goshawk *Accipiter trivirgatus*	Least Concern	Sch. I		✓	Rare
43.	Shikra *Accipiter badius*	Least Concern	Sch. I		✓	Common

44.	Black-winged Kite *Elanus caeruleus*	Least Concern	Sch. II			Common
45.	Brahminy Kite *Haliastur indus*	Least Concern	Sch. I		✓	Common
	Order: Strigiformes					
	Family: Strigidae					
46.	Brown Fish Owl *Ketupa zeylonensis*	Least Concern	Sch. I		✓	Very common
47.	Mottled Wood Owl *Strix ocellata*	Least Concern	Sch. I			Rare
48.	Spot-bellied Eagle Owl *Bubo nipalensis*	Least Concern	Sch. I			Rare
49.	Indian Scops Owl *Otus bakkamoena*	Least Concern	Sch. II			Common
50.	Jungle Owlet *Glaucidium radiatum*	Least Concern	Sch. II			Common
	Order: Falconiformes					
	Family: Falconidae					
51.	Common Kestrel *Falco tinnunculus*	Least Concern	Sch. II			Rare
	Order: Trogoniformes					
	Family: Trogonidae					
52.	Malabar Trogon *Harpactes fasciatus*	Least Concern	Sch. II		✓	Common
	Order: Bucerotiformes					
	Family: Upupidae					
53.	Common Hoopoe *Upupa epops*	Least Concern	Sch. II			Common
	Family: Bucerotidae					
54.	Great Hornbill *Buceros bicornis*	Vulnerable	Sch. I			Very rare
55.	Malabar Grey Hornbill *Ocyceros griseus*	Least Concern	Sch. I	Western Ghats	✓	Very common
	Order: Coraciiformes					
	Family: Alcedinidae					
56.	Common Kingfisher *Alcedo atthis*	Least Concern	Sch. II			Common
57.	White-throated Kingfisher *Halcyon smyrnensis*	Least Concern	Sch. II		✓	Very common
	Family: Meropidae					
58.	Blue-bearded Bee-eater *Nyctyornis athertoni*	Least Concern	Sch. II			Rare
59.	Green Bee-eater *Merops orientalis*	Least Concern	Sch. II		✓	Very common
60.	Blue-tailed Bee-eater	Least	Sch. II			Common

	Merops philippinus	Concern				
61.	Chestnut-headed Bee-eater *Merops leschenaultia*	Least Concern	Sch. II		✓	Very common
	Family: Coraciidae					
62.	Indian Roller *Coracias benghalensis*	Least Concern	Sch. II			Common
63.	Oriental Dollarbird *Eurystomus orientalis*	Least Concern	Sch. II			
	Order: Piciformes					
	Family: Megalaimidae					
64.	Malabar Barbet *Psilopogon malabaricus*	Least Concern	Sch. II	Western Ghats	✓	Very common
65.	White-cheeked Barbet *Psilopogon viridis*	Least Concern	Sch. II		✓	Very common
	Family: Picidae					
66.	Speckled Piculet *Picumnus innominatus*	LC	Sch. II		✓	Rare
67.	Heart-spotted Woodpecker *Hemircircus canente*	Least Concern	Sch. I		✓	Common
68.	Brown-capped Pygmy Woodpecker *Yungipicus nanus*	Least Concern	Sch. II			Common
69.	Yellow-crowned Woodpecker *Leiopicus mahrattensis*	Least Concern	Sch. I			Rare
70.	Greater Golden-backed Woodpecker *Chrysocolaptes guttacristatus*	Least Concern	Sch. II		✓	Very common
71.	Rufous Woodpecker *Micropternus brachyurus*	Least Concern	Sch. II			Very common
72.	Common Golden-backed Woodpecker *Dinopium javanense*	Least Concern	Sch. II			Rare
73.	Lesser Golden-backed Woodpecker *Dinopium benghalense*	Least Concern	Sch. II		✓	Very common
74.	Lesser Yellow-naped Woodpecker *Picus chlorolophus*	Least Concern	Sch. II			Common
75.	Streak-throated Woodpecker *Picus xanthopygaeus*	Least Concern	Sch. II			Very common
76.	White-bellied	Least	Sch. II			Rare

	Woodpecker *Dryocopus javensis*	Concern				
	Order: Psittaciformes					
	Family: Psittaculidae					
77.	Rose-ringed Parakeet *Psittacula krameria*	Least Concern	Sch. II			Rare
78.	Plum-headed Parakeet *Psittacula cyanocephala*	Least Concern	Sch. II		✓	Common
79.	Malabar Parakeet *Psittacula columboides*	Least Concern	Sch. II	Western Ghats	✓	Very common
80.	Vernal Hanging Parrot *Loriculus vernalis*	Least Concern	Sch. II		✓	Very common
	Order: Passeriformes					
	Family: Pittidae					
81.	Indian Pitta *Pitta brachyura*	Least Concern	Sch. II		✓	Rare
	Family: Campephagidae					
82.	Small Minivet *Pericrocotus cinnamomeus*	Least Concern	Sch. I			Common
83.	Orange Minivet *Pericrocotus flammeus*	Least Concern	Sch. II		✓	Very common
84.	Ashy Minivet *Pericrocotus divaricatus*	Least Concern	Sch. II			Common
85.	Large Cuckooshrike *Coracina javensis*	Least Concern	Sch. II			Common
86.	Black-headed Cuckooshrike *Lalage melanoptera*	Least Concern	Sch. II			Common
	Family: Oriolidae					
87.	Indian Golden Oriole *Oriolus kundoo*	Least Concern	Sch. II		✓	Common
88.	Black-naped Oriole *Oriolus chinensis*	Least Concern	Sch. II		✓	Common
89.	Black-hooded Oriole *Oriolus xanthornus*	Least Concern	Sch. II			Common
	Family: Artamidae					
90.	Ashy Woodswallow *Artamus fuscus*	Least Concern	Sch. II		✓	Very common
	Family: Vangidae					
91.	Malabar Woodshrike *Tephrodornis sylvicola*	Least Concern	Sch. II		✓	Very common
92.	Common Woodshrike *Tephrodornis pondicerianus*	Least Concern	Sch. II			Rare

93.	Bar-winged Flycatcher-shrike *Hemipus picatus*	Least Concern	Sch. II		✓	Very common
	Family: Aegithinidae					
94.	Common Iora *Aegithina tiphia*	Least Concern	Sch. II		✓	Very common
	Family: Dicruridae					
95.	Ashy Drongo *Dicrurus leucophaeus*	Least Concern	Sch. II		✓	Very common
96.	Black Drongo *Dicrurus macrocercus*	Least Concern	Sch. II		✓	Common
97.	Bronzed Drongo *Dicrurus aeneus*	Least Concern	Sch. II			Common
98.	Spangled Drongo *Dicrurus hottentottus*	Least Concern	Sch. II			Rare
99.	Greater Racket-tailed Drongo *Dicrurus paradiseus*	Least Concern	Sch. II		✓	Very common
	Family: Monarchidae					
100.	Black-naped Monarch Flycatcher *Hypothymis azurea*	Least Concern	Sch. II		✓	Common
101.	Indian Paradise Flycatcher *Terpsiphone paradisi*	Least Concern	Sch. II			Common
	Family: Laniidae					
102.	Brown Shrike *Lanius cristatus*	Least Concern	Sch. II			Very common
103.	Long-tailed Shrike *Lanius Schach*	Least Concern	Sch. II			Very common
	Family: Corvidae					
104.	Rufous Treepie *Dendrocitta vagabunda*	Least Concern	Sch. II			Rare
105.	White-bellied Treepie *Dendrocitta leucogastra*	Least Concern	Sch. II	Western Ghats	✓	Rare
106.	House Crow *Corvus splendens*	Least Concern	Sch. II		✓	Common
107.	Jungle Crow *Corvus macrorhynchos*	Least Concern	Sch. II		✓	Common
	Family: Stenostiridae					
108.	Grey-headed Canary Flycatcher *Culicicapa ceylonensis*	Least Concern	Sch. II		✓	Common
	Family: Paridae					
109.	Cinereous Tit *Parus cinereus*	Least Concern	Sch. II		✓	Rare

110.	Indian Tit *Machlolophus aplonotus*	Least Concern	Sch. II		✓	Common
	Family: Cisticolidae					
111.	Common Tailorbird *Orthotomus sutorius*	Least Concern	Sch. II		✓	Common
112.	Grey-breasted Prinia *Prinia hodgsonii*	Least Concern	Sch. II		✓	Common
113.	Plain Prinia *Prinia inornate*	Least Concern	Sch. II		✓	Rare
114.	Ashy Prinia *Prinia socialis*	Least Concern	Sch. II		✓	Rare
	Family: Locustellidae					
115.	Broad-tailed Grassbird *Schoenicola platyurus*	Vulnerable	Sch. I			Very rare
	Family: Acrocephalidae					
116.	Blyth's Reed Warbler *Acrocephalus dumetorum*	Least Concern	Sch. II		✓	Very common
117.	Clamorous Reed Warbler *Acrocephalus stentoreus*	Least Concern	Sch. II			Common
118.	Thick-billed Warbler *Arundinax aedon*	Least Concern	Sch. II			Common
	Family: Hirundinidae					
119.	Red-rumped Swallow *Cecropis daurica*	Least Concern	Sch. II			Rare
120.	Barn Swallow *Hirundo rustica*	Least Concern	Sch. II		✓	Common
121.	Hill Swallow *Hirundo tahitica*	Least Concern	Sch. II			Common
122.	Dusky Crag Martin *Ptyonoprogne concolor*	Least Concern	Sch. II		✓	Common
	Family: Pycnonotidae					
123.	Flame-throated Bulbul *Rubigula gularis*	Least Concern	Sch. II		✓	Common
124.	Red-vented Bulbul *Pycnonotus cafer*	Least Concern	Sch. II		✓	Common
125.	Red-whiskered Bulbul *Pycnonotus jocosus*	Least Concern	Sch. II		✓	Very common
126.	Yellow-browed Bulbul *Acritillas indica*	Least Concern	Sch. II		✓	Very common
127.	Black Bulbul *Hypsipetes ganeesa*	Least Concern	Sch. II		✓	Very common
	Family: Phylloscopidae					
128.	Greenish Leaf Warbler	Least	Sch. II			Very

	Phylloscopus trochiloides	Concern				common
129.	Green Leaf Warbler *Phylloscopus nitidus*	Least Concern	Sch. II			Common
130.	Large-billed Leaf Warbler *Phylloscopus magnirostris*	Least Concern	Sch. II			Common
131.	Western Crowned Warbler *Phylloscopus occipitalis*	Least Concern	Sch. II			Common
	Family: Zosteropidae					
132.	Indian White-eye *Zosterops palpebrosus*	Least Concern	Sch. II		✓	Very common
	Family: Timaliidae					
133.	Tawny-bellied Babbler *Dumetia hyperythra*	Least Concern	Sch. II		✓	Very rare
134.	Dark-fronted Babbler *Dumetia atriceps*	Least Concern	Sch. II		✓	Common
135.	Indian Scimitar Babbler *Pomatorhinus horsfieldii*	Least Concern	Sch. II		✓	Very common
	Family: Pellorneidae					
136.	Puff-throated Babbler *Pellorneum ruficeps*	Least Concern	Sch. II		✓	Very common
	Family: Leiothrichidae					
137.	Brown-cheeked Fulvetta *Alcippe poioicephala*	Least Concern	Sch. II		✓	Very common
138.	Junge Babbler *Argya striata*	Least Concern	Sch. II			Common
139.	Yellow-billed Babbler *Argya affinis*	Least Concern	Sch. II			Rare
140.	Rufous Babbler *Argya subrufa*	Least Concern	Sch. II	Western Ghats	✓	Common
141.	Wynaad Laughingthrush *Pterorhinus delesserti*	Least Concern	Sch. II	Western Ghats	✓	Rare
142.	Banasura Chilappan *Montecincla jerdoni*	Endangered	Sch. I	Western Ghats	✓	Very rare
	Family: Sittidae					
143.	Velvet-fronted Nuthatch *Sitta frontalis*	Least Concern	Sch. II		✓	Common
	Family: Sturnidae					
144.	Southern Hill Myna	Least	Sch. I		✓	Common

	Gracula indica	Concern				
145.	Chestnut-tailed Starling *Sturnia malabarica*	Least Concern	Sch. II			Rare
146.	Malabar Starling *Sturnia blythii*	Least Concern	Sch. II		✓	Common
147.	Jungle Myna *Acridotheres fuscus*	Least Concern	Sch. II		✓	Very common
148.	Common Myna *Acridotheres tristis*	Least Concern	Sch. II			Rare
	Family: Turdidae					
149.	Orange-headed Thrush *Geokichla citrina*	Least Concern	Sch. II		✓	Rare
150.	Indian Blackbird *Turdus simillimus*	Least Concern	Sch. II			Rare
	Family: Muscicapidae					
151.	Asian Brown Flycatcher *Muscicapa dauurica*	Least Concern	Sch. II		✓	Very common
152.	Brown-breasted Flycatcher *Muscicapa muttui*	Least Concern	Sch. II		✓	Common
153.	Indian Robin *Saxicoloides fulicatus*	Least Concern	Sch. II			Rare
154.	Oriental Magpie Robin *Copsychus saularis*	Least Concern	Sch. II		✓	Very common
155.	White-rumped Shama *Copsychus malabaricus*	Least Concern	Sch. II			Rare
156.	White-bellied Blue Flycatcher *Cyornis pallidipes*	Least Concern	Sch. II	Western Ghats	✓	Common
157.	Tickell's Blue Flycatcher *Cyornis tickelliae*	Least Concern	Sch. II		✓	Common
158.	Blue-throated Blue Flycatcher *Cyornis rubeculoides*	Least Concern	Sch. II			Rare
159.	Nilgiri Flycatcher *Eumyias albicaudatus*	Least Concern	Sch. II	Western Ghats		Common
160.	Verditer Flycatcher *Eumyias thalassinus*	Least Concern	Sch. II			Common
161.	Black and Orange Flycatcher *Ficedula nigrorufa*	Least Concern	Sch. II	Western Ghats		Rare
162.	Indian Blue Robin *Larvivora brunnea*	Least Concern	Sch. II			Common
163.	Nilgiri Sholakili	Endangered	Sch. I	Western		Very rare

	Sholicola major			Ghats		
164.	Malabar Whistling Thrush *Myophonus horsfieldii*	Least Concern	Sch. II		✓	Very common
165.	Rusty-tailed Flycatcher *Ficedula ruficauda*	Least Concern	Sch. II		✓	Common
166.	Blue-capped Rock Thrush *Monticola cincholorhyncha*	Least Concern	Sch. II			Very common
167.	Pied Bushchat *Saxicola caprata*	Least Concern	Sch. II		✓	Common
	Family: Dicaeidae					
168.	Thick-billed Flowerpecker *Dicaeum agile*	Least Concern	Sch. II			Rare
169.	Pale-billed Flowerpecker *Dicaeum erythrorhynchos*	Least Concern	Sch. II		✓	Common
170.	Nilgiri Flowerpecker *Dicaeum concolor*	Least Concern	Sch. II		✓	Very common
	Family: Nectariniidae					
171.	Purple-rumped Sunbird *Leptocoma zeylonica*	Least Concern	Sch. II		✓	Common
172.	Crimson-backed Sunbird *Leptocoma minima*	Least Concern	Sch. II	Western Ghats	✓	Very common
173.	Purple Sunbird *Cinnyris asiaticus*	Least Concern	Sch. II			Common
174.	Loten's Sunbird *Cinnyris lotenius*	Least Concern	Sch. II			Common
175.	Little Spiderhunter *Arachnothera longirostra*	Least Concern	Sch. II		✓	Very common
	Family: Irenidae					
176.	Asian Fairy-bluebird *Irena puella*	Least Concern	Sch. II		✓	Very common
	Family: Chloropseidae					
177.	Jerdon's Leafbird *Chloropsis jerdoni*	Least Concern	Sch. II		✓	Common
178.	Golden-fronted Leafbird *Chloropsis aurifrons*	Least Concern	Sch. II		✓	Common
	Family: Estrildidae					
179.	White-rumped Munia *Lonchura striata*	Least Concern	Sch. II		✓	Common

180.	Black-throated Munia *Lonchura kelaarti*	Least Concern	Sch. II		✓	Common
181.	Scaly-breasted Munia *Lonchura punctulate*	Least Concern	Sch. II			Rare
	Family: Motacillidae					
182.	Forest Wagtail *Dendronanthus indicus*	Least Concern	Sch. I		✓	Rare
183.	Grey Wagtail *Motacilla cinerea*	Least Concern	Sch. II			Common
184.	White-browed Wagtail *Motacilla maderaspatensis*	Least Concern	Sch. II		✓	Very common
	Family: Fringillidae					
185.	Common Rosefinch *Carpodacus erythrinus*	Least Concern	Sch. II			Common

*IUCN: International Union for Conservation of Nature **Wild Life (Protection) Act, 1972

On surveying the seven transects, a total of 555 individuals of 97 bird species were recorded. The analysed results are indicative of a very high diversity of birds in the area (Shannon Diversity H = 3.988) with an even distribution of species (Simpson 1-D = 0.9697). Results from the relative abundance analysis (Table-4.26) show that Red-whiskered Bulbul (*Pycnonotus jocosus*) is the most abundant (10.631) followed by Brown-cheeked Fulvetta (*Alcippe poioicephala*) and Velvet-fronted Nuthatch (*Sitta frontalis*) with a relative abundance of 6.126 and 4.144 respectively.

Table-4.26: Relative abundance of birds recorded during the study

Sl. No.	Common name	Scientific name	Relative abundance
1.	Red-whiskered Bulbul	*Pycnonotus jocosus*	10.631
2.	Brown-cheeked Fulvetta	*Alcippe poioicephala*	6.126
3.	Velvet-fronted Nuthatch	*Sitta frontalis*	4.144
4.	Yellow-browed Bulbul	*Acritillas indica*	3.784
5.	Jungle Crow	*Corvus macrorhynchos*	3.423
6.	Malabar Parakeet	*Psittacula columboides*	3.243
7.	Orange Minivet	*Pericrocotus flammeus*	3.243
8.	White-cheeked Barbet	*Psilopogon viridis*	2.703
9.	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	2.703
10.	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	2.703
11.	Indian White-eye	*Zosterops palpebrosus*	2.703
12.	Red-vented Bulbul	*Pycnonotus cafer*	2.162
13.	Nilgiri Flowerpecker	*Dicaeum concolor*	2.162
14.	Vernal Hanging Parrot	*Loriculus vernalis*	1.982
15.	Little Spiderhunter	*Arachnothera longirostra*	1.982
16.	Indian Pond Heron	*Ardeola grayii*	1.802
17.	Ashy Woodswallow	*Artamus fuscus*	1.802
18.	Southern Hill Myna	*Gracula indica*	1.802
19.	White-bellied Treepie	*Dendrocitta leucogastra*	1.622

20.	Indian Scimitar Babbler	*Pomatorhinus horsfieldii*	1.441
21.	Rufous Babbler	*Argya subrufa*	1.441
22.	Jungle Myna	*Acridotheres fuscus*	1.441
23.	Malabar Whistling Thrush	*Myophonus horsfieldii*	1.261
24.	Grey-fronted Green Pigeon	*Treron affinis*	1.081
25.	Indian Golden Oriole	*Oriolus kundoo*	1.081
26.	Crimson-backed Sunbird	*Leptocoma minima*	1.081
27.	White-rumped Munia	*Lonchura striata*	1.081
28.	Crested Serpent Eagle	*Spilornis cheela*	0.901
29.	Chestnut-headed Bee-eater	*Merops leschenaultia*	0.901
30.	Bar-winged Flycatcher-shrike	*Hemipus picatus*	0.901
31.	Indian Tit	*Machlolophus aplonotus*	0.901
32.	Black Bulbul	*Hypsipetes ganeesa*	0.901
33.	Puff-throated Babbler	*Pellorneum ruficeps*	0.901
34.	Asian Fairy-bluebird	*Irena puella*	0.901
35.	Black-throated Munia	*Lonchura kelaarti*	0.901
36.	Malabar Imperial Pigeon	*Ducula cuprea*	0.721
37.	Little Cormorant	*Microcarbo niger*	0.721
38.	Malabar Grey Hornbill	*Ocyceros griseus*	0.721
39.	Malabar Woodshrike	*Tephrodornis sylvicola*	0.721
40.	Common Tailorbird	*Orthotomus sutorius*	0.721
41.	Dusky Crag Martin	*Ptyonoprogne concolor*	0.721
42.	Banasura Chilappan	*Montecincla jerdoni*	0.721
43.	Malabar Starling	*Sturnia blythii*	0.721
44.	Grey Jungle Fowl	*Gallus sonneratii*	0.541
45.	Greater Coucal	*Centropus sinensis*	0.541
46.	Shikra	*Accipiter badius*	0.541
47.	Malabar Trogon	*Harpactes fasciatus*	0.541
48.	Speckled Piculet	*Picumnus innominatus*	0.541
49.	Ashy Drongo	*Dicrurus leucophaeus*	0.541
50.	Black-naped Monarch Flycatcher	*Hypothymis azurea*	0.541
51.	House Crow	*Corvus splendens*	0.541
52.	Barn Swallow	*Hirundo rustica*	0.541
53.	Dark-fronted Babbler	*Dumetia atriceps*	0.541
54.	Oriental Magpie Robin	*Copsychus saularis*	0.541
55.	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	0.541
56.	Golden-fronted Leafbird	*Chloropsis aurifrons*	0.541
57.	Spotted Dove	*Streptopelia chinensis*	0.360
58.	Black Eagle	*Ictinaetus malaiensis*	0.360
59.	White-throated Kingfisher	*Halcyon smyrnensis*	0.360
60.	Green Bee-eater	*Merops orientalis*	0.360
61.	Black Drongo	*Dicrurus macrocercus*	0.360
62.	Ashy Prinia	*Prinia socialis*	0.360
63.	Blyth's Reed Warbler	*Acrocephalus dumetorum*	0.360
64.	Flame-throated Bulbul	*Rubigula gularis*	0.360
65.	Tickell's Blue Flycatcher	*Cyornis tickelliae*	0.360
66.	Pied Bush chat	*Saxicola caprata*	0.360
67.	Purple-rumped Sunbird	*Leptocoma zeylonica*	0.360
68.	Red Spurfowl	*Galloperdix spadicea*	0.180
69.	Asian Emerald Dove	*Chalcophaps indica*	0.180
70.	Common Hawk Cuckoo	*Hierococcyx varius*	0.180
71.	Crested Hawk Eagle	*Nisaetus cirrhatus*	0.180
72.	Rufous-bellied Eagle	*Lophotriorchis kienerii*	0.180
73.	Booted Eagle	*Hieraaetus pennatus*	0.180
74.	Crested Goshawk	*Accipiter trivirgatus*	0.180
75.	Brahminy Kite	*Haliastur indus*	0.180
76.	Brown Fish Owl	*Ketupa zeylonensis*	0.180

77.	Malabar Barbet	*Psilopogon malabaricus*	0.180
78	Heart-spotted Woodpecker	*Hemircircus canente*	0.180
79.	Greater Golden-backed Woodpecker	*Chrysocolaptes guttacristatus*	0.180
80.	Lesser Golden-backed Woodpecker	*Dinopium benghalense*	0.180
81.	Plum-headed Parakeet	*Psittacula cyanocephala*	0.180
82.	Indian Pitta	*Pitta brachyura*	0.180
83.	Black-naped Oriole	*Oriolus chinensis*	0.180
84.	Common Iora	*Aegithina tiphia*	0.180
85.	Cinereous Tit	*Parus cinereus*	0.180
86.	Grey-breasted Prinia	*Prinia hodgsonii*	0.180
87.	Plain Prinia	*Prinia inornate*	0.180
88.	Tawny-bellied Babbler	*Dumetia hyperythra*	0.180
89.	Wayanad Laughingthrush	*Pterorhinus delesserti*	0.180
90.	Orange-headed Thrush	*Geokichla citrina*	0.180
91.	Asian Brown Flycatcher	*Muscicapa dauurica*	0.180
92.	Brown-breasted Flycatcher	*Muscicapa muttui*	0.180
93.	White-bellied Blue Flycatcher	*Cyornis pallidipes*	0.180
94.	Rusty-tailed Flycatcher	*Ficedula ruficauda*	0.180
95.	Jerdon's Leafbird	*Chloropsis jerdoni*	0.180
96.	Forest Wagtail	*Dendronanthus indicus*	0.180
97.	White-browed Wagtail	*Motacilla maderaspatensis*	0.180

The endemic and endangered Banasura Chilappan (*Montecincla jerdoni*) is a severely range-restricted laughingthrush species, whose distribution is limited to the high-altitude shola forests (above 1400 msl) (Praveen and Nameer, 2012; Robin *et al.*, 2017), between Brahmagiri Hills in Coorg and Vavulmala Hills in Wayanad, Kerala. Fragmented populations are found in Banasura Hill, Chembra Peak, and Vellarimala in Wayanad (Praveen and Nameer, 2012). Being range-restricted, endemic, and endangered, the species is extremely vulnerable and threatened due to habitat loss and fragmentation for agriculture, settlements, and other developmental activities. Camel Hump Mountains were chosen as Important Bird Area for protection of the habitat of the Banasura Chilappan. In the present study, they were observed in one of the transects in the highest point of Wayanad part in the proposed Meppadi-Anakkampoyil Tunnel Road stretch, which consequently suggest potential danger to the already fragmented and small population of these laughingthrush species of the shola sky islands.

Herpetofauna

Amphibians evolved about 365 million years ago during Late Devonian period and they are one among the most diverse groups of vertebrates on land (Hoffmann *et al.*, 2010). Their ability to live both in land and water and the absence of a protective covering or an eggshell (anamniotic) makes them vulnerable to the smallest changes in the atmosphere. Most of them lay eggs in water that hatch out in aquatic tadpoles which live in water for some time and metamorphosize into miniature adults (Altig and McDiarmid, 1999).

Amphibians are the ones with great percentage (41%) of the described species in the world that are threatened and are likely to be the major group of vertebrates that are already in a race towards extinction (Wake and Vredenburg, 2008). Amphibian decline around the world are triggered by several factors and the most important ones are global climate change, habitat destruction and infectious disease (Stuart *et al*., 2004; Pechmann and Wake, 2005). These animals are generally adapted to live in wet and humid conditions owing to their vascularised moist skin and cutaneous respiration. Any change in the surrounding environments, quality of water and air can have serious impacts on their life (Vitt *et al*., 1990; Murphy *et al.*, 2000). Species inhabiting the tropical regions are more susceptible even to the slightest change in the atmosphere as they are normally subjected to very little temperature variations. With the increase in human population, came the need for space and it resulted in speeding up of land conversion for agriculture and developments. Rate of habitat destruction increased over a period and eventually led to decline of many animals including amphibians.

Reptiles are the first land vertebrates that radiated to almost all the microhabitats, from wet to dry habitats and from fossorial to arboreal habitats. Reptiles contribute a great percentage of world's vertebrate diversity, a total of 11,940 species of reptiles were described till December 2022 (Uetz *et al*., 2023). Our tropical regions harbour very high reptile diversity and endemism and also the highest number of threatened and data deficient species (Bohm *et al*., 2013). Their diversity and distribution are always a fascinating world for ecologists. Physical characteristics of their habitat and their requirements play a crucial role in their distribution (Wells, 2007; Vitt and Caldwell, 2014) and they partition their resources with others to survive in a community. About 59% of reptiles present in Kerala are endemic to the hill ranges of Western Ghats (Nameer *et al*., 2015). In the current face of 6th mass extinction, these endemic and range-restricted species are going to be the prime victims.

Studies have reported that many of the reptile species use the same home range for years (Marvin, 2001; Rebelo and Leclair, 2003; Wells, 2007) and this makes them the most vulnerable group of vertebrates to habitat modifications (Gibbons, 2000). According to Araújo *et al*. (2006), this is far detrimental than the global environmental changes. The exponential growth of human population leads to the expansion of agriculture and farmlands resulting in clearing of natural habitats like the forest, grassland and aquatic ecosystems (Vitt and Caldwell, 2014). This leads to a reduction in the reptile abundance in the modified areas and even local extinction of species. This will hamper the equilibrium of the ecosystem and ecosystem services (Loreau *et al*., 2001; Diaz *et al*., 2006). Therefore, it is an important aspect to study the amphibian and reptile diversity in the proposed tunnel area to understand the quality of the habitat and to what extent the modification will affect the diversity. The

Amphibian Team was led by Dr. Sandeep Das (Aranyakam Nature Foundation) with Shri C. P. Nidheesh, Fidal R. Babu, as Team Members. The Reptiles were documented under the guidance of Dr. K. P. Rajkumar (Aranyakam Nature Foundation) with the support of Shri Ahammed Javad. The Herpetofauna teams were mutually assisting in the whole survey.

Strip transect method (Heyer *et al*., 1994; Balaji *et al*., 2014; Sutherland, 2006) was used to document the amphibian and reptile diversity in the proposed tunnel area. Twenty-meter strip transects with a fixed width of four meters (two meters either side) were spatially replicated at a total of 20 different locations across the proposed project area. The transects were walked during day and night hours at a uniform pace by two trained people, one person checking one side of the transect and the second person checking the other to get maximum sightings. All the microhabitats (fallen logs, under stones, in leaf litter, tree bark, rock crevices etc.) inside the transect were thoroughly searched. All the trees and shrubs inside the strip transect were thoroughly searched for documenting arboreal and semi-arboreal amphibian and reptile species. All the species found in the transects were identified and documented. Checklist of both amphibians and reptiles present in the proposed tunnel area and surroundings is compiled based on the results obtained from the present study and several observations from previous visits from 2012-2023 to the area as part of other research projects.

A total of 49 species of amphibians and 44 species of reptiles were recorded from the study area. Among the amphibians, 32 species were recorded during the study period from the strip transects and the rest of the species were the ones recorded from the previous visits to the study areas from 2012 -2023 (Table-4.27). A total of 627 individuals from 32 species of amphibians were recorded in the strip transects and the total checklist considering the previous visits accounts for a total of 49 species of amphibians. Rhacophoridae is the most represented family with 14 species from five genera. The Western Ghats endemic species form 73 % of the total species recorded. Of these, three species including Miniature Night Frog (*Nyctibatrachus minimus*), Rocky-terrain Leaping Frog (*Indirana paramakri*) and Long-headed Caecilian (*Ichtyhophis longicephalus*) are Kerala endemics. Species such as Malabar Torrent Toad (*Blaira ornate*), Malabar Tree Toad (*Pedostibes tuberculosus*), Minervarya Frog (*Minervarya sahyadris*), Jerdon’s Bush Frog (*Pseudophilautus wynaadensis*) are threatened under Endangered category of IUCN Red List. Three species, Ridged Toad (*Duttaphrynus parietalis*), Karaavali Skittering Frog (*Euphlyctis karaavali*) and Indian Bull Frog (*Hoplobatrachus tigerinus*) are in the Schedule II of the Wildlife (Protection) Act, 1972.

Table-4.27: List of Amphibians observed in the proposed tunnel-road area and surroundings

Sl.	Name of species	IUCN*	WPA**	Endemism	Present	Status in

No.		status	schedule		survey	the study area
	Order: Anura					
	Family: Bufonidae					
1.	Common Indian Toad *Duttaphrynus melanostictus*	Least Concern			✓	Very common
2.	Ridged Toad *Duttaphrynus parietalis*	Near Threatened		Western Ghats	✓	Common
3.	Malabar Torrent Toad *Blaira ornate*	Endangered		Western Ghats	✓	Very common
4.	Malabar Tree Toad *Pedostibes tuberculosus*	Endangered	Sch. II	Western Ghats	✓	Common
	Family: Dicroglossidae					
5.	Jaladhara Skittering Frog *Euphlyctis jaladhara*	Not Evaluated				Rare
6.	Karaavali Skittering Frog *Euphlyctis karaavali*	Least Concern	Sch. II			Very rare
7.	Indian Bullfrog *Hoplobatrachus tigerinus*	Least Concern	Sch. II		✓	Rare
8.	Common Indian Cricket Frog *Minervarya Agricola*	Least Concern			✓	Very common
9.	Short-webbed Frog *Minervarya brevipalmata*	Data Deficient		Western Ghats	✓	Common
10.	Rufescent Burrowing Frog *Minervarya rufescens*	Least Concern		Western Ghats		Common
11.	Minervarya Frog *Minervarya sahyadris*	Endangered		Western Ghats	✓	Rare
12.	Bombay Warty Frog *Minervarya syhadrensis*	Least Concern				Rare
13.	Jerdon's Burrowing Frog *Sphaerotheca spp.*					
	Family: Micrixalidae					
14.	Elegant Torrent Frog *Micrixalus elegans*	Data Deficient		Western Ghats	✓	Rare
15.	Wayanad Torrent Frog *Micrixalus Saxicola*	Vulnerable		Western Ghats	✓	Very common
	Family: Microhylidae					
16.	Ornate Narrow-mouthed Frog *Microhyla ornate*	Least Concern		Western Ghats		Common
17.	Reddish Narrow-mouthed Frog *Microhyla rubra*	Least Concern			✓	Common
18.	Jerdon’s Ramanella *Uperodon montanus*	Near Threatened		Western Ghats	✓	Rare
19.	Painted Frog *Uperodon taprobanicus*	Least Concern				Rare
20.	Malabar Ramanella *Uperodon triangularis*	Vulnerable		Western Ghats	✓	Rare
21.	Variegated Ramanella *Uperodon variegatus*	Least Concern				Rare
	Family: Nyctibatrachidae					
22.	Wayanad Night Frog *Nyctibatrachus grandis*	Not Evaluated		Western Ghats	✓	Very common
23.	Kempholey Night Frog *Nyctibatrachus kempholeyensis*	Data Deficient		Western Ghats	✓	Very common
24.	Miniature Night Frog *Nyctibatrachus minimus*	Data Deficient		Kerala	✓	Very common
25.	VUB Night Frog *Nyctibatrachus vrijeuni*	Not Evaluated		Western Ghats	✓	Very common

	Family: Ranidae					
26.	Bicoloured Frog *Clinotarsus curtipes*	Near Threatened		Western Ghats	✓	Common
27.	Fungoid Frog *Hydrophylax malabarica*	Least Concern				Rare
28.	Yellowish Golden-backed Frog *Indosylvirana flavescens*	Not Evaluated		Western Ghats		Common
29.	Indian Golden-backed Frog *Indosylvirana indica*	Not Evaluated		Western Ghats	✓	Common
30.	Rao's intermediate Golden-backed Frog *Indosylvirana intermedius*	Not Evaluated		Western Ghats		Rare
	Family: Ranixalidae					
31.	Beddome's Leaping Frog *Indirana beddomii*	Least Concern		Western Ghats	✓	Common
32.	Rocky-terrain Leaping Frog *Indirana paramakri*	Not Evaluated		Kerala	✓	Common
	Family: Rhacophoridae					
33.	Green Tree Frog *Ghatixalus variabilis*	Endangered		Western Ghats	✓	Common
34.	Common Indian Tree Frog *Polypedates maculatus*	Least Concern		Western Ghats		Rare
35.	Charpa Tree Frog *Polypedates occidentalis*	Data Deficient		Western Ghats	✓	Common
36.	Jerdon's Bush Frog *Pseudophilautus wynaadensis*	Endangered		Western Ghats	✓	Very common
37.	Variable Bush Frog *Raorchestes akroparallagi*	Least Concern		Western Ghats	✓	Very common
38.	Anil's Bush Frog *Raorchestes anili*	Least Concern		Western Ghats		Very common
39.	Confusing Green Bush Frog *Raorchestes chromasynchysi*	Vulnerable		Western Ghats	✓	Very common
40.	Glandular Bush frog *Raorchestes glandulosus*	Vulnerable		Western Ghats	✓	Very common
41.	Kakkayam Bush Frog *Raorchestes kakkayamensis*	Not Evaluated				Very common
42.	Water Drop Frog *Raorchestes nerostagona*	Endangered		Western Ghats	✓	Very common
43.	Ochlandrae Reed Bush Frog *Raorchestes ochlandrae*	Data Deficient		Western Ghats		Very common
44.	Large Ponmudi Bush Frog *Raorchestes Ponmudi*	Least Concern		Western Ghats	✓	Very common
45.	Small Tree Frog *Rhacophorus lateralis*	Vulnerable		Western Ghats	✓	Common
46.	Malabar Gliding Frog *Rhacophorus malabaricus*	Least Concern		Western Ghats	✓	Common
	Order: Gymnophiona					
	Family: Ichthyophiidae					
47.	Long-headed Caecilian *Ichthyophis longicephalus*	Data Deficient		Kerala		Rare
48.	Bombay Caecilian *Uraeotyphlus bombayensis*	Least Concern		Western Ghats	✓	Very rare
49.	Caecilian *Uraeotyphlus* spp.					

*IUCN: International Union for Conservation of Nature **Wild Life (Protection) Act, 1972

Bicoloured Frog *Clinotarsus curtipes*

Green Tree Frog *Ghatixalus variabilis*

Analysed results from the present 20 strip transects shows that the area holds high amphibian diversity (Shannon Diversity H= 3.23) with an evenness of 0.95 (Simpson_1-D). The values show very high diversity of amphibians with even distribution of species. Results from the relative abundance analysis shows high abundance of Miniature Night Frog (*Nyctibatrachus minimus*) with a relative abundance of 9.569 followed by Jerdon's Bush Frog *Pseudophilautus wynaadensis* (8.771), Wayanad Torrent Frog *Micrixalus saxicola* (7.814) and Kempholey Night Frog *Nyctibatrachus kempholeyensis* (7.655) (Table-4.27).

Table-4.27: Relative abundance of Amphibian species in the study area

Sl. No.	Species	Relative Abundance
1.	*Duttaphrynus melanostictus*	2.871
2.	*Duttaphrynus parietalis*	1.754
3.	*Blaira ornate*	2.711
4.	*Pedostibes tuberculosus*	1.276
5.	*Hoplobatrachus tigerinus*	0.797
6.	*Minervarya Agricola*	3.190
7.	*Minervarya nilgirica*	1.754
8.	*Minervarya sahyadris*	1.435
9.	*Micrixalus elegans*	1.435
10.	*Micrixalus Saxicola*	7.815
11.	*Microhyla rubra*	2.392
12.	*Uperodon montanus*	2.552
13.	*Uperodon triangularis*	0.478
14.	*Nyctibatrachus grandis*	1.754
15.	*Nyctibatrachus kempholeyensis*	7.656
16.	*Nyctibatrachus minimus*	9.569
17.	*Nyctibatrachus vrijeuni*	1.754
18.	*Clinotarsus curtipes*	1.914
19.	*Indosylvirana indica*	1.914
20.	*Indirana beddomii*	2.711
21.	*Indirana paramakri*	2.711
22.	*Ghatixalus variabilis*	1.754
23.	*Polypedates occidentalis*	1.754
24.	*Pseudophilautus wynaadensis*	8.772
25.	*Raorchestes akroparallagi*	5.104
26.	*Raorchestes chromasynchysi*	2.711

27.	*Raorchestes glandulosus*	3.030
28.	*Raorchestes nerostagona*	4.147
29.	*Raorchestes Ponmudi*	5.104
30.	*Rhacophorus lateralis*	3.349
31.	*Rhacophorus malabaricus*	3.509
32.	*Uraeotyphlus bombayensis*	0.319

Forty-five individuals of 17 species of reptiles were recorded during the present survey. When compiling the data from previous visits to the study area, the checklist yields a total of 44 species of reptiles belonging to two Orders and 14 Families (Table-4.28). Family Colubridae (9) has more species followed by the family Agamidae and Gekkonidae with eight and five species respectively. About 32% of reptiles recorded are endemic to the Western Ghats, of which the Wayanad Day Gecko (*Cnemaspis wynadensis*) and Mountain Day Gecko (*Cnemaspis monticola*) are highly range restricted and endemic to Kerala part of the Western Ghats. Five species of reptiles are threatened and fall under different threatened categories of IUCN Red List Assessment. The Wayanad Day Gecko (*Cnemaspis wynadensis*) is an Endangered species, the Travancore Tortoise (*Indotestudo travancorica*) is Vulnerable, and the Bengal Monitor (*Varanus bengalensis*), Indian Rock Python (*Python molurus*) and Common Sand Boa (*Eryx conicus*) are Near Threatened. A total of 25 species are protected under different schedules of Wildlife (Protection) Act, 1972. The Travancore Tortoise (Indotestudo *travancorica*), Bengal Monitor (*Varanus bengalensis*), Indian Rock Python (*Python molurus*), Checkered Keelback (*Fowlea piscator*), Spectacled Cobra (*Naja naja*) and Russel's Viper (*Daboia russelii*) under Schedule I category.

Table-4.28: List of Reptiles recorded from the proposed tunnel area and surroundings

Sl. No.	Name of species	IUCN* status	*Endemism*	WPA** schedule	Present survey	Status in the study area
	Order: Testudines					
	Family: Geomydidae					
1.	Indian Black Turtle *Melanochelys trijuga*	Least Concern		Sch. II		Rare
	Family: Testudinidea					
2.	Travancore Tortoise *Indotestudo travancorica*	Vulnerable	Western Ghats	Sch. I		Very rare
	Order: Squamata					
	Family: Agamidae					
3.	Common Green Forest Lizard *Calotes calotes*	Least Concern			✓	Common
4.	Indian Garden Lizard *Calotes versicolor*	Least Concern			✓	Very common
5.	Nilgiri Forest Lizard *Calotes nemoricola*					Very rare
6.	Elliot's Forest Lizard *Monilesaurus ellioti*	Least Concern	Western Ghats		✓	Very common
7.	Roux's Forest Lizard *Monilesaurus rouxii*	Least Concern				Common

8.	Montane Forest Lizard *Monilesaurus montanus*				✓	Rare
9.	South Indian Flying Lizard *Draco dussumieri*	Least Concern		Sch. II		Rare
10.	South Indian Rock Agama *Psammophilus dorsalis*	Least Concern				Rare
	Family: Gekkonidae					
11.	Wayanad Dravidogecko *Dravidogecko septentrionalis*	Not Evaluated	Western Ghats			Rare
12.	Spotted House Gecko *Hemidactylus parvimaculatus*	Least Concern			✓	Common
13.	Asian House Gecko *Hemidactylus frenatus*	Least Concern				Common
14.	Wayanad Day Gecko *Cnemaspis wynadensis*	Endangered	Kerala		✓	Common
15.	Mountain Day Gecko *Cnemaspis monticola*	Data Deficient	Kerala		✓	Very common
	Family: Scincidae					
16.	Common Keeled Skink *Eutropis carinata*	Least Concern			✓	Very common
17.	Bronze Grass Skink *Eutropis macularia*	Least Concern			✓	Very common
18.	Beddome's Cat Skink *Ristella beddomii*	Least Concern	Western Ghats			Rare
19.	Dussumier's Litter Skink *Sphenomorphus dussumieri*	Least Concern	Western Ghats			Very common
	Family: Varanidae					
20.	Bengal Monitor *Varanus bengalensis*	Near Threatened		Sch. I		Common
	Family: Typhlopidae					
21.	Brahminy Worm Snake *Indotyphlops braminus*	Least Concern		Sch. II		Rare
	Family: Uropeltidae					
22.	Wynad Shieldtail *Melanophidium wynadense*	Least Concern	Western Ghats	Sch. II		Very rare
23.	Elliot's Shieldtail *Uropeltis ellioti*	Least Concern		Sch. II		Very rare
	Family: Pythonidae					
24.	Indian Rock python *Python molurus*	Near Threatened		Sch. I		Rare
	Family: Erycidae					
25.	Common Sand Boa *Eryx conicus*	Near Threatened		Sch. II	✓	Rare
	Family: Colubridae					
26.	Montane Trinket Snake *Coelognathus helena monticollaris*	Least Concern		Sch. II		Rare
27.	Indian Rat Snake *Ptyas mucosa*	Least Concern		Sch. I	✓	Common
28.	Common Kukri Snake *Oligodon arnensis*	Least Concern		Sch. II		Common
29.	Bronzeback Tree Snake *Dendrelaphis chairecacos*	Data Deficient		Sch. II		Rare
30.	Common Wolf Snake *Lycodon aulicus*	Least Concern		Sch. II		Common
31.	Travancore Wolf Snake *Lycodon travancoricus*	Least Concern		Sch. II	✓	Common
32.	Dumeril's Black-headed	Least Concern		Sch. II		Rare

	Snake *Sibynophis subpunctatus*					
33.	Thackarey's Cat Snake *Boiga thackareyi*	Not Evaluated	Western Ghats	Sch. II	✓	Common
34.	Malabar Vine Snake *Ahaetulla malabarica*	Not Evaluated	Western Ghats	Sch. II	✓	Common
	Family Natricidae					
35.	Striped Keelback *Amphiesma stolatum*	Least Concern		Sch. IV		Common
36.	Beddome's Keelback *Hebius beddomei*	Least Concern	Western Ghats		✓	Common
37.	Hill Keelback *Hebius monticola*	Least Concern	Western Ghats			Rare
38.	Checkered Keelback *Fowlea piscator*	Least Concern		Sch. I	✓	Common
	Family: Elapidae					
39.	Common Indian Krait *Bungarus caeruleus*	Least Concern		Sch. II		Rare
40.	Spectacled Cobra *Naja naja*	Least Concern		Sch. I		Rare
41.	Bibron's Coral Snake *Calliophis bibroni*	Least Concern		Sch. II		Rare
	Family: Viperidae					
42.	Common Hump-nosed Pit Viper *Hypnale hypnale*	Least Concern		Sch. II	✓	Common
43.	Russel's Viper *Daboia russelii*	Least Concern		Sch. I		Rare
44.	Malabar Pit Viper *Craspedocephalus malabaricus*	Not Evaluated	Western Ghats	Sch. II	✓	Common

*IUCN: International Union for Conservation of Nature **Wild Life (Protection) Act, 1972

Travancore Tortoise

(*Indotestudo travancorica*)

Nilgiri Forest Lizard

(Calotes nemoricola)

Analysed results from the present 20 strip transects show that the area holds good reptile diversity (Shannon Diversity H = 2.738) with an evenness of 0.93 (Simpson_1-D). The values show comparatively high diversity with even distribution of species. Results from the relative abundance analysis shows the Indian Garden Lizard (*Calotes versicolor*) is abundant (11.111) followed by Spotted House Gecko (*Hemidactylus parvimaculatus*), Bronze Grass Skink (*Eutropis macularia*) and Malabar Pit Viper (*Craspedocephalus malabaricus*) with a relative abundance of 8.889 (Table-4.29).

Table-4.29: Relative abundance of Reptile species in the study area

Sl. No.	Scientific name	Relative Abundance
1	*Calotes calotes*	4.444
2	*Calotes versicolor*	11.111
3	*Monilesaurus ellioti*	4.444
4	*Monilesaurus montanus*	6.667
5	*Hemidactylus parvimaculatus*	8.889
6	*Cnemaspis wynadensis*	6.667
7	*Cnemaspis monticola*	6.667
8	*Eutropis carinata*	6.667
9	*Eutropis macularia*	8.889
10	*Eryx conicus*	2.222
11	*Ptyas mucosa*	2.222
12	*Lycodon travancoricus*	4.444
13	*Boiga thackareyi*	4.444
14	*Ahaetulla malabarica*	4.444
15	*Hebius beddomei*	2.222
16	*Hypnale hypnale*	6.667
17	*Craspedocephalus malabaricus*	8.889

Butterflies and grasshoppers

Invertebrates are normally not considered while assessing the diversity of an area or while conducting Impact Assessment. This is mostly because of the lack of expertise in the group and more often due to short duration available for such study. The present biodiversity assessment considered the Butterflies and Grasshoppers using the expertise of Dr. Dhaneesh Bhaskar (Aranyakam Nature Foundation), a grasshopper specialist with experience on butterflies.

The selected habitats were covered on foot recording the butterflies and grasshoppers observed. Care was taken to cover different representative habitats. The heavy rain has affected the survey to a great extent. However, the proposed tunnel mouth areas were well covered. The number of each species seen was later extracted from the observations. The grasshoppers were identified by following the online portals of Orthoptera Species file online (Cigliano *et al.*, 2023) and Butterflies of India (Kunte *et al.*, 2023) was referred for identification of butterflies. The taxonomy follows latest version of the Orthoptera Species

File (Cigliano *et al.*, 2023) and Butterflies of India (Kunte *et al*., 2023). Thirty-two species of butterflies were recorded during the survey. Based on the number of observations, only eight species are rare in the area (Table-4.30). Twenty-three species of grasshoppers were observed during the present survey (Table-4.31).

Table-4.30: List of butterflies observed in the proposed project area and surroundings

Sl. No.	Name of scpecies	Anakkampoyil (Kozhikode)	Meppadi (Wayanad)	Abundance Rating **	Conservation Status (IUCN/WPA)
	Family: Papilionidae (Swallowtails)				
1.	Tailed Jay *Graphium agamemnon* (Linnaeus, 1758)	+	+	Common	-
2.	Common Bluebottle *Graphium sarpedon* (Linnaeus, 1758)	+	+	Common	WPA-II
3.	Lime Swallowtail *Papilio demoleus* (Linnaeus, 1758)	+	-	Common	Not Applicable
4.	Red Helen *Papilio helenus* (Linnaeus, 1758)	+	+	Common	-
5.	Common Mormon *Papilio polytes* Linnaeus, 1758	+	-	Common	-
6.	Paris Peacock *Papilio paris* (Linnaeus, 1758)	+	+	Rare	-
7.	Sahyadri Birdwing *Troides minos* (Cramer, [1779])	+	+	Rare	Least Concern /WPA-II
	Family: Hesperiidae (Skippers)				
8.	Common Spotted Flat *Celaenorrhinus leucocera* (Kollar, [1844])	+	-	Rare	-
9.	Sahyadri Fulvous Pied Flat *Pseudocoladenia dandan* (Fabricius, 1787)	+	-	Rare	-
10.	Indian Common Small Flat *Sarangesa dasahara dasahara* (Moore, [1866])	+	-	Common	-
11.	Water Snow Flat *Tagiades litigiosa* Möschler, 1878	+	-	Common	-
12.	Southern Chestnut Bob *Iambrix salsala luteipalpis* (Plötz, 1886)	+	-	Common	-
13.	Tawny-spotted Grass Dart *Taractrocera ceramas* (Hewitson, 1868)	+	-	Common	-
14.	Indian Pale Palm-Dart *Telicota colon colon* (Fabricius, 1775)	+	-	Common	-
	Family: Pieridae (Whites and Yellows)				
15.	Oriental Mottled Emigrant *Catopsilia pyranthe pyranthe*	+	+	Common	-

	(Linnaeus, 1758)				
16.	Common Grass Yellow *Eurema hecabe* (Linnaeus, 1758)	+	+	Common	-
	Family: Nymphalidae (Brush-Footed Butterflies)				
17.	Oriental Striped Tiger *Danaus genutia genutia* (Cramer, [1779])	+	+	Rare	-
18.	Indian Common Crow *Euploea core core* (Cramer, [1780])	+	+	Common	-
19.	Glassy Tiger *Parantica aglea* (Stoll, [1782])	+	-	Common	-
20.	Oriental Blue Tiger *Tirumala limniace exoticus* (Gmélin, 1790)	+	+	Common	-
21.	Sahyadri Yeoman *Cirrochroa thais thais* (Fabricius, 1787)	+	-	Rare	-
22.	Dakhan Common Castor *Ariadne merione merione* (Cramer, [1777])	+	-	Common	-
23.	Danaid Eggfly *Hypolimnas misippus* (Linnaeus, 1764)	+	+	Rare	WPA-II
24.	Lemon Pansy *Junonia lemonias* (Linnaeus, 1758)	+	+	Common	-
25.	Grey Pansy *Junonia atlites* (Linnaeus, 1763)	+	+	Common	-
26.	Common Five-ring *Ypthima baldus* (Fabricius, 1775)	+	+	Common	-
27.	Rustic *Cupha erymanthis* (Drury, [1773])	+	+	Common	-
28.	Medus Brown *Orsotriaena medus* (Fabricius, 1775)	+	+	Common	-
	Family: Riodinidae (Metalmarks)				
29.	Double-banded Judy *Abisara bifasciata* Moore, 1877	+	-	Rare	-
	Family: Lycaenidae (Blues)				
30.	Tamil Long-banded Silverline *Spindasis lohita lazularia* (Moore, [1881])	+	-	Rare	WPA-II
31.	Red Pierrot *Talicada nyseus* (Guérin-Méneville, 1843)	+	-	Common	-
32.	Common Quaker *Neopithecops zalmora* (Butler, [1870])	+	-	Common	-

** The Abundance Rating was determined by considering the frequency of occurrences. "Rare" indicates a single encounter with less than two individuals; "Common" indicates multiple encounters with more than two individuals.

Junonia lemonias

Abisara bifasciata

Chitaura indica

Biodiversity survey

Table-4.31: Grasshoppers recorded from the proposed project area and surroundings

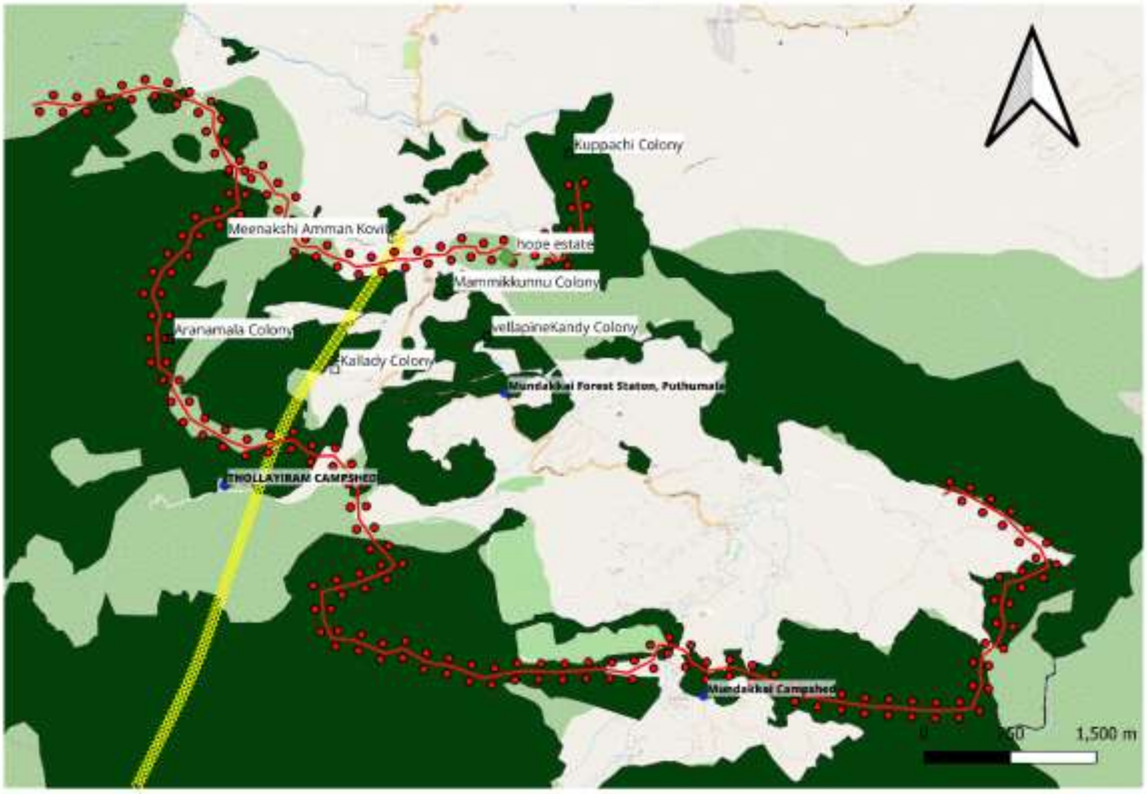
Sl. No.	Name of species	Anakkampoyil (Kozhikode)	Meppadi (Wayanad)	Abundance Rating **	Conservation Status (IUCN/WPA)
	Family: Acrididae				
1.	*Acrida exaltata* (Walker, 1859)	+	+	Common	-
2.	*Phlaeoba antennata antennata* Brunner von Wattenwyl, 1893	+	-	Common	-
3.	*Choroedocus illustris* (Walker, 1870)	+	-	Common	-
4.	*Diabolocatantops innotabilis* (Walker, 1870)	+	+	Common	-
5.	*Xenocatantops humilis* (Serville, 1838)	+	+	Common	-
6.	*Cyrtacanthacris tatarica tatarica* (Linnaeus, 1758)	+	+	Common	-
7.	*Tylotropidius varicornis* (Walker, 1870)	+	-	Rare	-

8.	*Dittopternis venusta* (Walker, 1870)	+	-	Common	-
9.	*Trilophidia annulata* (Thunberg, 1815)	+	+	Common	-
10.	*Chitaura indica* Uvarov, 1929	+	-	Common	-
11.	*Oxya hyla* Serville, 1831	+	+	Common	-
12.	*Spathosternum prasiniferum prasiniferum* (Walker, 1871)	+	+	Common	-
	Family: Chorotypidae				
13.	*Phyllochoreia ramakrishnai* Bolívar, 1914	+	-	Rare	-
	Family: Mastacideidae				
14.	*Paramastacides ramachendrai* (Bolívar, 1930)	+	+	Rare	-
	Family: Pyrgomorphidae				
15.	*Neorthacris acuticeps acuticeps* (Bolívar, 1902)	+	+	Common	-
16.	*Atractomorpha crenulata* (Fabricius, 1793)	+	+	Common	-
17.	*Poekilocerus pictus* (Fabricius, 1775)	+	+	Common	-
18.	*Aularches miliaris miliaris* (Linnaeus, 1758)	+	+	Rare	-
	Family: Tetrigidae				
19.	*Eucriotettix flavopictus* (Bolívar, 1902)	+	-	Rare	
20.	*Euscelimena harpago* (Serville, 1838)	+	-	Common	-
21.	*Euparatettix personatus* (Bolívar, 1887)	+	-	Common	-
22.	*Deltonotus subcucullatus* (Walker, 1871)	-	+	Common	-
23.	*Deltonotus gibbiceps* (Bolívar, 1902)	-	+	Common	-

**The Abundance Rating was determined by considering the frequency of occurrences. "Rare" indicates a single encounter with less than two individuals; "Common" indicates multiple encounters with more than two individuals.

Elephant movement pattern

Information on movement of elephants in the project area and surroundings were collected through discussion with the Forest Staff and famers in the area. Elephant movement in the area was recorded by the staff of the Puthumala Section. A diagrammatic representation was prepared by Shri Jomish K. Johny, Beat Forest Officer. Elephants are seen to move in Punchirimattom, Elamala, Attamala, Erattaikundu Colony, Aranamalai, Chuluka, Cholamalai and then move up to Kuppachi Colony.



FDiagrammatic representation of elephant movement path in Puthumala Section

The schematic diagram indicates the current movement pattern as observed by the Forest Staff and general public. Elephant moves to Kuppachi forest through the Meenakshi Vilasom Estate (Survey No.36), Block 26, Kotta, proposed tunnel mouth (Mr. Pappan's plot) to Meppadi-Chooralmala-Hope Estate. An alternate route would be through Kalladi (Michabhoomi colony)-Vellapinekandi Colony and then to Kuppachi Forest through Hope Estate. Elephants do not cross to Baderi Section, north of Kuppachi due to steep terrain.

At Anakkampoil area of Thamarassery Forest Range, discussions were held with Shri P. Basheer and Shri P. Vijayan (Section Forest Officers) on elephant movement pattern. The farmers who provided information include Shri P.A. Saju (Pottananical, Kundanthodu), Shri A.M. Joseph (Anikkudiyil House, Kundanthodu), Shri K.P. Thankachan (Kootianical house, Kundanthodu), Shri A.J. John (Anakkallungal, Maripuzha), Smt. Alphonsa Joseph (W/o Shri Jose), Smt. Mercy (W/o Shri John) and Shri P.B. Sreekanth (Forest Watcher /Palathingal, Kodenchery).

At Anakkampoil side, the proposed tunnel mouth is on the side of Kundanthodu and is known as Swargam. Swargam is a private hill area with no habitation, but there are a few cultivated areas; these cultivations are mostly in private lands. There are also a few encroached areas. Large scale cultivation is not done mainly because of the interference of elephants. According to the information provided by the Forest Staff and farmers, immediately after the hanging bridge near Kundanthodu, there is a property of Shri Jose. Just above, on the northern side, of Kundanthodu, there is a 10-acre cultivation by Shri Shaji. Just above the plot of Shri Jose, there is the 4-acre property of Shri Saju and the tunnel passes through underside of the property. Three acres of this (of Saju, Kootiyanikkal) is just above the tunnel mouth. This part is reported to be proposed for acquisition. There is also one and half acre plot of Keetappilly Sunny near Shri Shaji’s plot. In Anakkampoil Forest Section, elephants are reported near Muthappanpuzha town area. Elephant movement was also witnessed above the proposed tunnel after the government plots (allotted to 28 people).

Human-wildlife interaction

The negative interaction leading to loss for wildlife and human beings is termed human-wildlife conflict. This is one of the major challenges before the wildlife managers all over the world. Developmental programmes leading to alteration/disturbance to the habitat, loss or degradation of habitat or even significant changes in the environmental quality are considered to have negative impact on the wildlife, its ecology and behaviour. This in turn leads to redirected aggression in the landscape and hence it is considered to make an assessment of the human-wildlife interaction situation in the study area. Dr. P. S. Easa and Shri Dhruv Raj (Aranyakam Nature Foundation) were responsible for the assessment in the proposed project area and surroundings.

The details regarding human death/injury due to wildlife, retaliatory killing of wildlife by human beings in the project area and surroundings were collected for the last few years. Most of the information were collected during discussion with the Forest Staff of Meppadi Range and of Anakkampoil Section of Thamarassery Range. The information on conflict incidences in Puthumala Section of Meppadi Range was mostly provided by Shri Harilal (Range Forest Officer), Shri Mani (Section Forest Officer, Puthumala) and Shri Jomish K. Johny (Beat Forest Officer, Puthumala). The notable conflict incidences in the Puthumala of Meppadi Range, as per record are as follows.

1. Shri Mani, a Watcher working in the Chuluka Estate (13th Number) died during February-March, 2017 in an interaction with elephants. The incident happened about 300 m from the proposed tunnel mouth. Shri Mani lost his life while going for switching on the motor for pumping water. His dependents were paid an ex-gratia amount of Rs. 5 lakhs.

2. On 23 January, 2021, Ms Shahana, a 27-year-old teacher died in an interaction at Elimbileri, about one kilometre air distance from the proposed tunnel area. The Teacher was reportedly staying in a tent pitched as part of Rani Forest Resort in the elephant movement path. The elephant was feeding on date palm on one side of Elimbileripuzha. The tent was on the other side of the river. A jeep came from behind the elephant and the disturbed animal crossed the river and the teacher was unfortunately standing there.
3. In 2021, Smt. Leela of Elamalai had a fracture of the ribs because of an attack by elephants. The location is at about 600-700 m from the proposed tunnel area.
4. On the foothills of Aranamalai S-Valavau, Shri Mohanan (34 years) died in interaction with elephants on 13 June, 2022. The incident was at night and Shri Mohan, belonging to Kattu Naiker community was with a group of people from Aranamala Colony. Shri Mohan was advised not to go closer to the elephant. However, he didn't listen to others and got killed. His family was paid Rs. 10 lakh as ex-gratia.

But for these, there had been no serious conflict incidences. However, a number of cattle lifting incidences by Tiger was reported at Attamalai, about 7.5 km from the proposed tunnel mouth. No conflict incidences are reported from Aranamala and Kalladi Colonies. These locations are about 500 m from the proposed tunnel mouth.

Aquatic life forms

Aquatic life forms associated with river Iruvazhinjipuzha was analysed through sampling in the tunnel-road crossing point (adjacent to the proposed tunnel mouth) and its upstream and downstream areas (two locations each) within 15 km (totalling five locations). Aquatic plant samples were collected from the surface of submerged rocks and other materials by scraping their surface. Samples of plankton were collected with fine meshed plankton net. Benthos, insects and insect larvae were collected by placing a fine meshed net in running water followed by churning and vigorously shaking pebbles and bottom sand in front of it. Samples collected were preserved in 4% buffered formalin for subsequent identification. Fishes from all five sampling locations were collected using different types of nets. Common fishes were identified in the field itself and released into the river. Doubtful specimens were preserved in formalin for later identification using secondary data and keys (Easa and Shaji, 2003; Jayaraman, 2012); conservation status of the fishes was ascertained as per IUCN Red list.

Planktons, macrophytes and benthic fauna

Phytoplanktons of the river stretch represent (i) Cyanophyta (Oscillatoriales and Nostocales) (ii) Chlorophyta (Chaetophorales and Zygnematales). Notable macrophytes of are *Indotristicha ramosissima, Dalzellia zeylanica, Polypleurum wallichii* (Karimpayal) and *Zeylanidium lichenoides* of family Podostemaceae. Of these, one species *Indotristicha* *ramosissima* is endemic. While zooplanktons are represented by the groups (i) Cladocera (ii) Copepoda (iii) Diptera (iv) Protozoa and (v) Rotifera. The benthic fauna consisted mainly of insects, insect larvae and worms.

Fishes

A total of 22 species of fishes were recorded during the present study (Table-4.32). Of these, two species, *Horabagrus brachysoma* and *Carinotetraodon travancoricus*, are assessed as 'Vulnerable', one species *Anguilla bengalensis* as 'Near Threatened', one species *Opsarius malabaricus* as 'Not Evaluated', and the remaining as 'Least Concern' in the IUCN Red List of Threatened Species.

Table-4.32: Fishes found in Iruvazhinjippuzha (Anattampoil stretch)

Sl. No.	Name of species	Common/local name	Family	Status (IUCN)
1.	*Anabas testudineus* Bloch	Climbing perch, Karooppu	Anabantidae	Least Concern
2.	*Anguilla bengalensis* J.E. Gray	Long fin eel, Mlanjil	Anguillidae	Near Threatened
3.	*Aplocheilus lineatus* Valenciennes	Malabar killifish	Aplocheilidae	Least Concern
4.	*Opsarius malabaricus* Jerdon	Malabar baril, Poovalchi	Cyprinidae	Not Evaluated
5.	*Channa gachua* Hamilton	Dwarf snakehead	Channidae	Least Concern
6.	*Channa striata* Bloch	Striped snakehead, Varal	Channidae	Least Concern
7.	*Devario malabaricus* Jerdon	Malabar danio	Daniodinae	Least Concern
8.	*Garra stenorhynchus* Jerdon	Nilgiri garra, Kallunthi	Cyprinidae	Least Concern
9.	*Garra mullya* Sykes	Mulliya garra. Kallotti	Cyprinidae	Least Concern
10.	*Glyptothorax annandalei* Hora	Sucker catfish, Kalkari	Sisoridae	Least Concern
11.	*Horabagrus brachysoma* Gunther	Yellow catfish, Manjakkoori	Horabagridae	Vulnerable
12.	*Mastacembelus armatus* Lacepede	Malabar spiny eel, Kallarokan	Mastacembelidae	Least Concern
13.	*Mesonoemacheilus guentheri* Day	Gunther's loach, Koyma	Nemaccheilidae	Least Concern
14.	*Ompok malabaricus* Valenciennes	Butter catfish, Thonnavala	Siluridae	Least Concern
15.	*Parambassis thomassi* Day	Western Ghat perchlet	Ambassidae	Least Concern
16.	*Pseudsophromenus cupanus* Valenciennes	Karinkana	Osphronemidae	Least Concern
17.	*Haludaria fasciata* Jerdon	Melon barb, Vazhakkavarayan	Cyprinidae	Least Concern
18.	*Dawkinsia filamentosa* Valenciennes	Filament barb	Cyprinidae	Least Concern
19.	*Salmostoma acinaces* Valenciennes	Silver razor belly minnow, Mathiparal	Danionidae	Least Concern
20.	*Carinotetraodon travancoricus* Hora & K.K. Nair	Travancore puffer fish	Tetraodontidae	Vulnerable
21.	*Tor malabaricus* Jerdon	Black Masheer, Kuyil	Cyprinidae	Least Concern

22.	*Xenentodon cancila* F. Hamilton	Freshwater garfish	Belonidae	Least Concern

Of the fishes found in the study area, *Anguilla bengalensis* and *Tor malabaricus* are considered as migratory species. Certain fishes make only short distance movements within a limited space mainly for the purpose of feeding. In stream fishes spawning takes place among large pebbles, gravel beds, rooted vegetation, twigs and sandy substratum, where there is low water flow and higher depth. Rapids are not ideal for spawning of stream fishes. No specific breeding grounds of fishes were found the present river stretch during the study. Commercial fishery as such does not exist in the river stretch. Only sustenance fishing exists in certain parts of the river; local inhabitants occasionally catch fishes for their own consumption.

4.9. Socio-Economic and Health Environment

4.9.1 Revenue and Administrative Jurisdiction

The proposed project site falls in ward number 01 Thiruvambady grama panchayath and 07 of Kodanchery gramapanchayath and revenue jurisdiction of Thiruvambady village in Thamarassery taluk of Kozhikode district of Kerala, on the South zone. Ward numbers 08, 09 and 13 of Meppadi gramapanchayath and revenue jurisdiction of Vellarimala village in Vythiri taluk of Wayanad District of Kerala, on the north zone.

4.9.2. Towns and Villages along the Project Corridor

The project tunnel passes mainly through forest and no major/minor settlements along the alignment. Major settlements within 15 km radii of the alignment and its distance to the alignment is presented in **Table 0.19.**

Table 0.19. Details of Settlements within 15 km radii of the Project Alignment

Sl No	Name of the Settlement	Approx. Distance to the Project Alignment (km)
1	Maripuzha	0.04
2	Kalladi	0.42
3	Nellimunda	1.76
4	Muthappanpuzha	1.79
5	Cholamala	2.66
6	Meppadi	3.47
7	Punchiri Mattam Colony Mundakkai	3.61
8	Vellarimala Colony	3.65
9	Thinapuram	3.68
10	Chooralmala	3.78
11	Vavul Mala	4.16
12	Rippon	4.27
13	Vellarimala	4.33
14	Attamala	4.65
15	Kappenkolly	4.83
16	Anankkampoyil	5.02
17	Nedumkarana	5.63

Sl No	Name of the Settlement	Approx. Distance to the Project Alignment (km)
18	Nellipoyil	6.70
19	Chembukadavu	6.80
20	Poovaranthode	7.77
21	Pullurampara	8.12
22	Medappara	8.16
23	Padivayal	8.20
24	Ponnamkayam	8.44
25	Urumi	9.99
26	Chunadale	10.00
27	Punnakkal	10.25
28	Adivaram	10.29
29	Vaduvanchal	10.42
30	Chitragiri	10.46
31	Manjakkadavu	10.66
32	Kodencherry	10.73
33	Pookode	10.79
34	Kuliramutti	10.83
35	Vythiri	10.89
36	Lakkidi	11.03
37	Murampathy	11.08
38	Kalpetta	11.55
39	Velamcode	12.33
40	Choladi	12.41
41	Kakkadampoyil	12.77
42	Karimkutty	13.20
43	Vendekkumpoyil	13.31
44	Kainatti	13.38
45	Muttil	13.51
46	Koodaranhi	13.72
47	Vengappaly	13.73
48	Ambalavayal	13.87
49	Thiruvambady	14.16
50	Pozhuthana	14.53
51	Nelliyalam	14.62
52	Maikave	14.65
53	Engapuzha	14.68

4.9.3. Demographic Profile

Demographic Profile of the Project Districts

Census of India, 2011 gives the Kozhikode district a ranking of 115th in India. In 2011, Kozhikode had population of 3,086,293 of which male and female were 1,470,942 and 1,615,351 respectively. In 2001 census, Kozhikode had a population of 2,879,131 of which males were 1,399,358 and remaining 1,479,773 were females. There was change of 7.20 percent in the population compared to population as per 2001.

In 2011, Wayanad had population of 817,420 of which male and female were 401,684 and 415,736 respectively. In 2001 census, Wayanad had a population of 780,619 of which males were 391,273 and remaining 389,346 were females. Wayanad District population constituted 2.45 percent of total Kerala population[K10]. There was change of 4.71 percent in the population compared to population as per 2001.

Table 0.20 gives a comparative picture of the various socio-economic indicators for the Project districts.

Table 0.20. Demographic Profile of the Project Districts*

Sl No.	Demographic Indicators	Kerala State	Kozhikode District	Wayanad District
1	Total Area in Sq.Kms.	38,852	2345	2132
2	Total Population (Nos)	33,406,061	3,086,293	817,420
3	Male Population (Nos)	16,027,412	1,470,942	401,684
4	Female Population (Nos)	17,378,649	1,615,351	415,736
5	Sex ratio (Ratio of males to females in total population)	1,084	1098	1051
6	Scheduled Caste (Nos)	3,039,573	1,991,191	32,578
7	Scheduled Tribe (Nos)	484,839	15,228	151,443
8	Decadal Population Growth (2001-2011) Percentage	4.91	7.2	6.6
9	Population Density (Persons/Sq.Km)	860	1316	775
10	Literacy rate (Percentage) total population	94	95	91
11	Literacy rate (Percentage) male population	96.11	97	94
12	Literacy rate (Percentage) female population	92.07	93	88
13	Total Workers (Main & Marginal) Nos	11,619,063	948,991	34,007
14	Total main workers (Nos)	9,329,747	754,187	263,445
15	Total male main workers (Nos)	7,179,828	637,099	191,411
16	Total female main workers (Nos)	2,149,919	117,088	72,034
17	Cultivators (Nos)	670,253	19,905	46,410
18	Agricultural labourers (Nos)	1,322,850	37,555	69,133
19	People working in Household industry (Nos)	273,022	9,228	2,917
20	People working in Other activities (Nos)	9,352,938	687,499	144,985

4.9.4. Demographic Profile of IIZ

Demographic profile of the villages and grama panchayats were studied to understand the socio-economic profile of the Indirect Impact Zone (IIZ) of the project, i.e., 15 km either side of the project alignment. Detailed analysis of Census Data-2011, village records and other published works were refered for the study.

Kodenchery, Nellippoyil, Thiruvambady, Puthuppady, Engapuzha, Raroth, Kedavur, Koodaranhi are the villages coming to the southern side of the alignment. Kottapady, Vellarimala, Thrikaipetta, Chundale, Kunnathidavaka, Pozhuthana, Muttil South, Vengappally and Muppainad area the villages in northern side of the alignment. Demogarphic characteristics of the project villages are briefed in **Table 0.21.**

Table 0.21. Demographic Profile of the Project Villages (in IIZ)†

Sl No	Name of the Village	No of HH	Population			0-6 Age Group			SC	ST
			Total	Male	Female	Total	Male	Female		
South Zone										
1	Kodenchery	5210	21268	10476	10792	2197	1128	1069	1224	886

* Source: Census of India, 2011

† Source: Census of India, 2011

Sl No	Name of the Village	No of HH	Population			0-6 Age Group			SC	ST
			Total	Male	Female	Total	Male	Female		
2	Nellippoyil	1727	7043	3478	3565	701	384	317	271	16
3	Thiruvambady	6771	28820	13998	14832	3278	1680	1598	1673	365
4	Puthuppady	6271	26886	12882	14004	3422	1769	1653	2549	553
5	Engapuzha	3535	15197	7266	7931	1970	1017	953	1391	71
6	Raroth	6345	27435	13100	14335	3206	1553	1653	2974	114
7	Kedavur	1827	8271	3953	4318	1095	566	529	400	13
8	Koodaranhi	4423	18678	9242	9436	2076	1041	1035	812	627
North Zone										
1	Kottapady	6312	27890	13446	14444	3459	1763	1696	2674	2152
2	Vellarimala	1077	4669	2301	2368	540	278	262	598	130
3	Thrikaipetta	1272	5226	2602	2624	511	259	252	230	1295
4	Chundale	1286	5490	2597	2893	622	307	315	1224	207
5	Kunnathidavaka	2,873	12815	6218	6597	1472	706	766	1584	1082
6	Pozhuthana	1161	4771	2306	2465	585	302	283	351	2104
7	Muttil South	4952	21384	10328	11056	2481	1258	1223	567	3416
8	Vengappally	2478	10931	5334	559	1289	678	611	250	2740
9	Muppainad	4721	20877	10190	10687	2464	1222	1242	1457	1213

Demographic Profile of the LSGs coming in IIZ:

There are 24 Local Self Government institutions are coming within 15 km radii of the project alignment (IIZ). Map showing the LSGs coming wihin the IIZ is presented in **Figure 0-25**. Out of these Mukkam and Kalpetta are municipalities and remainings are gram panchayaths. General demographic profile of these LSG institutions are given in **Table 0.22.**

The project alignment passes through Thiruvambadi and Kodenchery gram panchayaths of Kozhikode district and Meppadi gram panchayath of Wayanad district. Out of these, Meppadi panchayath is the most populated panchayath (37,785), followed by Kodenchery (34,854) and Thiruvambadi (28,820) panchayths. 3,577 tribes (1,792 males & 1785 females) are residing at Meppadi panchayath. Tribal population of Kodenchery and Thiruvambadi panchayaths are 1003 and 365. Kodenchery panchayath (29,761) show the highest literacy among the project panchayaths, followed by Meppadi and Thiruvambadi panchayaths. Details are presented in the following table.

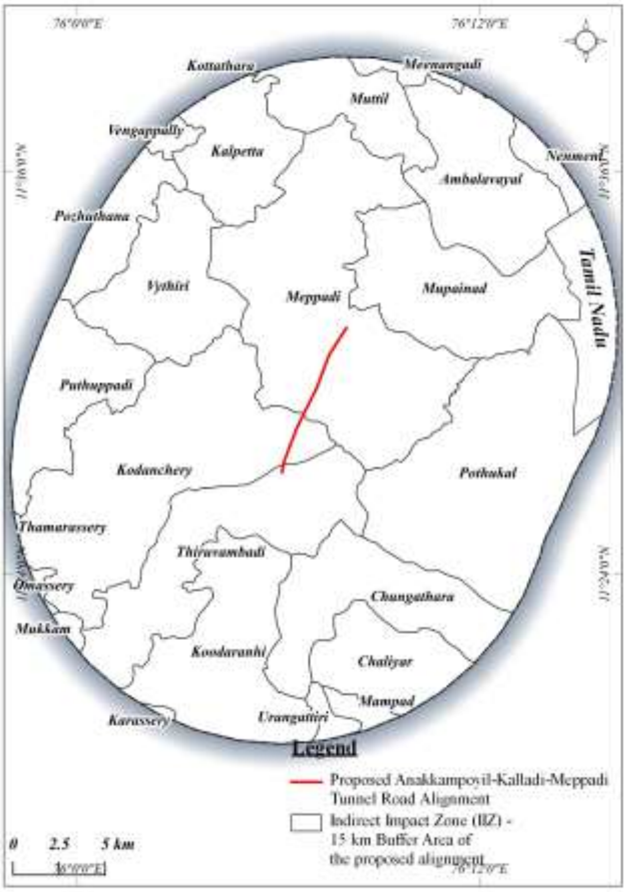


Figure 0-25. LSG Institutions Coming in IIZ

Table 0.22. Demographic Profile of the Project LSGs (in IIZ)*

Sl No	Name of the District	Name	Type	No. of HH	Total Population			Age group 0-6			Scheduled Castes			Scheduled Tribes			Literates		
					Persons	Male	Female	Persons	Male	Female	Persons	Male	Female	Persons	Male	Female	Persons	Male	Female
1	Wayanad	Pozhuthana	GP	4,256	18,406	8,854	9,552	2,433	1,257	1,176	1,222	620	602	3,622	1,824	1,798	13,802	6,907	6,895
2		Kottathara	GP	3,787	16,670	8,195	8,475	1,914	953	961	531	259	272	4,808	2,337	2,471	13,092	6,724	6,368
3		Vengappally	GP	2,676	11,756	5,735	6,021	1,352	706	646	266	125	141	2,977	1,473	1,504	9,143	4,622	4,521
4		Meenangadi	GP	8,199	33,450	16,624	16,826	3,381	1,696	1,685	908	477	431	7,775	3,843	3,932	27,111	13,948	13,163
5		Ambalavayal	GP	8,568	35,207	17,214	17,993	3,706	1,844	1,862	955	495	460	5,867	2,813	3,054	28,434	14,332	14,102
6		Nenmeni	GP	11,330	46,950	22,929	24,021	4,904	2,499	2,405	1,866	910	956	7,871	3,786	4,085	37,717	19,028	18,689
7		Vythiri	GP	4,159	18,305	8,815	9,490	2,094	1,013	1,081	2,808	1,420	1,388	1,289	627	662	14,670	7,324	7,346
8		Kalpetta	M	7,519	31,580	15,401	16,179	3,597	1,836	1,761	2,200	1,125	1,075	3,228	1,465	1,763	25,515	12,769	12,746
9		**Meppadi**	**GP**	**8,661**	**37,785**	**18,349**	**19,436**	**4,510**	**2,300**	**2,210**	**3,502**	**1,786**	**1,716**	**3,577**	**1,792**	**1,785**	**29,491**	**14,856**	**14,635**
10		Muttil	GP	7,998	35,281	17,150	18,131	4,169	2,133	2,036	1,030	521	509	5,279	2,617	2,662	27,636	13,863	13,773
11		Mupainad	GP	5,562	24,590	11,936	12,654	2,858	1,416	1,442	1,832	906	926	1,899	899	1,000	19,476	9,856	9,620
12	Kozhikode	Mukkam	M	3,602	15,554	7,574	7,980	1,947	1,039	908	1,545	753	792	55	24	31	12,769	6,334	6,435
13		Karassery	GP	6,847	31,536	15,114	16,422	4,167	2,163	2,004	3,026	1,488	1,538	606	297	309	26,028	12,577	13,451
14		Puthuppadi	GP	9,806	42,083	20,148	21,935	5,392	2,786	2,606	3,940	1,875	2,065	624	331	293	34,619	16,801	17,818
15		**Kodanchery**	**GP**	**8,578**	**34,854**	**17,170**	**17,684**	**3,529**	**1,829**	**1,700**	**1,913**	**943**	**970**	**1,003**	**483**	**520**	**29,761**	**14,805**	**14,956**
16		**Thiruvambadi**	**GP**	**6,771**	**28,820**	**13,988**	**14,832**	**3,278**	**1,680**	**1,598**	**1,673**	**776**	**897**	**365**	**154**	**211**	**24,629**	**12,011**	**12,618**
17		Koodaranhi	GP	4,423	18,678	9,242	9,436	2,076	1,041	1,035	812	412	400	627	310	317	15,836	7,919	7,917
18		Omassery	GP	7,933	35,009	16,764	18,245	4,595	2,293	2,302	3,340	1,622	1,718	132	56	76	28,725	14,072	14,653
19		Thamarassery	GP	8,172	35,706	17,053	18,653	4,301	2,119	2,182	3,374	1,635	1,739	127	57	70	30,192	14,641	15,551
20	Malappuram	Pothukal	GP	6,072	28,077	13,498	14,579	3,580	1,831	1,749	1,039	503	536	1,294	603	691	22,759	11,099	11,660
21		Chungathara	GP	8,054	36,269	17,326	18,943	4,634	2,363	2,271	2,530	1,224	1,306	2,237	1,044	1,193	29,247	14,130	15,117
22		Chaliyar	GP	4,614	20,834	10,059	10,775	2,677	1,345	1,332	1,473	725	748	2,058	1,005	1,053	16,295	8,092	8,203
23		Mampad	GP	7,533	37,221	18,037	19,184	5,539	2,870	2,669	2,923	1,464	1,459	1,209	597	612	29,675	14,561	15,114
24		Urangattiri	GP	8,300	40,297	19,925	20,372	5,509	2,757	2,752	3,255	1,624	1,631	1,052	531	521	32,517	16,437	16,080

* Source: Census of India, 2011

4.9.5. Workforce Population

The work force classification in the project panchayaths (Meppadi, Kodanchery & Thiruvambadi) helps in formulating strategies in any development programme. It also helps in identifying the potential workforce, their aptitude, skill etc in any targeted population. As per Census data, 2011, the panchayathwise work group participation is as follows.

Table 0.23. Workforce Population of the Project Panchayaths

Sl No	Description	Population		Meppadi GP	Kodanchery GP	Thiruvambadi GP
1	Total Workers	Persons		14,882	12,526	11,477
		Male		9,918	9,544	7,710
		Female		4,964	2,982	3,767
2	Main Workers	Persons		11,858	10,112	9,041
		Male		8,508	8,043	6,650
		Female		3,350	2,069	2,391
3	Cultivators	Main Workers	Persons	857	1,199	2,195
			Male	748	955	1,647
			Female	109	244	548
4	Agricultural Labours		Persons	1,572	1,015	1,831
			Male	1,048	758	1,300
			Female	524	257	531
5	Household industry workers		Persons	155	107	112
			Male	117	82	85
			Female	38	25	27
6	Other workers		Persons	9,274	7,791	4,903
			Male	6,595	6,248	3,618
			Female	2,679	1,543	1,285
7	Marginal Workers	Persons		3,024	2,414	2,436
		Male		1,410	1,501	1,060
		Female		1,614	913	1,376
8	Cultivators	Main Workers	Persons	188	128	443
			Male	85	88	129
			Female	103	40	314
9	Agricultural Labours		Persons	665	405	544
			Male	307	246	266
			Female	358	159	278
10	Household industry workers		Persons	57	27	56
			Male	23	11	29
			Female	34	16	27
11	Other workers		Persons	2,114	1,854	1,393
			Male	995	1,156	636
			Female	1,119	698	757
12	Non - workers	Persons		22,903	22,328	17,343
		Male		8,431	7,626	6,278
		Female		14,472	14,702	11,065

Thiruvambadi panchayath has the maximum per cent of work force. Out of the total population, 12,526 persons (about 39.82%) are workers and 17,343 (about 60.18%) persons are non-workers. This can be inferred that almost half of the population is depending on others for their livelihood.

Kodenchery panchayath has least working population (35.94% of total population). Meppadi panchayath has working population of 39.39% of total population.

4.9.6. Brief Description of Socio-Economic Profile of PAPs

This section comprises of the details of the families that are directly and indirectly affected by the project, extend of impact and the mitigation measures. The objective of Social Impact Assessment is to enumerate affected land and structures, affected families and persons, and to identify extent of social impacts.

Methodology: In order to capture data for the study, present exercise, both primary as well as secondary sources were systematically tapped. As part of the study, census, socio-economic survey has been conducted in the Direct Impact Zone (500 m either side of the project alignment) to list out the favorable and adverse impacts due to the project.

Ward No. 08 (Nellimuda), Ward No. 09 (Puthumala) and Ward No. 13 (Chulika) of Meppady Panchayath in Wayanad district and Ward No. 01 (Muthappanpuzha) of Thiruvambadi Panchayath and Ward No. 07 (Kooruttupara) of Kodanchery Gramapanchayath in Kozhikode district are the surrounded area (within 500 m buffer) of the project alignment and hence the DIZ. Random sampling was adopted for the study. 31 families were surveyed in the southern portion of project alignment (Aanakkampoyil side) and 22 families were surveyed in the northern portion of the project alignment (Meppadi side) including a tribal settlement observed within DIZ, Aranamala Kattunaikka Colony. Due to the COVID-19 outbreak situation, survey is restricted only to the houses where COVID patients were not observed.

4.9.6.1. Estimation of Families.

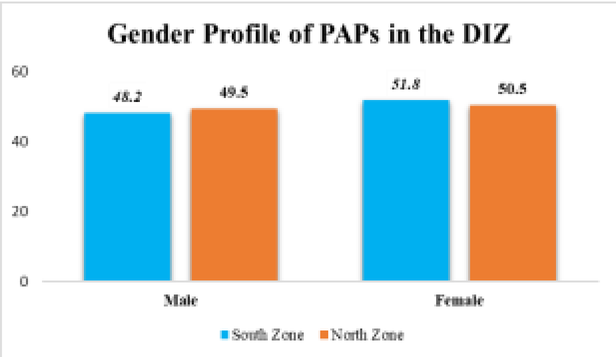
50 families were surveyed in the southern portion of project alignment (Aanakkampoyil side) and 123 families were surveyed in the northern portion of the project alignment (Meppadi side) including a tribal settlement observed within DIZ, Aranamala Kattunaikka Colony. Out of these 27 families were identified as PAFs (Project Affected Families) during this survey.

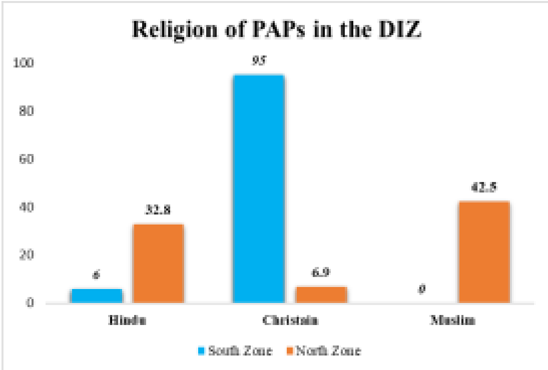
General characteristics of population of the DIZ is as follows.

Table 0.24 (a). General Characteristics of the Population

Sl No	Description	Side	%			
1	Population		**Male**		**Female**	**ST**
		South Zone	48.2		51.8	-
		North Zone	49.5		50.5	17.8
2	Religion		**Hindu**	**Christain**	**Muslim**	**Others**
		South Zone	6	95	0	0
		North Zone	32.8	6.9	42.5	0

Sl No	Description	Side	%						
3	Age Compositio n		**0-6**	**6-14**	**14-25**	**25-40**	**40-60**	**60-70**	**70-85**
		South Zone	1.90	6.30	15.60	20.7	29.3	16.9	9.30
		North Zone	8.2	9.3	13	27.7	27	11	3.8
4	Occupation	South Zone	**Agricult ure**	**Govt. Service**	**Private**	**Driver**	**Expatri at**	**Cow Rearing**	**Other**
			88.8	6.6	3.9	9	3.3	7.7	16
		North Zone	**Agricult ure**	**Govt. Service**	**Business**	**Driver**	**Expatri ate**	**Coolie**	**Other**
			7	3	3	6	7	50	23





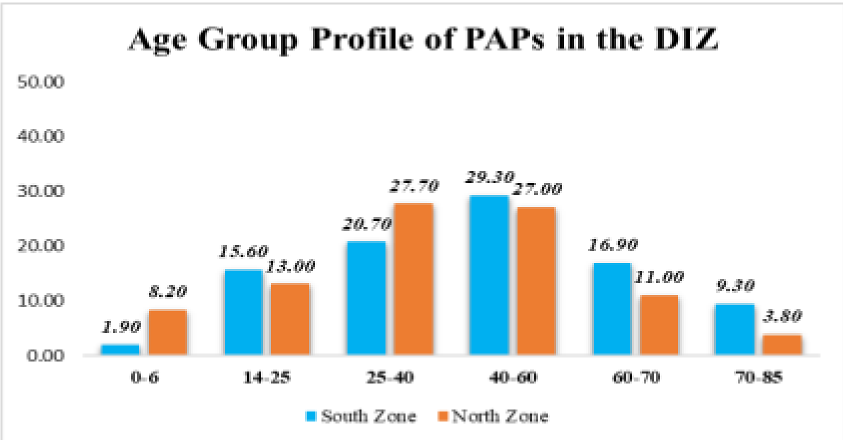


Figure 0-26. Graphical Representation of Profile of the PAP's in DIZ

The above table reveals the female population of southern side is almost equal tothat of the northern region of the project area. About 50.95 % of total population belongs to Christians followed by 19.4 % of Hindus and 21.25% of Muslims. The working-age population is the total population in an area that is considered able and likely to work based on the number of people in a predetermined age range. It observered that 17% of people are families belonging to Schedule Tribes in the North zone .

Among the 32 tribal settlement clolonies within Meppady forest range, Aranamala Mammikkunnu, Kuppachi and Kalladi Colony is located within the 500 to 1.5 km to the proposed tunnel road.

The principal tribes living in the forest plateau are Mullukurumas, Paniyans, Kattunaikas, Uralis and few Kurichiyars.The Kuttanaikas are considered the least civilized among the jungle dwellers and subsist on the forest collecting NTFP(Non-Timber Forest Products) such as honey, tubers,fruits,etc. The Paniyans used to practice shifting cultivation, but now they extend their labour to neighbouring estates and Forest Department. Details of tribal settlements in the forest areas of Meppady is added as attachment in Annexure 48.

4.9.6.2. Socio-Economic Status of DIZ

Various parameter were surveyed in the DIZ and summary of the same is presented in **Table 0.25**.

Table 0.25. Socio-Economic Status of the DIZ

Sl No	Description	Side	%				
1	Type of House		**Concrete**	**Tiled**	**Thatched**	**Asbestos**	
		South Zone	75	15	5	5	
		North Zone	63.5	15.5	10.5	10.5	
2	Toilet Facility		**With Toilet**		**Without Toilet**		
		South Zone	97		3		
		North Zone	99		1		
3	Drinking Water		**Own Well**	**Gravity Source**	**Jalanidhi**	**Public Tap**	
		South Zone	25	70	2.5	2.5	
		North Zone	37	49	1.5	4.6	
4	Land Holding	South Zone	**<60 Cent**	**60 Cent -1 Acre**		**1 – 5 Acre**	**>5Acre**
			27.58	41.4		27.58	3.44
		North Zone	**<10 Cent**	**10-25 Cent**	**25 Cent – 1 Acre**	**1 – 5 Acre**	**>5Acre**
			29.17	52.38	9.53	4.76	4.16
5	Duration of Occupancy		**Other**	**5-10 Yrs.**	**10-15 Yrs.**	**15-25 Yrs.**	**25-50 Yrs.**
		South Zone	-		6.8	-	93.2
		North Zone		9	13.6	22.7	54.7

4.9.6.2.1. Income and Proverty Level

Ration card issued by Civil Supplies Department was considered to assess the poverty level of the project region. Kerala Ration cards have four different colour. Types of ration card in Kerala are tabulated below:

Ration Card Colour		**Beneficiaries**
Yellow Card	:	Most economically backward section of society. Antyodaya Anna Yojana Beneficiaries
Pink Card	:	Priority or Below Poverty Line (BPL)
Blue Card	:	Non – Priority subsidy or Above Poverty Line (APL)
White Card	:	Non – Priority

Region wise poverty level profile in terms of ration card issued is given in **Figure 0-27**. As per the survey, 50% of population in the southern region belong to non-priority category. i.e., they are economically sound. But in northern region, 55% of total population belongs to BPL category, where in the southern region it is only 13 % of the total population. 12 % of total population in northern region is belongs to "Most economically backward class", whereas in the southern region, it is only 2.5%. Overall, the southern region is observed with more economically sound population compared to northern region.

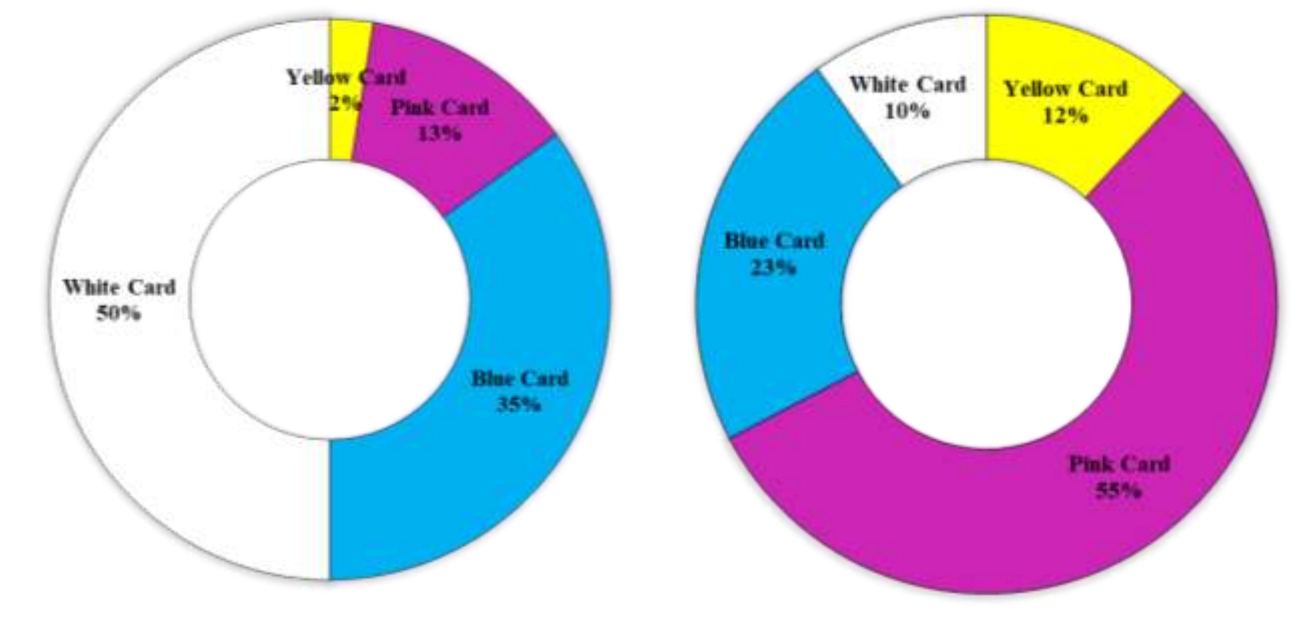


Figure 0-27. Graphical Representation of Profile of Poverty Level of PAP's in DIZ poverty Level of PAP's in DIZ

4.9.6.2.2. Literacy and Level of Education

Literacy and level of education are basic indicators of the level of development achieved by a society. Literacy forms an important input in overall development of individuals enabling them to comprehend their social, political and cultural environment better and respond to it appropriately. Literacy and level of education were assessed during the primary survey.

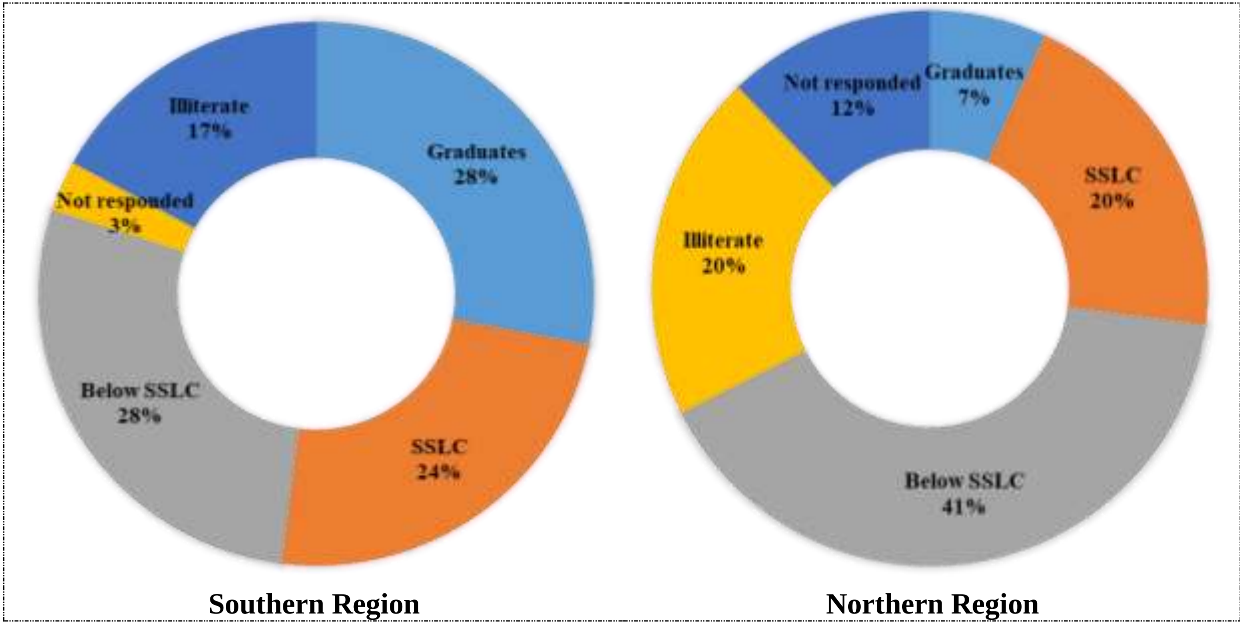
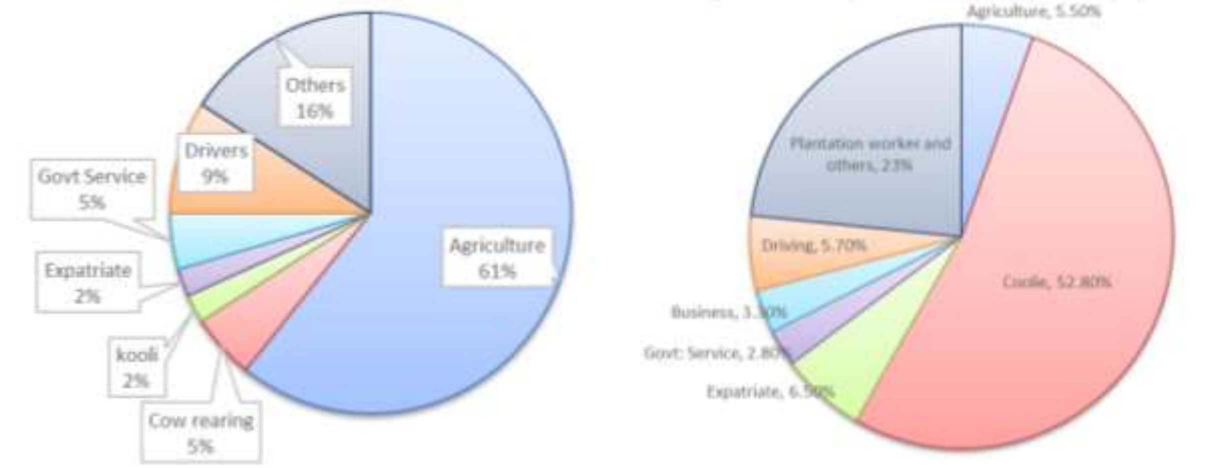


Figure 0-28. Graphical Representation of Literacy and Level of Education of PAP's in DIZ

The survey reveals that level of education for southern region is quite good compared to the northern region. 52 % of PAPs in the southern region is either SSLC or graduates, but in the northern region, it is only 27 %. The 17% of the PAPs in southern region is illiterate and 20 % for the northern region. 3% of PAPs in southern region and 12 % of PAPs in northern region are not willing to respond to the question.

4.9.6.2.3. Major Source of Income

Employment/occupation either in agriculture sector was the major source of income for most of the surveyed households in the DIZ. 6.6 % in south side and 2.8% in north side of the surveyed population worked in govt. sector. 3.3 % of surveyed population in the northern region is doing business. 13.3 % in south side and 5.7% in north side of the surveyed population worked as driver. Around 3.3 % in southern side and 6.5 % in northern population are expatriate. 52.8% of surveyed population in the northern side are daily wage labourers. 7.7 % of households in the southern region grazed cattle and goats in the pastures in the DIZ and earns an income. Income from casual/temporary jobs or other jobs was also one of the major source of income for almost all the households from northern region, which is contributed about 23.3% of the population in southernside and 23% of the northernside.



Southern Region **Northern Region**

Figure 0-29. Graphical Representation of Major Source of Income in the DIZ

4.9.6.2.4. Vulnerable Groups

Table 0.26 gives an overall picture on the type and volume of vulnerable groups and households covered through the SIA study. Most of the households in the directly affected groups are found to be comparatively better off than those at the indirectly affected group. However, there are three families belonging to BPL list amongst whom one household accommodated one differently abled person. This particular household was suffering from severe social and economic constraints. There was no Scheduled Caste or Scheduled Tribe household in [M A11]this category. Further, two households were female headed.

Table 0.26. Vulnerable Groups and population in the DIZ

Sl No	Group	Number	
		Southern Region	Norther Region
1	Children	15	6
2	Differently abled	0	1
3	Elderly	26	11
4	Schedule Tribe Family	0	17
5	BPL Family	4	16
6	Women	63	36

[M A12]4.9.6.2.5. Health Status

Health is a multi-dimensional concept, which "encompasses a complete state of physical, mental, and social wellbeing and not merely the absence of disease or infirmity". Health status of the PAPs in the DIZ were surveyed and the outcome is presented in **Figure 0-30**.

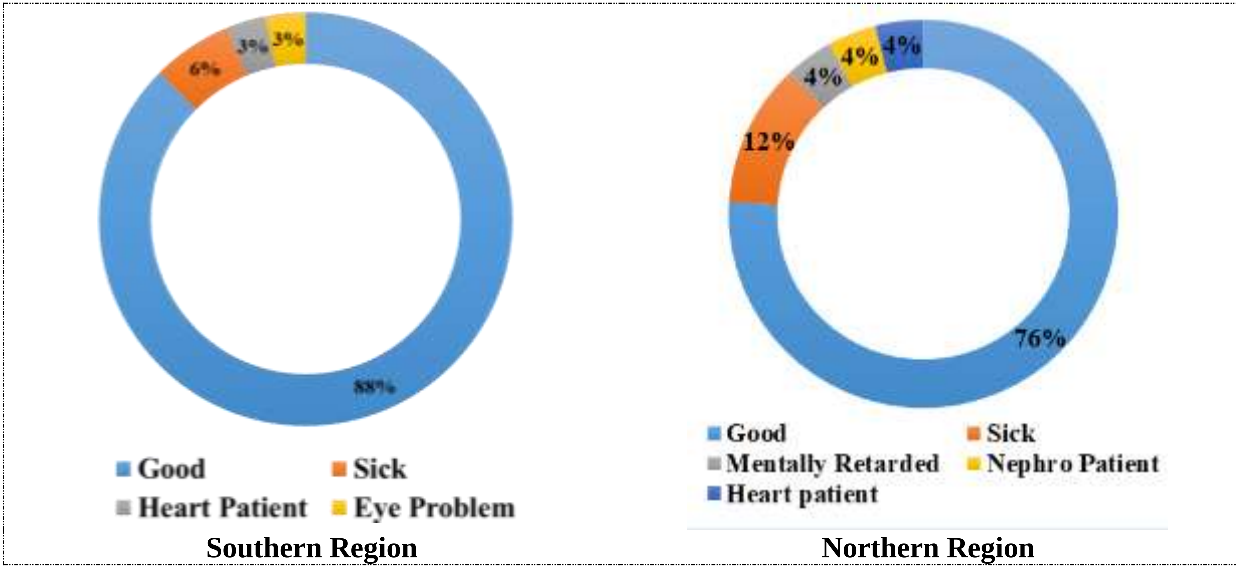
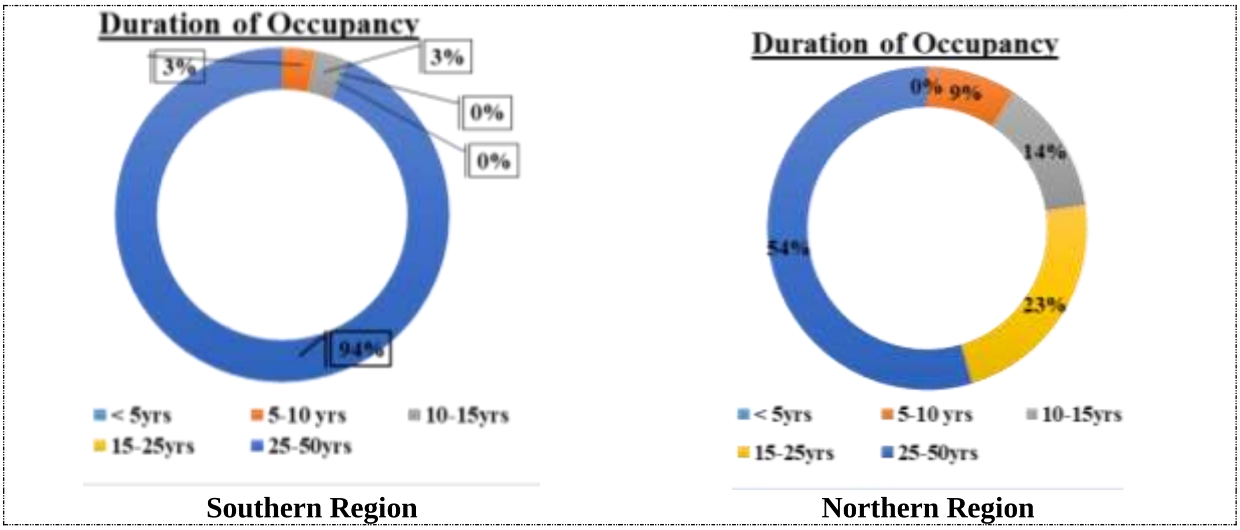


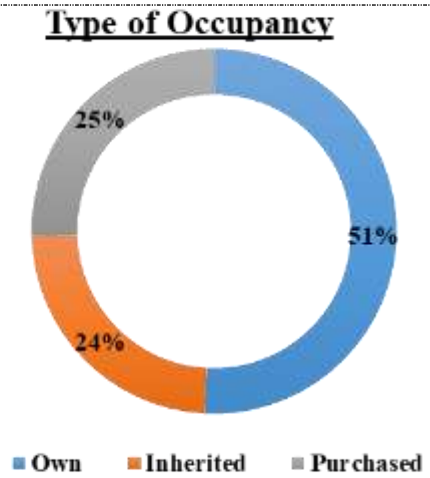
Figure 0-30. Graphical Representation of Health Status of PAP's in DIZ

The survey results reveals that health status of the PAPs in both regions is comparatively good. Covid-19 pandemic threaten situation is observed in many of the surveyed places. 3 % of the PAPs in the southern region and 4 % of the PAPs in the northern region is suffered with cardiac problems.

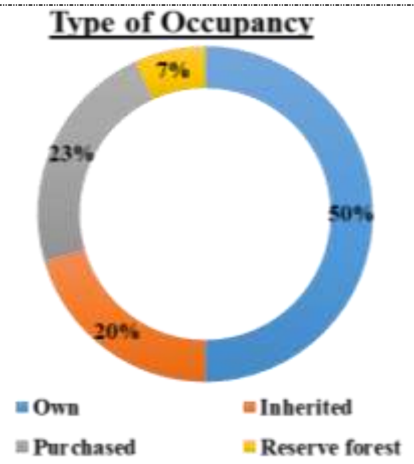
4.9.6.2.6. Details of Residence

Details of residence were assessed with various parameters like, duration of occupancy, type of occupancy, type of house, type of floor etc. Summary of these results are presented graphically in **Figure 0-31**.

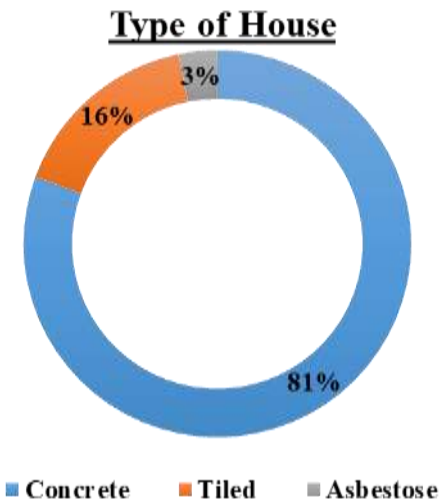




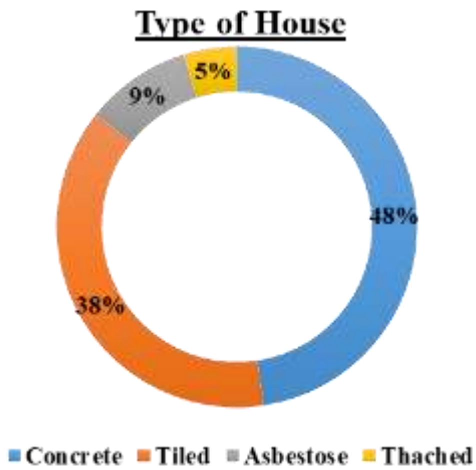
Southern Region



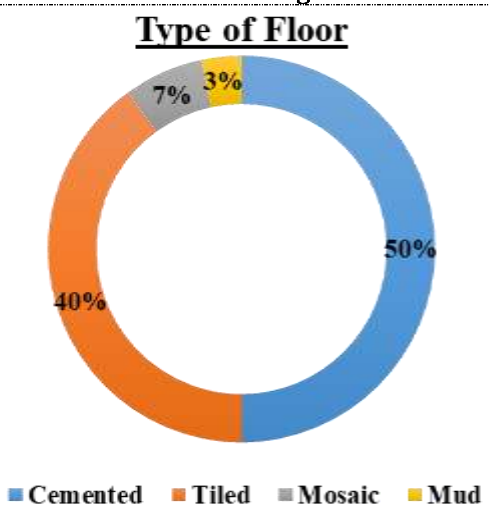
Northern Region



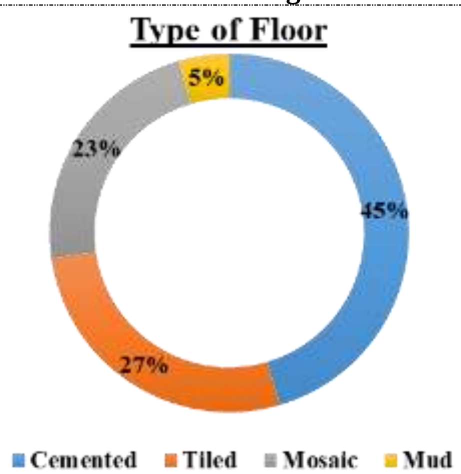
Southern Region



Northern Region



Southern Region



Northern Region

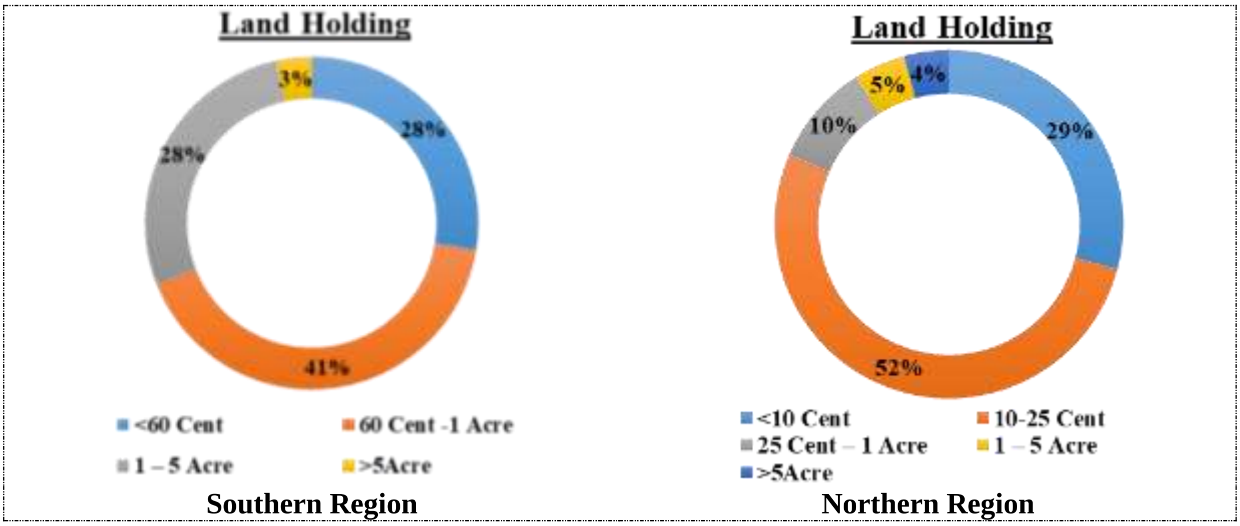


Figure 0-31. Graphical Representation of Details of Residence of PAP's in DIZ

4.9.6.2.7. Access to Services

Water supply through gravity and own wells were the primary sources of water for the PAFs in the DIZ. A few households holds public tap and Jalanidhi connection for their primary source of water. With respect to the directly affected group, the quantity and quality of water is not affected in anyway because of the project as major part of the alignment passes through tunnel and as they live at different places away from the project site.

Safe toilet and closed bathing space is being used by cent percent of the households in the DIZ. Eventhough it is reported that one of the respondent in the northern region uses public toilet facility with septic tank or single pit mode for the purpose. All the respondent in the southern region have gas connection and electricity. All the respondents in the northern region have electricity connection in their house, but only 19 of them have gas connection. Details of the estimation is presented in the following table.

Table 0.27. Details of Access to Service (Households)

Item		No. of Families in	
		Southern Region	Northern Region
Source of Water			
1	Open Well	8	9
2	Gravity	21	11
3	Jalanidhi	1	-
4	Public tap	-	1
5	Not responded	1	1
Toilet Facility			
1	Own	30	21
2	Other	0	1
3	Not responded	1	0
Electricity		31	22
Gas Connection		31	19
Total No. of Families Surveyed		**31**	**22**

4.9.6.2.8. Credit Facility

42% (13 Nos.) (in southern portion) and 27% (6 Nos) (in northern portion) of the surveyed households had availed credit facilities for various reasons. The major purposes for availing the credit facility were house maintenance, business and agriculture.

Co-operative banks, public sector banks and private sector banks were the major sources utilized for availing the credit facility. In the northern region, among the six households who availed the credit, four had taken it from nationalized bank, and one each from Cooperative bank and private sector banks. Whereas in the southern region, among the thirteen households, six had taken it from nationalized bank, nine had taken from cooperative bank and two respondents had taken from both the above banks.

4.9.7. Infrastructure Facilities within the IIZ

List of educational institutes, health care institutues, religious worship places were given in **Table 0.1**. Other infrastructure facilities like public utilities is presented in the following table.

Table 0.28. List of Important Public Utilities in the IIZ

Sl No	Educational Institution	Distance)km(
1	Meppadi Panchayat Office	7
2	Meppadi Police Station	7.2
3	Meppady Post Office	6.9
4	Village Office Kottapady	7
5	Govt. Press Meppady	6.9
6	W C F Forest office	7.8
7	Forest Range Office Meppady	8
8	Model Forest Station Vythiri	8.2
9	Meppady Krishibhavan	7.5
10	Post Office Anakkampoil	5.3

4.9.8. Natural Resource Availability

The project districts are having natural resources in terms of forest wealth, fauna, protected areas and water sources. The topography, soil and land use of the project districts support the above mentioned aspects. Clay, limeshell, magnetic iron ore, ilmenite and building stones are the economic minerals seen in Kozhikode district. Economic minerals like, quarts reef, containing minute qualities of gold occur in Wayanad district.

4.9.9. Natural Hazards and Vulnerability of the Sub project Area

Soil erosion, landslide or landslip problems are reported from the project area (within 15 km radii of the project area). As per the District Disaster Management Plan for Wayanad and Kozhikode districts, areas near to the proposed tunnel road is marked as high or moderately (see **Figure 0-12**). The plantation village of Puthumala is approximately 0.85 km away from the proposed tunnel road, where a massive destructive landslide occurred during monsoon season of 2019.

4.9.10. Tribal Settlements

The indigenous/tribal peoples of Wayanad include 14 different communities. Officially recognized by the state as Scheduled Tribes. The Kurichia, Paniya, Adiya, Thenukuruma and Mullukuruma are the major communities. Historically, these indigenous communities had maintained their time-tested patterns of self-governance, social institutions and cultural heritage living in symbiotic relationship with the nature and forest.

As per the "Details of Tribal Settlements inside the Forests of Kerala*" published by the Dept. of Forests, Govt. of Kerala, there are 32 tribal settlements in Meppadi Forest Range (where the major part of the project alignment falls). Among these, Mammikkunnu, Kuppachi, Kalladi and Aranamala colony falls close to the proposed tunnel road. Details of the tribal settlements falls in Meppadi Forest range is given in **Table 0.29**.

Table 0.29. Details of Tribal Settlements inside the Forest Area of Meppady

Sl No	Name of settlement	Area of settlement)in Ha(	No of Tribal families possessing land	No of Landless Tribal Families	No of Non-Tribal Families Possessing Land in Settlement	No of Families Possessing Record of Right
1	Kuppachi Colony	10.53	33	0	0	0
2	Kalladi Colony	2.43	7	0	0	6
3	Mammikkunnu Colony	2.43	7	0	9	5
4	Athichodu Colony	0.08	2	0	0	0
5	Chooralmala Colony	0.40	4	0	0	0
6	Punchirimattom colony	0.20	0	0	0	0
7	Attamalakkuzhi Colony	0.20	3	0	0	0
8	Parappanpara Colony	0.00	0	7	0	0
9	Nellimala Colony	1.26	14	1	0	14
10	Kadasikkunnu Colony	1.54	10	3	0	0
11	Clubmattam colony	0.11	12	0	0	0
12	Vattakundu Colony	12.15	46	0	0	0
13	Aranamala Adivasi colony	61.62	43	0	0	23
14	Olakkunnu Naika Colony	4.86	9	0	0	0
15	Anappara Naika Colony	8.10	13	0	0	0
16	AnakkaduAdivasiColony	4.86	29	2	0	0
17	Kottathara Wayal Paniyar Colony	0.51	6	0	0	0
18	Idinjakkolli Adivasi Colony	24.29	36	4	0	33
19	Vellakkettu Adivasi Colony	7.69	20	1	0	17
20	Vengachola Adivasi Colony	32.39	46	4	0	40
21	Govindappara Adivasi Colony	10.93	33	0	0	30
22	Jaihind Colony	25.07	97	7	0	22
23	Kallumala Colony	12.15	82	0	38	120
24	Kariyatthanpara	1.75	7	2	0	0
25	Kolppara	6.82	25	0	0	0
26	Rattakkolli	1.70	13	7	0	0

* Source: https://forest.kerala.gov.in/images/flash/triballatest.pdf

Sl No	Name of settlement	Area of settlement)in Ha(	No of Tribal families possessing land	No of Landless Tribal Families	No of Non-Tribal Families Possessing Land in Settlement	No of Families Possessing Record of Right
27	Ambukuthi	1.91	6	3	0	0
28	Arambukuthi	0.27	16	3	0	0
29	Chullimoola	0.16	5	15	0	0
30	Kuttamangalam	1.42	3	3	0	0
31	Ambalakkunnu	1.21	8	0	0	0
32	Valiyammoola Colony	16.19	2	3	0	0

It is observed that there are no tribal settlement in southern side (in Kozhikode side).

Chapter 5. Anticipated Environmental Impacts and Mitigation Measures

5.1. Introduction

With increasing socio-economic activities, the demand for an efficient transportation network also increases. It is required to establish an efficient, optimized and durable road infrastructure for the overall social and economic development throughout the country. It is quite evident from past experiences that road revamping / construction projects give rise to diverse impacts that are beneficial as well as adverse on environmental and social profile of the project influence zone. The adverse impacts associated with the project may be long term or temporary and its intensity may also vary both spatially and temporally depending on the nature of project intervention during the various stages of the project and the baseline environmental quality of the project area. Major factors that influence the environmental impacts are:

- Settlement pattern - urban or rural
- Topography / terrain - plain, rolling or hilly
- Land use pattern - agricultural, built-up (residential, commercial, industrial) etc.
- Other physical features

Environmental Impact Assessment is carried out with the aim of ensuring that potential environmental problems are foreseen and avoided at an early stage in planning cycle so as to pre-empt problems. The EIA mechanism applied to the project comprises following key principles in the following order of priority:

- Avoid adverse environmental impact
- Minimise and control adverse environmental impact
- Mitigate adverse environmental impact

The entire project cycle Matrix method was followed for the identification and evaluation of impacts. The activity - impact identification matrix is presented as Annexure 18**.**

5.2. Identification of Impacts

5.2.1. Positive Impacts of the Project

The potential positive environmental impacts due to project apart from its economic importance include the following.

- ***Reduced noise and air pollution***. With the proposed tunnel development project, noise and air pollution levels are expected to go down in the existing NH-766 where human exposure is more. Though, there will be rise in pollutant levels in the proposed tunnel road alignment, the overall human exposure to noise and air pollution will be minimal due to less congestion.

- ***Reduced risk of accidents***. The proposed alignment shall provide adequate safety measures and proper sight distances thereby resulting in reduced accidents. Moreover, with expected decrease in overall traffic density due to increased road carrying capacity, the chances of accidents will reduce considerably.
- ***Improved accessibility and connectivity***. The accessibility and connectivity increases as the project road is the major connectivity between Kozhikode and Wayanad district. The project will also boost the interstate connectivity to Kerala and Karnataka. Thus, the time of travel between these places will be reduced significantly.
- ***Reduced vehicle operating and maintenance cost***. With advent of the four-lane tunnel road, the vehicle operating and maintenance cost is expected to go down substantially. These benefits can be attributable to smooth and even roads and low congestion.
- ***Savings in fuel consumption***. Savings in fuel consumption can be attributed to low congestion and relatively less travel time due to proposed improvements.
- ***Improved quality of life***. The proposed project is expected to improve the quality of life of the people residing in the project zone in terms of their economic, social and health status. Land value in the nearby areas of the project area will increase substantially.
- ***Improved Aesthetics***. The overall aesthetics of the area will be improved with proposed landscaping in the project stretch.
- ***Generation of local employment***. Both skilled and unskilled labours shall be employed during the construction stage of the project.

To achieve the potential benefit due to the project road, improvement of existing road between Mukkam - Thiruvambady – Pulloorampara- Anakkampoyil- Muthappanpuzha section and junction improvement in the road approaching Meppadi town would be warranted. Government of Kerala will be executing the same as a separate project for which land acquisition would be required. The same is not considered within the purview of present EIA Study.

5.2.2. Negative Impacts of the Project

5.2.2.1. Negative Impacts of the Project during Construction Phase

The activities during the construction phase of the tunnel road includes open cutting and embankment construction, tunneling of the hilly section, removal, transport and disposal of muck generated, leveling of site, clearing of trees along the entry and exit section of alignment, widening of the approach road (existing) with paved shoulders, construction of bridge and culvert and quarry operations for the project work. Some of the potential direct and indirect negative impacts of the project during construction phase will be the following:

- Heavy and lengthy construction activities within Forest areas can lead to changes in accessing the fringe areas by wildlife.
- Elephants are reported on both Portal opening areas; inappropriate barricading of construction site can lead to accidents related with wildlife.
- Tunneling along hilly areas – resultant noise and vibrations.

- Additional traffic load on existing road networks accessing muck disposal site, quarry, crusher, water source, construction camp and labour camp etc., especially with heavy vehicles for construction purpose.
- Filling in low-lying areas of Iruvazhinjipuzha for embankments of the road
- Cutting of trees along the approach road to the tunneling section
- Loss of topsoil due to clearing and grubbing of new alignment, borrow area and quarry operation, construction of camps and material stacking yard
- Temporary impacts on flora and fauna due to the construction activities
- Temporary impact on the drainage pattern due to embankment, culvert and bridge constructions
- Impact on traffic management system
- Increased air pollution (including dust) due to the movement of vehicles and construction activities
- Increased noise levels due to the movement of vehicles and construction activities
- Increased soil erosion leading to loss of top soil and pollution of Iruvazhinjipuzha, Kalladi river and Meenakshi river along the project alignment
- Spillage of oils and other hazardous materials leading to pollution of surface and sub-surface waters.
- Pollution of rivers and canals due to construction of bridges and culverts

5.2.2.2. Negative Impacts of the Project during Operation Phase

During the operational phase of the project, traffic in the project road will increase along with the increased average speed of vehicles. Some of the potential direct and indirect negative impacts of the project during operation phase are as follows:

- Introduction of increased traffic operation Thiruvambadi – Muthappanpuzha route and Meppadi Vellarimala route will lead to change from existing calm rural setting to regular vehicle operating route. Air and Noise emission due to the vehicular movement at high speed would be inducted in the region.
- The land use changes would be gradually happening along the project route where more commercial establishments are likely to arise.
- Any accident within tunnel for vehicles carrying hazardous chemicals can impact the water quality since the drainage would lead to natural course; especially critical if close to Iruvazhinjipuzha river.
- Since elephants are frequented at both Anakkampoyil and Meppadi section especially during summer, barricading if not done can lead to conflict with vehicular operations, trapping of animals within tunnel etc.

5.3. Land Environment

5.3.1. Land use / Land Cover

5.3.1.1. Anticipated Impacts

Construction Phase

The proposed tunnel road development requires acquisition of agricultural land and forestland. Loss of productive agricultural land may result from the establishment of construction camps, batch mix plant and WMM plant, quarry, muck disposal site and borrow area. This results in minor change in agricultural yield due to project activities. Also, slight impacts are anticipating in the land use or land cover while developing construction camps and labour camps.

Operation Phase

Better access can leads to conversion of agricultural land to commercial and residential purpose in the project area, especially in settlements near to the proposed tunnel road. This leads to decrease in agriculture production and loss of productive land. Aesthetics of the region shall change permanently.

5.3.1.2. Mitigation Measures

Construction Phase

- The land acquisition would be in accordance with the RAP and entitlement framework. All R&R activities are to be completed before starting the construction.
- All the utilities and common property resources being impacted due to the project will have to be relocated with prior approval of the concerned Departments / Agencies before construction starts.
- Guidelines for siting, management and redevelopment of Borrow areas are presented as Annexure 24**.**
- Guidelines for siting[M A13], management and redevelopment of Quarry areas are presented as Annexure 23**.**
- Compliance to all the State norms towards operation and environmental protection of borrow and quarry areas shall be done by contractor.
- Guidelines for siting, management and redevelopment of Construction and Labour camp are presented as Annexure 21 & Annexure 22**.**[M A14]

5.3.2. Geology and Topography

5.3.2.1. Anticipated Impacts

Construction Phase

The project area falls in the foothills and mountainous region of the Western Ghats, which is very fragile and vulnerable to landslides and tremours. Removal of soil and earth strata will cause changes in topography. Further, collection and transportation of material may be allowed from the identified quarries and borrow pits only, which would have minimal impact on the geology of the project corridor.

- Change in topography and resultant change in drainage pattern and vegetation due to soil removal through open cutting areas (Anakkampoyil and Mepppadi).
- Vibration due to blasting
- Potential opening of fractures and resultant ground water seepage.
- Potential triggering of landslips on steep/vulnerable slops of the mountain top.
- Disturbance due to noise for people and wildlife.

- Air pollution due to dust during removal of muck and transporation.
- Impact at muck disposal site due to vegetation removal, alteration of drainage, dust impacts and probable water pollution.
- Vibration depending on the tunnelling method (blasting) and peak particle velocity (ppv) therein. If unregulated, fracture regulated vibration can trigger landslips on ground, also during the operational stage.
- Ground settlement/chance of dislocation/subsidence in the fracture zones, especially in the backdrop of complicated geology as discerned during field observations and logging and study of core samples.
- Ground water seepage through fractures.
- As per site observations, the rock formations are hard in nature and fractured. The hills over the tunnel have varying thickness of soil and fractured rocks at various places. At locations of steep slops over the hills vibration from blasting may trigger land slips/land slides. The land slip/land slide material may be carried by drainage channels causing damage at lower reaches.
- Rolling stone on ground in the vicinity of very steep and extremely steep slopes.
- Maximum noise during construction stage is due to blasting and muck transportation.

Construction of embankments results in alteration of geography of the area. Removal of soil and earth strata will cause changes in topography. Further, extraction of construction materials from selected borrow area, quarry location and sand mining areas will alter the terrain, affects the aesthetics of landscape and alters the contours of the geographical region.

Geological impacts - widening of fractures, ground water seepage.

Operational Phase

No significant impact is envisaged on topography during operation phase.

5.3.2.2. Mitigation Measures

As practiced in the tunneling operation, maximum charge per relay will be carefully computed taking note of the ground vibration magnitude to ensure vibration values of 2mm/s in areas of sensitive structures and 5mm/s for residential structures expecting the frequency of vibaration waves generated from blasting less than 8Hz. As usual all the parameters related to vibration and noise and subsidence will be monitored on a daily basis as practiced in tunneling operations. Detailed blast design parameters, firing pattern and the pertinenet design parameters has been conducted as special studies in this study. Through continuous monitoring, these parameters will be modified on a daily basis and appropriate operational modifications need to be effected. (Ref: Report from Rock Excavation Engineering Division, CSIR – Central Institute of Mining and Fuel Research, Dhanbad). In compliance with the above and additional measures as needed, the intensity of anticipated environmental impact on geology of the area will be medium and extent of anticipated impact will be local. No impact is anticipated on the geology of the area during the operation phase.

Construction Phase

- Strict adherence to the recommendations contained in the Report from Rock Excavation Engineering Division, CSIR – Central Institute of Mining and Fuel Research, Dhanbad.

- A larger network of facilities for real time meauresment of virbaton shall be deployed within the DIZ, especially along the settlements on both Anakkampoyil and Meppadi side and real time data shall be monitored. Vulnerable structures shall be retrofitted during the operational phase.
- Vibration monitoring prior to the commencement of tunnelling, demarcation of impact area, regulating the blasting charge to limit the impact on ground. If unresolved by this way, tunnelling method may be shifted to TBM (Tunnel Boring Machine).
- Seepage water will be collected and directed outside the tunneling area and all fractures plugged/sealed with provision for water channelization.
- Controlled blasting with use of multisecond delay detonators shall be adopted at geologically fragile locations.
- during embankment construction and cutting process, the natural drainage pattern in the areas and adjacent flora should not be affected.
- Appropriate contour benching techniques shall be adopted to sustain the topographic features and to avoid erosion supplemented by vegetation cover.
- Remedial measures shall be suggested on understanding the vibration extent. On understanding that, landscaping with the full consent and participation of the Forest Department may be thought of to avoid scree and boulder removal and transportation to downstream areas resulting in tragedies such as the Puthumala Wayanad landslide.
- Controlled removal of large boulders and fragmented strata from the tunnel portal shall be carried out.
- Rehabilitation of borrow area and quarry area shall be carried out in order to control the water logging problem and to avoid the soil erosion and landslides of the adjacent area.
- Guidelines presented in IRC:SP -48-1998 – Hill Road Manual should be followed

5.3.3. Impacts on Soils

5.3.3.1. Anticipated Impacts

Construction Phase

The impact on soil due to the project will be in terms of topsoil contamination and soil erosion. The proposed improvement will not cause significant soil erosion. Soil erosion may occur at proposed bridge locations, along the steep and un-compacted embankment slopes, earth stockpile locations and areas wherever vegetation is cleared. Soil erosion will have cumulative effect such as destabilization of embankments, turbidity and siltation of water bodies, drainage problems, etc. Establishment of construction camp and movement of construction vehicle and machineries on agriculture land will results in compaction of top soil. Impacts due to utilisation of productive top soil present in borrow area, muck disposal site and quarry area for construction. Further, soil pollution would take place to a negligible extent due to spillage of construction material, oil, fuel, grease and asphalt around the construction yards. Disposal of construction waste and domestic waste in unscientific way may result in loss of productive land.

Operational Phase

The DIZ of the project areas is majorly agriculture based. Better access can leads to conversion of agricultural land to commercial and residential purpose in the project area. The areas of road embankments and approaches of bridge can have erosion issues during heavy monsoon. Borrow areas, muck disposal sites etc., if not rehabilitated appropriately can result in loss of productive land and agriculture produce..

5.3.3.2. Mitigation Measures

Construction Phase

- Turfing of road embankment slopes, development of compensatory afforestation, Borrow area rehabilitation will control the soil erosion to a greater extent.
- The topsoil from all areas of cutting and all areas to be permanently covered shall be stripped to a specified depth of 150 mm and stored in stockpiles of height not exceeding 2m.
- The stored topsoil will be spread back to restore the productivity of the exhausted borrow areas.
- The device for checking soil erosion include the formulation of sediment basins, slope drains etc. Such works and maintenance thereof will be deemed as incidental to the earthwork.
- In borrow pits, the depth of the pit should be regulated so that the sides of the excavation will have a slope not steeper than 1 vertical to 4 horizontal from the edge of the final section of bank.
- Construction vehicles, machinery and equipment shall move, or be stationed in pre-identified designated areas only.
- If operating from temporarily hired land, it will be ensured that the topsoil for agriculture remains preserved & not get compacted.
- Borrow areas will be opted preferably from barren, infertile lands.
- Vehicles and machinery shall be maintained and refilled in designated paved areas. All used oil shall be disposed off through approved oil recyclers and the site will be fully cleaned before handing over.
- The construction wastes should be dumped in selected pits, developed on infertile land. All applicable waste disposal norms to be followed. Wasteland to be preferred for construction debris disposal.
- Soil quality monitoring should be conducted as per Environmental Monitoring Plan to ascertain level of contamination.

Operational Phase

- The exhausted borrow areas could be developed into water bodies for local use, practicing fishery.
- Compaction and Landscaping shall be carried out at all embankment-developed locations to control the soil erosion during operation phase.

5.3.4. Slope Stability

5.3.4.1. Anticipated Impacts

Construction Phase

Landslide is a natural disaster whose effects are mostly localized. The project area is known for frequent landslide especially during monsoon season on the mountain slopes. However, the tunnel alignment runs almost perpendicular to the mountain alignment in the project site area. Vibration induced landslips may be a possibility at steep slops over the mountains just in the vicinity of the tunnel where soil thickness is high.

Operational Phase

No impact is envisaged during operation phase of the project and hence no mitigation proposed. However, periodic surveillance shall be conducted to check slope stability of the landslide prone areas.

5.3.4.2. Mitigation Measures

Construction Phase

Impact of vibration on vulnearable slopes (>20 degree slopes) will be monitored and slope stabilization measures shall be adopted.

5.4. Water Environment

5.4.1. Surface Water

5.4.1.1. Anticipated Impacts

Construction Phase

The project road is crossing rivers – Iravajipuzha fand the tunnel road passes under Kalladi river The debris generated due to tunneling including dust shall be contained as otherwise would reach Iravajipuzha. Access facilities created temporary for the construction activities across the river shall not interfere with the normal flow during the monsoon season. Disposal of construction debris near the vicinity of water bodies may cause stagnation / diversion of natural drainage. Drawing of water for construction camps for domestic use from local water sources may disturb water supply use for the local inhabitants. Construction activity at bridge and culvert locations may cause water pollution.

Operation Phase

Lack of proper drainage arrangement may results in soil erosion subsequently leads to turbidity and siltation of nearby natural water bodies. Spillage of edible oil, lubricants and other hazardous chemical due to road accidents close to natural drainage will lead to alter in water quality. Unscientific disposal of debris and construction materials in low laying area shall leads to flooding during rainy season.

5.4.1.2. Mitigation Measures

Construction Phase

- Retaining of the water from the tunnel area shall be done to avoid dust/particles reaching the river. Appropriate detention mechanism shall be incorporated.
- Tunnelling below Kalladi river and a stream is proposed where precuations for avoiding leakage to the tunnel shall be done as per the Standard tunneling practices.

- All affected community water supply sources will be rehabilitated in such a way that local public should not be disturbed for daily water use due to project activity. Relocation of these water systems will be carried out in consultation with concerned govt. officials and the owners.
- Precautions shall be taken during the construction work of culverts and bridges across these rivers and streams such that the flow in these water bodies is not obstructed.
- At hilly areas, appropriate drainage arrangements with catch drain will be provided to avoid the stagnating of water on carriageway.
- Any embankment work in low lying areas will have provisions for cross drainage for natural drains to ensure that flow is not affected.
- Pitching, stabilization of soil, slope protection measures should be taken up to reduce erosion of soils and to achieve slope stability.
- Arrangement for supply and storage of water shall be made by the contractor in such a way that the water availability and supply to nearby communities remain unaffected. If a new tube-well is to be bored, proper sanction and approval by Ground Water Department is needed.
- The wastage of water during the construction should be minimized. In case of tapping water from community sources, consent to be obtained from local Administration for the same.
- Guidelines presented in IRC: SP -42-1994 – "Guidelines for Road Drainage" and IRC: 36 – 1974 – "Recommended Practice for Treatment of Embankment Slopes for Erosion Control" should be followed for construction of drainages and embankments for the proposed project.

Operation Phase

- Seepage water from the tunnel add to thee quantum of surface run off. In order to offset any adverse impact, the seepage water has to be storned in artificial ponds before discharging to the natural stream. The act will also take care of contamination factors.
- Tunelling exposes the rocks and fractures/joints, if any. Seepage of water is a reality to be tackled on the site. If the seepage is in small quantities, the source will be channnelised and taken out of the tunnel and released to natural drains after quality ascertained.
- In the event of breach of any confined, fracture controlled aquifer, the same shall be sealed/pluged on the spot then and there by grouting and subsequent concreting. I
- In the event of subsidence or collapse, resort to support, grouting and concreting depending upon the requirements
- This procedure is contained in the mining manual and will be taken care of during the tunnelling activity. As a rule, before blasting of the segment, horizontal exploratory drilling is conducted to ascertain the rock type, presence of joints/fractures and precautionary preparation for roof support, void plugging et are arranged in advance to face the situation.
  Taken care of are : (i) Extreme Seepage and (ii) Subsidence / Rock Failure
- If seepage water is in excess quantity then the normal drop dripping, additional storage facility will be constructed in the tunnel segment and outside the portal area for regulated release.
- Landscaping shall be developed on embankment slopes so that soil erosion and siltation of natural drain can be avoided.

- contractor shall ensure disposal of construction debris and domestic waste at the designated project site.
- Daily Inspection shall be undertaken to clear the blockages and silts from the drainage facilities if found any
- Permission shall be obtained from Irrigation Department in case of water withdrawal from surface water bodies for maintenance of avenue trees.

5.4.2. Surface Water Quality

5.4.2.1. Anticipated Impacts

Construction Phase

Theoretically, tunnels can be: impermeable (allowing no ingress of water and developing the full water pressure on the lining), permeable or semi-permeable (allowing some ingress of water and avoiding the development of full water pressure on the lining). In the subject project scenario, the proposed tunnel is permeable during their construction and impermeable or semi-permeable during their operation. As a general rule water ingress into road tunnels are normally not accepted as it may have severe impact on the tunnel structure and in special cases can cause severe deformations, displacements, settlements and unwanted stresses leading to deterioration and in worst case collapse of tunnel walls and ceiling (bursting and squeezing of bare rock as well). For mechanical and electrical installations, it may impact their functionality and lifetime expectation.

Some impacts are anticipated on the water quality of water bodies in the project area during the construction phase. Discharge of untreated wastewater generated from construction camps, labour camps to nearby water bodies will leads to deterioration water quality. Runoff from hill slopes, embankments and earthen shoulder may increase the chances of soil erosion, which result in turbidity and siltation of water bodies. Cleaning of construction machineries, equipments and vehicles shall deteriorate the water quality.

Operation Phase

Impact during operational phase is comparatively minimum than construction phase. The common impact during operation stage is spillage of petroleum and other hazardous materials due to road accidents, which may deteriorate the water quality to considerable extent. The water entering a tunnel can dissolve the free lime hydroxide in the concrete lining, becoming more alkaline and releasing solid deposits in the drainage systems.

5.4.2.2. Mitigation Measures

Construction Phase

- Suitable silt screen and sedimentation traps shall be provided to these drains, to minimise the turbidity and silting in natural drainage.
- Tunnel should be designed with waterproofing systems to be delivered as completely waterproofed tunnels.
- Piling activity for bridge construction shall be carried out during non-monsoon season
- Washing of construction equipments, machineries and vehicles used for transporting materials should be strictly prohibited in rivers, nalas and other water bodies.

- The worker's camp must not be located within 1-km from the dense built up areas and water reserves.
- Runoff from the construction camps including workshops and vehicle garages should be passed through catch drain followed by oil interceptors (**Annexure 19**).
- Adequate sanitary facilities, drainage, washing and toilet facilities with septic tanks and refuse collection and disposal should be provided to the workers. The provision of water supply and toilet facilities should be made as per the stipulated guidelines in the Indian Labour Act.
- Construction debris and domestic waste should be collected, stored, transported and disposed safely to the approved land fill site nearby the project area.
- Awareness program for workers and proper training for the personals handling oil, paints and lubricants and vehicle repairing employees to response immediately on spillages of hazards materials shall be provided by contractors.
- Guidelines presented in IRC: SP -42-1994 – "Guidelines for Road Drainage" and IRC: 36 – 1974 – "Recommended Practice for Treatment of Embankment Slopes for Erosion Control" should be followed for construction of drainages and embankments for the proposed project.
- Water quality monitoring should be conducted as per Environmental Monitoring Plan so that appropriate measures are taken up towards abatement of pollution.

Operation Phase

- Appropriate drainage arrangements with catch drains and catch pits designed to safely drain out the hazardous chemicals should be provided.
- The tunnel should be equipped with specific gutters in order to limit the spread of flammable liquids on the pavement. If an accidental spill occurs, the flow rate of pollutant liquid in these gutters may be higher than what is encountered on a regular road surface, and the water management system should be capable of coping with these flow rates.

5.4.3. Ground Water

5.4.3.1. Anticipated Impacts

Construction Phase

The southern portal area comprises hard rock with thin veneer of soil. Ground water potential is confined to a shallow phreatic zone. The construction of the portal is not bound to substantially impact the phreatic acquifer. On the northern front, phreatic acquifer will be affected. Since there is no use of phreatic zone acquifer, there it is not going to affect the people/wildlife directly. It is however recommended that the open phase should be totally sealed to avoid the leakage and evaporational loss.

In both portals there is no springs. As the soil over the mountain is not affected by the tunneling activity, any spring /water sources confined to the upper phreatic zone will have no impact in the gorund water front.

Fracture controlled deep acquifer configuration /presence can be determined only through deep resistivity surveys. Considering the altitude and presence of wild life conduct of such a survey has practical limitations. Any leakage during construction stage need to be tackled technologically and plugged.

Extraction of ground water for construction activities and domestic use of labour camps will result in depletion of local ground water table. Selection of construction camps adjacent to open well will lead to contamination of ground water due to unscientific usage of water near open wells. Modification of drainage is possible only near the portals. Renovation of the drainage channels through comparable slopes will be done to resemble the original drainage.

The ground water levels in the region could not be established, as is often the case in mountainous terrain. Since the water usage will be mainly from the river water for construction purposes, no adverse impact on groundwater availability is expected. Dumping of wastes shall also be undertaken at specified exposed surface locations only and hence, no negative effect is envisaged on the groundwater quality of the area.

Three surface streams shall cross the tunnel alignment with the stream bed well above the crown of the tunnel at the point of crossing. Any leakage during construction stage need to be tackled technologically and plugged.

Operation Phase

Along the portal areas, proposed construction of embankments will reduce the permeability of the unpaved shoulder further decrease the ground water recharging rate to greater extent due to surface runoff. Paved surface of the road will reduce the percolation of runoff water and decrease the ground water recharge.

5.4.3s.2. Mitigation Measures

Construction Phase

- Fracture controlled deep acquifer if breached during construction stage, the same need to be tackled technologically and plugged.
- Requisite permission shall be obtained from the Central Ground Water Board to utilise the water for construction and domestic use.
- Sources of ground water affected during widening will be rehabilitated in consultation with concerned govt. officials and the owners.

Operation Phase

- Develop a groundwater disposal strategy that confirms disposal option, contingency measures and emergency measures and emergency response plan if unexpected groundwater contamination is encountered and require disposal.
- Groundwater monitoring stratergy would set out monitoring required to ensure no significant impacts to groundwater dependent values and contingency measures for if impacts exceed acceptable levels.

5.4.4. Ground Water Quality

5.4.4.1. Anticipated Impacts

Construction Phase

Selection of construction camps adjacent to open well will lead to contamination of ground water due to unscientific usage of water near open wells. Other than this, no other impacts are anticipated on ground water quality.

Operation Phase

No activities of the project during operation phase are expected to interfere with the ground water characters of the region and hence the impacts on the ground water quality are not anticipated.

5.4.4.2. Mitigation Measures

Construction Phase

- The construction camp must not be located within 1 km from the dense built up areas and water reserves.
- Runoff from the construction camps including workshops and vehicle garages should be passed through catch drain followed by oil interceptors (**Annexure 19**) finally utilized for dust suppression at construction camp.
- Water quality monitoring should be conducted as per Environmental Monitoring Plan so that appropriate measures are taken up towards abatement of pollution.

5.5. Air Environment

5.5.1 Meteorology / Climate

5.5.1.1. Anticipated Impacts

Construction Phase

Due to felling of trees, laying of pavement and other construction activity may cause temporary impact on microclimate of the project influence area. Other than this, no other significant impacts are envisaged in climatic parameters such as precipitation, wind speed, wind direction, temperature, relative humidity etc.

Operation Phase

The objective of the present project is only to improve the existing road. Hence, no changes in climatic conditions are anticipated.

5.5.1.2. Mitigation Measures

Construction Phase

- Efforts shall be made by the contractor during implementation stage to minimise the felling of trees for the proposed improvements.
- About 273 trees will be planted as compensation to tree felled for the proposed improvement. Maximum number of trees will be planted within the proposed RoW in the available margin and additional excess trees will be planted in the designated areas as suggested by forest department.
- Compensatory plantation shall be made by contractor in consultation with forest officials during construction stage itself, so that microclimate during operation stage can be enhanced.
- Landscaping shall be carried out on embankments to augment the air quality at micro level.

Operation Phase

- Compensatory plantation and landscaping will help in improving the overall microclimate of the area.

5.5.2. Ambient Air Quality

5.5.2.1. Anticipated Impacts

Construction Phase

Change in Ambient Air and GLC: The air pollution impact of excavation in ordinary earth and boulders and also rock is directly dependent upon construction methodology, annual rate of excavation, mode of transport within the construction site, mode of screening and method of crushing. The air pollution sources at the proposed tunnel site can be broadly classified into three categories, viz. area source, line source and instantaneous point source.

Extraction of stone by various activities in tunneling area is construed as an area source, which includes excavation pit(s) and activities happening in the excavation area like drilling, blasting, hauling and loading/unloading. The dust emission from these areas will be fugitive in nature. The excavator operations, loading/unloading operations will also cause dust emission though it will be confined to the area of operation of the machinery. The gaseous emission from their operation shall be minimal and limited within the project area.

Transportation of excavated material from the project site to either dumping sites or the stone crusher unit are categorized as line source. Since the dumper movement on haul road will be within the tunneling area, no adverse impact shall be felt in the settlement area.

Blasting is the major source of instantaneous emission sources of particulate matter and NOx. The large quantity of dust will be wind borne. With the proposed control measures, the fugitive emissions will be minimized in terms of their impact on environment.

Effects on Soil Materials, Vegetation and Human Health: Excavation results in land degradation and formation of loose soil particles, which are mainly fugitive dust. The transportation of excavated/construction material on unpaved roads cause fugitive dust emission. These dust particles are usually blown away along the wind direction and get deposited on the canopy of surrounding vegetation and agricultural crops thereby interfering with photosynthesis and other physiological activities of the green cover. Finally, this may result in reduced ecological functions of the forest ecosystems as well as economic productivity of the agro-ecosystems.

Drilling and blasting invariably results in land degradation and formation of loose soil particles, which are mainly fugitive dust. These dust particles are usually blown away along the wind direction and get deposited on the canopy of surrounding vegetation and agricultural crops thereby interfering with photosynthesis and other physiological activities of the green cover. Finally, this may result in reduced ecological functions of the forest ecosystems as well as economic productivity of the agro-ecosystems. Nitrogen oxides also upset the chemical balance of nutrients in the water, which can cause problems with the animals and plants that are dependent upon the water, leading to reduction of the fish population.

The gaseous pollutant Oxides of Nitrogen (NOx) react in the atmosphere to form Nitrogen Dioxide (NO_2), which can have adverse effects on health, particularly among people with respiratory illness. NOx are pollutants that cause lung irritation and weaken the body's defenses against respiratory infections such as pneumonia and influenza, can cause shortness of breath and chest pains and increase a person's susceptibility to asthma.

Carbon monoxide (CO) is a product of incomplete combustion and at low concentrations; it may pose a health risk and is especially dangerous to the elderly, people with cardiovascular disease or other circulation disorders, anemic individuals, young infants, and pregnant women. CO reduces the blood's oxygen carrying capacity, and, when inhaled, blocks the transport of oxygen to the brain, heart, and other vital organs in the body. Extreme levels of exposure, such as might occur due to blockages in tailpipes, can be fatal. Fetuses, newborn children, and people with chronic illnesses are especially susceptible to the effects of CO. In addition, carbon monoxide is directly linked to visual impairment, reduced work capacity and mental dexterity, poor learning ability, nausea, headaches, dizziness, and even death.

Sulfur dioxide can react in the atmosphere to form fine particles and poses the largest health risk to young children and asthmatics. Exposure to SO_2 can create a number of health problems, including sweating, papillary constriction, muscle cramps, excessive salivation, dizziness, laboured breathing, nausea, vomiting, convulsions, and unconsciousness, as well as possibly being absorbed by the skin and creating severe diarrhoea. In addition, it may cause effects on the nervous system, resulting in respiratory depression. It is also quite deleterious for the environment.

Particulates are tiny solid particles consisting of particles of soot and metals, which can bind to and clog the respiratory tract. These are detrimental when found in both fine ($PM_{2.5}$) and coarse (PM_{10}) forms as it accumulates in the respiratory system, and can lead to decreased lung function, respiratory disease and even death. $PM_{2.5}$ consists of particles less than one-tenth the diameter of a human hair and poses the most serious threat to human health, particularly among those with existing respiratory disorders, as they can penetrate deep into lungs. Of the pollutants emitted by off-road vehicles, particulates are of special concern because their small size makes them easily respirable and thus deliverable directly into the lungs, causing any number of the aforementioned maladies.

Impacts of Emissions from DG Sets used for Power during construction: Emissions from diesel generator sets are a mixture of gases primarily comprising of Carbon Monoxide (CO), Oxides of Nitrogen (NOx), unburned Hydrocarbons (HC), and soot particles i.e. particulate matter).

The emission norms in India cover CO, NOx, PM, and HC and are specified based on the number of grams of these compounds present in diesel exhaust when one kilowatt-hour of electricity is generated. These norms have been revised in December 2013 (G.S.R. 771 (E) / 11th Dec 2013 notification), its amendment vide GSR 232(E) dated 31st March, 2014 and GSR(E) dated 7th March, 2016 and have come in force from 1st July 2016. These norms are presented in **Table 0.1.**

Table 0.1. Emission Limits for DG Sets

Power Category	Emission Limits (g/kWh)			Smoke Limit (Light absorption co-efficient per meter)
	NOx + THC or NOx + NMHC or RHC	CO	PM	

Power Category	Emission Limits (g/kWh)			Smoke Limit (Light absorption co-efficient per meter)
	NOx + THC or NOx + NMHC or RHC	CO	PM	
Up to 19 kW	≤ 7.5	≤3.5	≤ 0.3	≤0.7
More than 19 kW up to 75 kW	≤4.7	≤3.5	≤0.3	≤0.7
More than 75 kW up to 800 kW	≤4.0	≤3.5	≤0.2	≤ 0.7

NOx also contributes to smog formation, the formation of particulate matter, acid rain, can damage vegetation and contributes to ground level ozone formation. Nitrogen oxides also upset the chemical balance of nutrients in the water, which can cause problems with the animals and plants that are dependent upon the water, leading to reduction of the fish and shellfish population. When carbon monoxide comes in contact with oxygen, carbon monoxide is formed which fall in category of greenhouse gases which contribute to global climate change.

Pollution due to Fuel Combustion in Equipment and Vehicle: Vehicular emissions are one of the major sources of air quality impacts of highway projects. As the project envisages improvement of road conditions for smooth traffic flow, the project will have beneficial impact on air quality of the region during its operation. However, with respect to compliance of ambient air quality standards during the post improvement phase of the road, due to increase in the traffic volume, the impact on air quality along the project corridor is likely to be minor.

Impacts on air quality during the construction phase of the project will be considerable as the amount of work involved in improvement of the road is significant. However, any possible impacts will be transitory. Provision of adequate air pollution control equipment, like dust filters and measures like dust suppression by water sprinkling and planting of green belt may further help to significantly reduce the impact.

Emission of CO_2 and NO_X due to combustion of diesel from vehicles, WMM plant, batch mix plant, diesel generator sets etc. will be a principal cause of air pollution during the construction phase. The data on fuel utilization rates of units likely to be in operation during the road improvement are provided in **Table 0.2**.

Table 0.2. Fuel Consumption Rates for Construction Machinery

Machines	Fuel Consumption (Litres / hour)
Cement concrete mixer	7
Truck	8
Bulldozer	20
Grader	12
Roller	20
Dumpers & Tippers	18
Water Tanker	8
Paver	12

Source: Indian Institute of Petroleum

Due to ground level temperature inversion at site during winter months, meteorological conditions after the sunset tend to become stable. The overall meteorological parameters thus constitute adverse conditions for dispersion of ground based air pollution emissions. Under adverse meteorological conditions, it may be possible that the NO_X standards (80 µg / m^3 for 24 hourly averages) may be violated only if the construction work is carried out round the clock. However, this scenario is not envisaged, as the construction is not proposed to be carried out round the clock.

Operation Phase

After improvement of the existing road, the traffic is expected to move smoothly at higher designed speed, which will assure lower emissions of gaseous pollutants. Further, improve air quality in the region and hence, the project will not be expected to affect the air quality adversely. The rate of emissions of various types of vehicles is presented in **Table 0.3**. However, the extent of these impacts, at any given time will depend upon the rate of vehicular emission within a given stretch of the road and the prevailing meteorological conditions. The impacts will have strong temporal dependence as both of these factors vary with time. The temporal dependence would have diurnal, seasonal as well as long-term components.

Table 0.3. Rate of Emissions of Various Types of Vehicles

Emissions	**Emission Factors in gm/km/Vehicle**					
1. For Diesel Vehicles						
	Speed (km/hr)					
	30	40	50	60	70	80
CO	12.53	9.40	7.52	6.27	5.37	4.70
NO_X	22.28	16.71	13.37	11.14	9.55	8.36
2. For Petrol Vehicles						
	Vehicles					
	Car	2 Wheeler	3 Wheeler			
CO	2.72	2.0	4.0			
NO_X	0.58	0.5	0.5			

Source: Indian Institute of Petroleum

5.5.2.2. Mitigation Measures

Construction Phase

- In order to curb the increased fugitive dust emissions in the area due to vehicular movement raw material transport and burrough area excavation, provisions should be made for sprinkling of water on all the roads in the area of improvement. Sprinkling of water should be carried out at least twice a day on a regular basis during the entire construction period especially in the winter and summer seasons. Special attention should be given in the sections where the alignment passes through village and urban areas. Daily inspection at construction site should be carried out to ensure removal of construction debris to the landfill sites.
- Dust covers / tarpaulins should be provided to cover construction material loaded on trucks, which will be used for the transportation of materials prone to fugitive dust emissions.
- Construction requiring street closings in heavy traffic areas should be performed during off-peak hours.
- Idling of delivery trucks or other equipment should not be permitted during periods of unloading or when they are not in active use.
- Construction vehicles and machineries should obtain “Pollution under Control” certificate from the concerned regulatory authority.

- The fugitive emission from the construction yards is expected to have significant influence up to 1 km distance on the downwind direction under adverse meteorological conditions. Hence, it is essential that the construction yards should be located beyond 1km distance from the major settlements.
- All stationary equipment should be located as far as practicable from receptor locations in order to allow dispersion of emitted pollutants.
- Suitable air pollution control techniques such as electro static precipitator, cyclone separators, bag filters and scrubber should be adopted for WMM plants, batching mix plants to avoid fugitive emissions.
- To mitigate adverse impact DG sets should be located from the consideration of prominent and first prominent wind direction so that on the downwind direction the human habitats are least impacted by the flue gas emissions. The norms prescribed by the CPCB in respect of fixing the minimum stack height for generator, should be strictly complied with. In no case, it should be lesser than the 20% of the under root of generator capacity in KVA added to the height of the building where it is installed
- Construction workers should be provided with Personal Protective Equipments.
- The construction operations during nights should be carried out under restricted conditions. The work schedule and the operation time of each machine should be suitably modified and have limited construction activity to exercise a control on the ambient air quality levels.
- Proper care should be taken for storage of furnace oil, Light Diesel Oil (LDO) etc.
- Air quality monitoring should be conducted as per Environmental Monitoring Plan.

Operation Phase

- As soon as construction is over the surplus earth should be utilised to fill up low-lying areas. In no case, loose earth should be allowed to pile up along the alignment.
- During operation stage, the most effective control methods of air pollution due to vehicular emissions is to use fuel efficient engines, introduction of catalytic converters for petrol vehicles and use of smoke traps for diesel vehicles.
- It should be made compulsory for all vehicles to adhere to the engine maintenance schedules and standards to reduce air pollution due to vehicular emissions.
- Along the project road, plantation of trees such as Neem, which is known to absorb Hydrocarbons, is recommended. Development of landscape along the road can reduce concentration of pollutants at the ground level. It is, therefore, recommended that the area available on both sides of the road be used to develop a green belt with dense canopy to minimize the air quality impacts in the downwind regions. Such development will also improve the general aesthetics in the region.
- Air quality monitoring should be conducted as per Environmental Monitoring Plan.

5.6. Noise Environment

5.6.1. Ambient Noise Levels

5.6.1.1. Anticipated Impacts

A cumulative effect of surface excavation activities and tunnel forming activities during tunneling process generates noise and vibration in the project area and its surroundings. Prolonged exposure to high noise levels over a Period of years invariably causes permanent damage to the auditory nerve and/or its sensory components. The irreversible damage, commonly referred as noise-induced hearing loss (NIHL), is the commonest occupational diseases amongst the construction workers especially at such sites, which have multiple noise sources. Besides this, the fauna of surrounding area is also affected by noise, as the wildlife is more sensitive to noise and vibration than the human beings.

Construction Phase

During the construction phase of the road, the major sources of noise pollution are vehicles transporting the construction material to the construction yard and the noise generating activities at the yard itself. Mixing, casting and material movement are primary noise generating activities in the yard and will be uniformly distributed over the entire construction period. Construction activities are expected to produce noise levels in the range of 80 - 95 dB (A).

The main sources of noise in the tunnel during construction include;

- Noise from blasting for excavation tunnels
- Noise from drilling machines, instruments, loading etc.,
- Noise from traffic and transportation around the tunnel
- Noise from loading and haulage
- Noise from fans for tunnel ventilation

The construction equipment will have high noise levels, which can affect the personnel operating the machines. Use of proper Personal Protective Equipment (PPE) such as earmuffs will mitigate any adverse impact of the noise generated by such equipment.

The noise levels in the working environment are compared with the standards prescribed by CPCB which in-turn are being enforced by Government of India through model rules framed under the Factories Act. The acceptable limit for each shift being of 8-hour duration; the equivalent noise level exposure during the shift is 90 dB (A). Hence, noise generated due to various activities in the construction camps may affect workers, if equivalent 8-hour exposure is more than the safety limit. ACGIH (American Conference of Government Industrial Hygienists) proposed an 8-hour L_{eq} limit of 85 dB (A). Exposure to impulses or impact noise should not exceed 140 dB (A) (Peak acoustic pressure). Exposure to 10,000 impulses of 120 dB (A) is permissible per day.

Noise due to Drilling

The drilling is contemplated to be carried out by hydraulic rock drills with air compressor which entail a noise level of 88.0 dB(A) and will be a worst-case scenario. Nonetheless, the noise generated due to drilling is within the standards prescribed by Occupational Safety and Health Administration (OSHA) for 8-hour exposure i.e. 90 dB (A). It is worth mentioning here that drilling shall be carried in a shift of 8 hours and the equivalents noise level exposure during the shift shall be less than the safety limit of 90 dB(A).

Noise due to Blasting

Blasting generates instantaneous and impulsive noise and is site specific dependent on many factors like the dimension of the holes, type and quantity of explosive i.e. charge/delay and degree of stemming in the hole. At the blast site with the given diameter of holes and their pattern, the noise levels are expected to be in the range of 120-130 dB (A) and tend to decrease with increase in distance of receptor. As the blasting is envisaged over a fixed time period in a day, the blasting is considered to last for 2-3 minutes for one blasting operation depending on the charge. The noise levels over this time would be instantaneous and short in duration thus implying that impact on noise levels from blasting are not of concern.

Noise due to crushing, Screening and Loading Plant

The average noise levels generated due to proposed crushing activities will be about 88.5 dB(A) which is within the exposure limit of 90 dB(A). The crusher shall be housed in a shed to contain noise. Screening activities shall generate average noise level of about 96.5 dB (A). Workers in the noise generating zone will be provided with earmuffs/earplugs besides dust mask.

Noise due to Excavation and Transportation

Noise generated due to deployment of rock breaker, excavators, loaders and dump trucks are shown in **Table 0.4.**

Table 0.4. Machines Employed and Noise Generated at 15 m from Source*

S No	Machinery / Activity	Noise Produced in dB(A) at 15 m from source*
1	Excavator/Shovel	85
2	Front end loader	85
3	Dump Truck/ Tippers (at full throttle)	92
4	Near Haul road (while dumpers are moving)	88
5	Dozer (when dozing)	102
6	Drill machine (drilling with Jack hammer)	88
7	Aggregate processing unit / Stone Crusher (outside crusher cabin)	100
8	Aggregate processing unit / Stone Crusher (inside crusher cabin)	86

50 feet from source = 15.24 meters

The noise likely to be generated during excavation, loading and transportation of material will be in the range of 90 to 105 dB (A) and this will occur only when all the equipment operate together and simultaneously. This is however, is a remote possibility. The workers in general are likely to be exposed to an equivalent noise level of 80 to 90 dB (A) in an 8-hour shift, for which all statutory precautions should be taken into consideration. The range of typical noise levels in relation to distance from a construction site is shown in **Table 0.5.**

Table 0.5. Construction Noise / Distance Relationship†

Distance from Construction Site (m)	Range of Typical Noise Level dB(A)

* Source: U.S. Department of Transportation (Federal Highway Administration) – Construction Noise Handbook
† Source: Department of Transportation, State of Wisconsin (USA)

8	82-102
15	75-95
30	69-89
61	63-83
91	59-79
122	57-77
152	55-75
305	49-69

Operation Phase

Uninterrupted movement of heavy and light vehicles at high speeds may cause increase in ambient noise levels on the project road. It may have negative environmental impacts on the sensitive religious receptors along the project area. Variation of noise level with vehicle speed is given in **Table 0.6**.

Table 0.6. Noise Level Variation with Vehicle Speed

Speed (km/h)	Noise Levels in dB (A) at 15 m			
	Cars*	Trucks	Buses	2/3 Wheelers
40	59.0	76.0	76.0	61.0
50	63.0s	80.0	80.0	66.0
60	65.0	81.0	81.0	68.0
70	68.0	81.5	81.5	70.0
80	70.0	82.0	82.0	72.0
90	72.0	83.0	83.0	74.0
100	74.0	83.5	83.5	76.0

*Noise levels for new cars are 5dB (A) or lower.

With the proposed improvement, the residential areas near to the project area are likely to experience high day and nighttime noise levels. These noise levels significantly vary with vehicle speed as presented in **Table 0.6**.

5.6.1.2. Mitigation Measures

Construction Phase

- Careful planning of machinery selection, operations and scheduling of operations can reduce noise levels.
- Construction contract should clearly specify the use of equipment emitting noise of not greater than 90 dB(A) for the eight hour operation shift.
- Proper maintenance of noise generating transport vehicles.
- To check the noise, pollution noise filters may be erected around the batching plant.
- Regular maintenance of heavy earth vehicles may be adopted to reduce noise levels
- The citing of construction yards should be done leaving at least 100 m distance from any residential areas, which will allow noise to attenuate.
- The main noise producing sources such as the concrete mixers, generators, grader etc. should be provided with noise shields around them. The noise shields can be any physical barriers, which is effective in adequate attenuation of noise levels. A 3 m high enclosure made up of

brick and mud with internal plastering of a non-reflecting surface will be very effective in this regard.

- For protection of construction workers, earplugs should be provided to those working very close to the noise generating machinery.
- To avoid significant impacts on human health, it is being recommended to avoid construction work at certain sections during night times and ensure that only minimum required machinery is deployed on the site. At construction sites within 150 m of human settlements, noisy construction should be stopped between 10:00 pm and 8:00 am
- Noise level monitoring should be conducted as per Environmental Monitoring Plan.

Operation Phase

- The proposed avenue plantation and other noise mitigative measures are expected to minimize the impacts on the immediate influence area of the project road.
- Development of greenbelt comprising selected species of trees with high canopy along the project road for attenuation of noise.
- Use of horns should be restricted at sensitive locations like schools and hospitals through the use of appropriate signboards along the road. Use of air horns should be minimized during night.
- Noise monitoring should be conducted as per Environmental Monitoring Plan.
- Depending on the nocturnal wild life, operation timing needs to be regulated to giver relief from noise hazard.

5.6.2. Vibrations (due to Blasting and Drilling)

The ground vibrations, noise and fly rock constitutes the chief environmental impact of blasting. The ground vibration sets the ground in transverse, longitudinal and vertical direction and which in turn causes the foundation of structure to vibrate in these directions and damage the structures. Air overpressure is transient impulse, which traverses through the atmosphere and is both audible and inaudible and has the energy to vibrate a structure like ground vibration and is much of concern, as animals are more sensitive than human being.

5.6.2.1. Anticipated Impacts

Construction Phase

Guidelines in the Federal Transit Administration (FTA) guidance manual (FTA 2006) provide the basis for the construction vibration assessment. FTA provides construction vibration criteria designed primarily to prevent building damage, and to assess whether vibration might interfere with vibration sensitive building activities or temporarily annoy building occupants during the construction period.

Table 0.7. Construction Vibration Damage Criteria*

Sl No	Building Category	Peak Particle Velocity (PPV), inch/sec	Approximate Lv

*Source: FTA, 2006

Sl No	Building Category	Peak Particle Velocity (PPV), inch/sec	Approximate Lv
1	Reinforced concrete, steel, or timber (no plaster)	0.5	102
2	Engineered concrete and masonry (no plaster)	0.3	98
3	Non-engineered timber and masonry buildings	0.2	94
4	Buildings extremely susceptible to vibration damage	0.12	90

* An Root Mean Square (RMS) vibration velocity level in VdB relative to 1 micro-inch/second

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. **Table 0.8** provides the approximate distances within which receivers could experience construction related vibration effects.

Table 0.8. Approximate Distances to Vibration Criterion – Level Contours*

Sl No	Landuse Category	Vibration Criterion Level (VdB)	Approximate Vibration Contour Distance (feet)
1	Tracts of land where silence is an essential element	65	175 (53.35 m)
2	Residences and buildings where people normally sleep	72	130 (39.624 m)
3	Institutional land uses with primarily day time and evening use	70	70 (21.336 m)

Operation Phase

The objective of the present project is only to construct Twin Tube Unidirectional Tunnel Road (2+2 Lane). Hence, no impacts due to vibration during operation stage.

5.6.2.2. Mitigation Measures

Construction Phase

The parameters associated with ground particle vibrations (peak particle velocity) are acceleration, velocity and displacement and their respective frequencies. It is observed that the PPV in the medium at the site of the structure represents a good general index of damageindependent of the frequency. It may, therefore, be adopted for specifying the safety criteria against threshold damage. The PPV at any point mainly depends on the amount of charge exploded, distance between the shot point and the station of observation and the local geology of the medium. The other less important variables are the explosive used, its coupling state with the surrounding medium and structural peculiarities of the medium, which generally don not figure in velocity charge distance relationship.

The threshold of human perception of vibrations is far below the threshold of damage, whereas the vibrations become intolerable at ground velocities higher thatn the velocity of threshold damage. Therefore, if the vibrations are kept below threshold of damage, they though perceptible, will not be perceptible nuissance to human being.

*Source: FTA, 2006

At short range a wave radiates spherically and the amplitude of vibration diminishes approximately inversely as the distance. At long range, the wave splits into different types travelling at different speed and variations in medium cause scattering. Geological discontinuities, such as faults may prevent propogation in a particular direction.

As the range increases, the charge required to cause damage increases and also the duration of pulse of vibration increases with the result that the area of damage in the structure would increase. For large charges and long ranges, an earthquake type analysis will be appropriate using response spectra for the ground motion caused by underground blast.

The response of a structure to the ground vibration, is the function of the natural frequency of the structure (N), frequency of ground motion (f), the damping in the material of the structure and duration and the intensity of ground vibration. It may be assumed that resonance is not likely to occur since the explosion causes impulsive ground notion, which is complex and irregular in character, changing in frequency and amplitude and lasting for small duration.

5.6.2.2.1. Safety Criteria against Threshold Damage

1. Assessment of Ground Particle Velocity – The value of ground particle velocity may be computed from the following expression:

$$v = K_1 (Q^{2/3}/R)^{1.25}$$

where

v = ground particle velocity in mm/s,

K_1 = constant which may be normally taken as given in the Note

Q = charge per delay in kg, and

R = distance from blast point in m.

Note: Value of $K_{1 - \text{Soils,}}$ weathered of soft rock = 880; and hard rock = 1400

1.1. Safe GroundParticle Velocity (v)

For safety of structures from threshold damage, the ground particle velocity (v) as computed shall not exceed the following values:

a) Soils, weatherd or soft roack 50 mm/s

b) Hard rock 70 mm/s

where monitoring of ground particle velocity by means of suitable instruments is adopted as a means of vibration control, the peak ground particle velocity may not exceed the following:

a) Soils, weatherd or soft roack 70 mm/s

b) Hard rock 100 mm/s

2. Safe Distance from Blast

For charges upto 100 kg per delay, the safe distance of the structure from the blast point may be obtained from the following graph (**Figure 0-1**).

If the delay time $r \geq$ R/4C the ground motions areagoverned by the total charge weight in a single delay,

Where

R = delay time in seconds,

R = distance from the blast point in m, amd

C = longitudinal seismic wave velocity of the medium in m/s.

Note – If the delay time is less than that given, the designer may look for references.

In the absesnce of actual data the values of longitudinal seismic wave velocity may be taken as follows:

Type of Medium	*Velocity C in m/s*	*Range of C*
Soils	1000	200 to 1800
Weathered and soft rocks	2500	1800 to 3200
Hard rock	5000	3200 to 7500

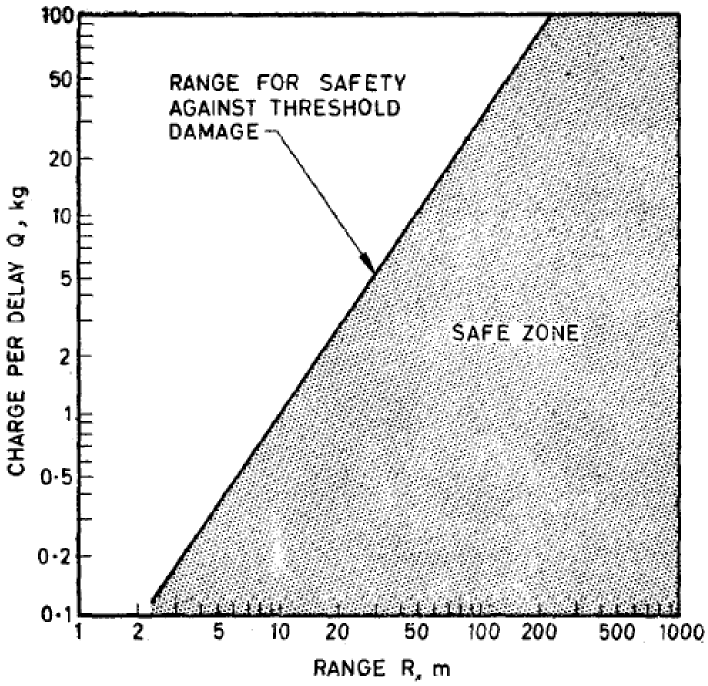


Figure 0-1. Charge per Delay as a Function of range *R* for Safety against Damage during Underground Blasting

5.6.2.2.2. Ground Acceleration for Design

For large charges more than 100 kg/delay, where the safety criteria against threshold damage are violated and it is desired to design structures for seismic effects of the blasts, the following equation may be used for finding the design acceleration in the horizontal direction.

$$\frac{a}{g} = \frac{K_2\, Q^{0.83}}{R^2}$$

where

a = design acceleration in cm/s^2

g = acceleration due to gravity in cm/m^2

K_2 =constant (which may be taken as 4 for soil, weatherd and soft rock and 6 for hard rock);

Q = charge per delay in kg; and

R = distance from structure from blast point in m.

The design acceleration so obtained should be uniformally applied to the structure.

5.6.2.2.3. Monitoring

Monitoring of ground vibrations may be necessary for various reasons as follows:

a. To determine by pilot tests, the maximum charge Q that may be used in blasting operations to keep the ground particle velocity at the site of strucures within the safe values or for determining the accelerations for design;

b. To determine by pilot tests the constant K_2 to be used and longitudinal wave velocity for use; and

c. To control the charge during actual excavation operations by keeping the ground particle velocity within the safe values. This will particularly be useful for excavations in built up areas.

For measurement of ground vibrations, three types of instruments could be used, namely accelerometer, velocity pick up or displacement meter. Of the three, the velocity pick up will be most appropriate for small charges and short ranges and the accelerometer for large charges and long ranges. The frequency response of velocity measurement should be flat above 10 c/s and in the case of acceleration measurement it should be flat in the range 0 to 100 c/s.

Where a threshold ground velocity is specified, peak velocity sensors could be used which would activiate a warning system, either visual in the form of light indication or sound in the form of alarm.

In case a displacement meter is used, the peak ground velocity shall be obtained from the displacement *vs* time record by measuring the maximum slope of the curve.

Subsidence of the structure could also be monitored.

Damaged buildings would be repaired, or compensation paid to the owners. The operation time shall be limited between 6:00 to 18:00. Although the vibration level caused by blasting is theoretically controlled within the threshold value, continuous monitoring is necessary during the construction for both NATM and blasting. Notify the local people prior to undertake the construction activities associating with higher vibration level such as activities using vibrating rollers. The vibrations should be reduced considerably by ensuring and keeping correct track geometry by advanced measurement.

- Blast holes shall be initiated by non-electric (NONEL down-the-hole (DTH) delay detonators.
- Care shall be taken to ensure that effective burden is not excessive and the face shall be kept sufficiently long.
- Optimum charge per delay shall be kept as low as possible.
- Adoption of two row blasting and V pattern of firing
- The firing of maximum possible no. of blast holes towards free face.
- Use of milli-second delay detonators between the holes and rows of blasting.

Operation Phase

Traffic-generated vibration is rarely a significant issue in the operation phase of proposed road tunnel (unlike rail tunnels, because trains generate much more vibration than road vehicles). Should such a problem occur, there is generally little that can be done apart from prohibiting access to the heaviest vehicles. Another source of vibration is the fans. These should be carefully balanced to avoid excessive vibration. However, fan vibration is generally not perceivable in the environment; it primarily affects the machine itself, and can compromise its longevity. It can also become a safety issue because jet fans, for example, may lose parts or even fall down from the tunnel ceiling due to excessive vibration. Vibration monitoring is crucial for the reliability and safety of jet fans.

5.7. Biological Environment

7. Anticipated Impacts:

Anticipated impacts of the proposed tunnel-road development project on ecological and biological environment with respect to flora, fauna, and habitats are discussed below. It is important to note that the project area and surroundings are part of the Western Ghats, one of the 36 global hotspots of biodiversity and one of the three mega diversity hotspots in India. The southern part of the Western Ghats chain of mountains including Kerala and parts of Karnataka and Tamil Nadu is exceptionally noteworthy for its species richness, diversity, endemism and rarity. As evident from the results of the periodic survey (covering all prominent seasons) conducted as part of the comprehensive EIA study and secondary records pertaining to the project environment, the area harbours diverse species, distributed over varied habitats. Higher concentration of endemic flora covering also exclusive endemics to the State of Kerala, further testifies ecological significance of the region.

Impact on habitat due to transport infrastructure development is receiving growing concern among conservationists (Van der Zande *et al*., 1980; Glitzner *et al*., 1999; Trombulak and Frissell, 2000; Holzang *et al*., 2000). Possible consequences to wildlife have been recognised and evidences brought in on the effects on both species and ecosystems at different spatial scales (Canters *et al*., 1997). With the increasing spatial demands of the road network and its physical encroachment on the land, conflicts between transport infrastructure and the natural, cultural and heritage of the landscape have become inevitable (Nihlén, 1966; Ellenberg *et al*., 1981; Jedicke, 1994). Though debated much among wildlife managers, there had been only a few studies on the complex impact of the linear infrastructure on wildlife and landscapes, and even on the ecological processes (Seiler, 2001) reviewed on the effects of roads.

Empirical data on the impacts of infrastructure on wildlife mostly refers to primary effects that derive from a single road or railroad, are easily measurable and matter to the organisms directly and at a local scale. The following five major categories of primary ecological effects have been identified (Van der Zande *et al*., 1980; Bennett, 1991; Forman, 1995).

Habitat loss: Construction of roads and railroads always implies a net loss of wildlife habitat. The physical encroachment on the land gives rise to disturbance and barrier effects that contribute to the overall habitat fragmentation.

Disturbance: Roads, railroads and traffic disturb and pollute the physical, chemical and biological environment and consequently alter habitat suitability for many plant and animal species for a much wider zone than the width of the road itself.

Corridor: Road verges and roadsides provide refuges, new habitats or serve as movement corridors for wildlife.

Mortality: Vehicular traffic leads to the death of many animals that utilise verge habitats or try to cross the road. Traffic mortality has been growing constantly over the years, but is considered as a severe threat only in few species. Collisions between vehicles and wildlife are also an important traffic safety issue.

Barrier: The linear infrastructure often acts as a barrier, especially for the non-flying terrestrial animals. These barriers that restrict the animals' range, make habitats inaccessible and can finally lead to an isolation of populations. The barrier effect is considered to be the most prominent factor in the overall fragmentation caused by infrastructure.

While the above ecological repercussions are pertinent to highways/roads, particularly passing through or along wilderness areas, anticipated impacts of the proposed tunnel-road project could be summarised as follows.

5.7.2. Impacts on Land Cover and Flora

Loss of vegetation cover

Total extent of forestland involved in the project execution is 17.263 ha of which 16.269 ha implicates only underground use (in tunnel development). Out of the total 36.745 ha of land required for the project, forestland is constituted by 17.263 ha in the tunnel section and 7.482 ha of private land located on the northern (Meppadi) and southern (Anakkampoil) ends of the proposed alignment, in addition to the land required for compensatory afforestation and to organise muck dump yard. Involvement of forestland is to the tune of 17.263 ha, which involves mainly underground use except for 0.994 ha riverine area of Iruvazhanjipuzha. Therefore, the project execution will not result in significant land cover modification or fragmentation of habitats. Being located between private lands on either side the small segments of riparian belts involved on both banks of the river, presently remain under pressure due to farming operation and related human interferences.

Loss of trees

The project development involves cutting and removal of 103 trees from the forestland (southern end of the tunnel in Anakkampoil area) under Kozhikode Forest Division (see **Table-5.9.**) for species-wise and girth-wise enumeration of trees in development sites).). This includes 28 species of trees, of which majority is constituted by *Melicope lunu-ankenda* (16 trees) followed by *Macaranga peltata* (15 trees) and *Artocarpus heterophyllus* (12 trees). Among affected trees in the forestland, nine species are endemic to the Western Ghats, viz. *Baccaurea courtallensis* (Moottilpazham), *Cynometra travancorica* (Koori), *Elaeocarpus munronii* (Neeli), *Flacourtia montana* (Chaliram), *Myristica malabarica* (Kattujathi), *Palaquium ellipticum* (Pali), *Reinwardtiodendron anamalaiense* (Cheeralam), *Syzygium mundagam* (Kattuchampa) and *Vateria indica* (Vellappayin). Further, *Cynometra travancorica* (Koori) is Endangered, *Myristica malabarica* (Kattujathi) and *Vateria indica* (Vellappayin) are Vulnerable, and *Elaeocarpus munronii* (Neeli) as per IUCN Red List of Threatened Species.

Table-5.9. Species wise and girth-class wise enumeration of trees to be cut and removed from the forestland in the project execution

Sl. No.	Scientific name	Local name	Girth-Class (cm)					
			1-30	31-60	61-90	91-120	121-150	>150
	Anakkampoyil area, Kozhikode (Forest Division)							
1.	*Artocarpus heterophyllus*	Plavu		5	7			
2.	*Macaranga peltata*	Vatta		11		2	2	
3.	*Memeceylon angustifolium*	Kayampoo		2			1	
4.	*Ficus drupacea*	Koli, Chela, Kallal			2		1	2
5.	*Erythrina variegata*	Murukku		1	1			
6.	*Baccaurea courtallensis*	Moottippazham		3				
7.	*Melicope lunu-ankenda*	Kambili		8	7		1	
8.	*Elaeocarpus tuberculatus*	Bhadraksham		5	1			
9.	*Spondias pinnata*	Ambazham		1				
10.	*Persea macrantha*	Kulirmavu		1				
11.	*Mallotus tetracoccus*	Charavatta		1	2			
12.	*Myristica malabarica*	Kattujathi			1			
13.	*Garcinia gummi-gutta*	Kudampuli			1	1		
14.	*Bischofia javanica*	Chorappali			3		1	1
15.	*Reinwardtiodendron anamalaiense*	Cheeralam		2	1			
16.	*Syzygium mundagam*	Kattuchampa		1			1	
17.	*Vateria indica*	Vellappayin		3				
18.	*Elaeocarpus munronii*	Neeli		1	1	1		1
19.	*Olea dioica*	Edala	1		1			
20.	*Mallotus tetracoccus*	Pottama				1		
21.	*Mangifera indica*	Mavu						1
22.	*Ficus tsjahela*	Chola			2			
23.	*Zanthoxylum rhetsa*	Mullilam			1			
24.	*Cynometra travancorica*	Koori			2			
25.	*Palaquium ellipticum*	Pali		1			1	
26.	*Mallotus philippensis*	Sindoori		1	2			
27.	*Flacourtia montana*	Chaliram, Vayyamkatha			1			
	Total (Anakkampoyil area)		**1**	**47**	**37**	**6**	**7**	**5**

Apart from the above, it requires removal of 44 trees (belonging to 10 species) from private land holdings of Anakkampoil area and 30 trees (covering seven species) from Meppadi area (see **Table-5.10**.) for species-wise and girth-class wise enumeration). Of the 44 trees in Anakkampoil area, majority is formed by *Vateria indica* (10 trees) followed by *Macaranga peltata* (9 trees) and four trees each of *Tectona grandis, Lagerstroemia macrocarpa and Artocarpus heterophyllus. Tectona grandis* (Thekku, Teak) is Endangered, and *Vateria indica* (Vellappayin) and *Dalbergia latifolia* (eetti) are as per IUCN Red List. *Lagerstroemia macrocarpa and Vateria indica* are endemic trees.[M A15]

Table-5.10. Species-wise and girth-class wise enumeration of trees to be cut and removed from private lands of Anakkampoil and Meppadi areas

Sl. No.	Scientific name	Local name	Girth-class (cm)					
			0-30	31-60	61-90	91-120	121-150	>150
	Anakkanpoil area							
1.	*Artocarpus heterophyllus*	Plavu			1	1	1	1
2.	*Dalbergia sissoides*	Veetti				1		1
3.	*Erythrina variegata*	Murukku		2				
4.	*Gmelina arborea*	Kumbil			1	2		
5.	*Lagerstroemia microcarpa*	Venmizhavu				1	1	2
6.	*Macaranga peltata*	Vatta		4	3	2		
7.	*Mangifera indica*	Mavu, Mango			2	1		
8.	*Pajanelia longifolia*	Azhantha		1	1	1		
9.	*Tectona grandis*	Thekku, Teak			2	1	1	
10.	*Vateria indica*	Vellappayin		1	2	4	1	2
	Total (Anakkampoyil area)			**8**	**12**	**14**	**4**	**6**
	Meppadi area							
1.	*Artocarpus heterophyllus*	Plavu, Jackfruit tree				3		
2.	*Dalbergia latifolia*	Eetti			3			
3.	*Gmelina arborea*	Kumbil				1	1	
4.	*Macaranga peltata*	Vatta		3	2			
5.	*Mangifera indica*	Mavu, Mango			1	1		
6.	*Psidium guajava*	Pera, Guava	1	1				
7.	*Tectona grandis*	Thekku, Teak		9	3	1		
	Total (Meppadi area)		**1**	**13**	**9**	**6**	**1**	

5.7.2.1. Impacts during construction

Earthworks, rock excavation, transport of muck and operation of heavy machinery will result in the alteration of air, land and surface water quality by emanation of dust and gaseous pollutants and through inflow of mud and suspended particles in to the river system. Though restricted to construction phase, such changes will affect both terrestrial and aquatic life forms and habitats. Air borne particulates and gaseous pollutants affect photosynthesis in plants and interfere with the pollination mechanism apart from changing the soil characteristics by deposition. Such changes in air characteristics will drive away insect pollinators to affect the reproduction of entomophilic plants, especially epiphytic orchids. As stated earlier, the area houses several species of epiphytic orchids. However, the spread of dust and emission of pollutant gases can be controlled by providing dust screens (at emission points), intermittent spray of water and through the use of fuel-efficient machines. By providing adequate cover to vehicles while transporting excavated materials, spread of dust to the nearby natural (forest) and domesticated (croplands/plantations) systems can be further reduced.

The mud and sediments entering the river/stream will change the water quality to affect aquatic and riparian habitats and life forms including benthic flora. Dumping of excavated materials adjacent to river or streams will further worsen the situation, especially during rains. Avoiding unorganised dumping of excavated materials by regular lifting from the site of generation and disposal at the designated muck dump yard together with setting up of retention pond in the path of surface runoff at a safe distance from the river/stream (to allow settlement of solid particles and flow of clear water) will remediate the problem considerably. Interference and collection of firewood from the forest by the workforce is another concern during construction phase. This can be remedied by setting up temporary construction camp for workers at a safe distance from the forest boundary. Checking illegal entry in to the forest system will provide an additional effective solution.

5.7.2.2. Impacts during Operation

Extensive vehicular traffic and influx of people in the area during operation phase might cause invasion of alien species (weeds) to cause habitat degradation. Accidental introduction and successive proliferation of alien species would alter the natural habitats to seriously affect food chains and ecosystem functions. Though weed infestation is evident in the fringe areas of the forests, it needs to be monitored and controlled through appropriate methods.

5.7.3. Impacts on Terrestrial Fauna and Wildlife

Alteration or loss of habitats and anthropogenic disturbances are the probable causes of negative impacts on wildlife due to the implementation of developmental projects in wilderness areas. Since the tunnel-road construction primarily involves underground use of forestland, significant alteration and fragmentation of habitats is not anticipated. However, considering the proposed location within the Western Ghats, especially cutting across a diverse species rich stretch of forests, the probable impacts on fauna need to be addressed critically. The following are the concerns with respect to the impact of project implementation on wildlife

5.7.3.1. Impacts during Construction

The concerns connected with project construction on terrestrial wildlife and habitats include disturbance due to vehicular movement, operation of heavy machines and use of flood light during night time, habitat modification due to unorganised dumping of muck in the forestland and causing annoyance or teasing of animals by people associated with construction. The tunnelling operation and transport of excavated materials would result in the spread of airborne particulates and noise pollution in the area to disturb wildlife. However, these effects could be controlled or minimized significantly by implementing appropriate mitigation measures, such as controlling dust/particulate emission by providing dust screens, intermittent sprinkling of water and through involving only fuel-efficient machines. Providing adequate cover to the vehicles while transporting excavated materials will check the spread of dust. It is also important to allow only good quality/fuel-efficient machines in construction related operations which cause minimum emission of gaseous pollutants and noise.

The elephant movement in the Anakkampoil area will not be affected due to opening of the tunnel mouth From the top portion of the tunnel mouth, elephants can move to areas of Edavanna Range and Meppadi Range. People have installed solar power fencing around some of the cultivated plots. However, currently only those installed by Shri Sunny is functional. A few have installed their own innovative technique to protect their cultivated areas.

There had been no human deaths due to wildlife for the last ten years in Anakkampoyil area However, one elephant was electrocuted at Hussain’s plot on the West extreme side of Kundanthodu in 2018. The tusks of the elephants were stolen but recovered later. Another incidence of elephant death was reported from Thenpara 90 section; the female elephant fell into an open well in 2020. The data for the last five years indicate no conflict related incidences in the areas nearer to the proposed tunnel road area. However, there are few incidences of injuries and crop damages due to wildlife in areas outside the proposed project site. The major issue in the nearby areas of the proposed tunnel is from the bonnet macaque.

The impact on elephants and human-wildlife interaction was critically analysed. The current movement pattern of elephants in Meppadi part as observed by the Forest Staff and general public. According to this, elephant moves to Kuppachi forest through the Meenakshi Vilasom Estate (Survey No.36), Block 26, Kotta, proposed tunnel mouth (Mr. Pappan’s plot) to Meppadi-Chooralmala-Hope Estate. An alternate route is through Kalladi (Michabhoomi colony)-Vellapinekandi Colony and then to Kuppachi Forest through Hope Estate. Elephants do not cross to Baderi Section, north of Kuppachi due to steep terrain. The Kalladi Colony and nearby settlements are more populated. Any barrier at the proposed tunnel mouth in Meppadi area would force the elephants to utilise the other route more which would increase the frequency of use of the area. Such a situation could lead to increased human-elephant interaction which could possibly lead to conflict situations. As it stands now, there is no possibility to avoid the movement of elephants to Kuppachi forest through the populated colonies once the tunnel mouth area is blocked.

The elephants in Anakkampoil area are not utilising the habitat near the proposed tunnel mouth obviously due to disturbance in the form of farming operations and human presence. Thus, the area is not affected because of the tunnel. Having said these, there is every possibility of elephants getting more disturbed during the construction phase because of vibration from boring and may be explosion. Such continuous disturbance could lead to redirected aggression in the nearby colonies and other populated areas in both Anakkampoil and Meppadi areas. It is therefore suggested to create a corpus fund for meeting the emergencies due to anticipated escalation of human wildlife conflict. The fund could be parked in an appropriate manner (VSS or EDC) with overall control of Range Forest Officers, preferably of Meppadi Range.

5.7.3.2. Impacts during Operation

The number of road kills, especially of birds is alarming as per the available information (Hodson, 1966; Hansen,1982; Van den Tempel, 1993; Rodts *et al*., 1998). Amphibians, especially due to its migration during breeding season, have been considered as one of the most affected due to transport infrastructures (Vestjens, 1973; Blaustein and Wake, 1990; Reh and Seitz, 1990; Fahrig *et al*., 1995); and Van Gelder (1973) found that roads with a traffic volume as low as 10 vehicles per hour could cause a 30% mortality in female toads (*Bufo bufo*). Roads with more than 60 vehicles per hour comprised an almost complete barrier. The number of collisions generally increases with traffic intensity, animal activity and density. Temporal variations in road kills indicate different biological periods that influence the species' activity, such as the daily rhythm of foraging and resting, mating and breeding season, dispersal of the young, or seasonal migration between winter and summer habitats (Aaris-Sorensen, 1995; GrootBruinderink and Hazebroek, 1996). The presence of a road may modify an animal's behaviour by shift in home range, altered movement pattern, altered reproductive success, altered escape response and changed physiological state (Trombulak and Frissell, 2000).

Presence of road and their impact on elephants have been described by Desai and Baskaran (1996), Leimgruber *et al.* (2003), Menon *et al.* (2005) and Vidya and Thuppil (2010). There are a number of studies in India on the road kills along the highways (Gokula, 1997; Sharma,1988; Kumara *et al.*, 2000; Vijayakumar *et al.*, 2001; Chhangani, 2004; Parasharya and Tere, 2007; Das *et al.*, 2007; Seshadri *et al.*, 2009; Selvan, 2011; Easa and Kumar, 2014). Most of these studies have highlighted the mortality of herpetofauna especially during breeding season.

The proposed tunnel of about 8 km passes through a comparatively undulating hilly area (Figs. 5.2 and 5.3). The distance from the tunnel, as measured from the surface of the hills above, will be much higher to have a visible impact on the habitat above or the wildlife in such areas. Most of the impact due to the proposed activity would be direct at the tunnel mouths and indirect due to the expected change in the movement pattern of elephants.

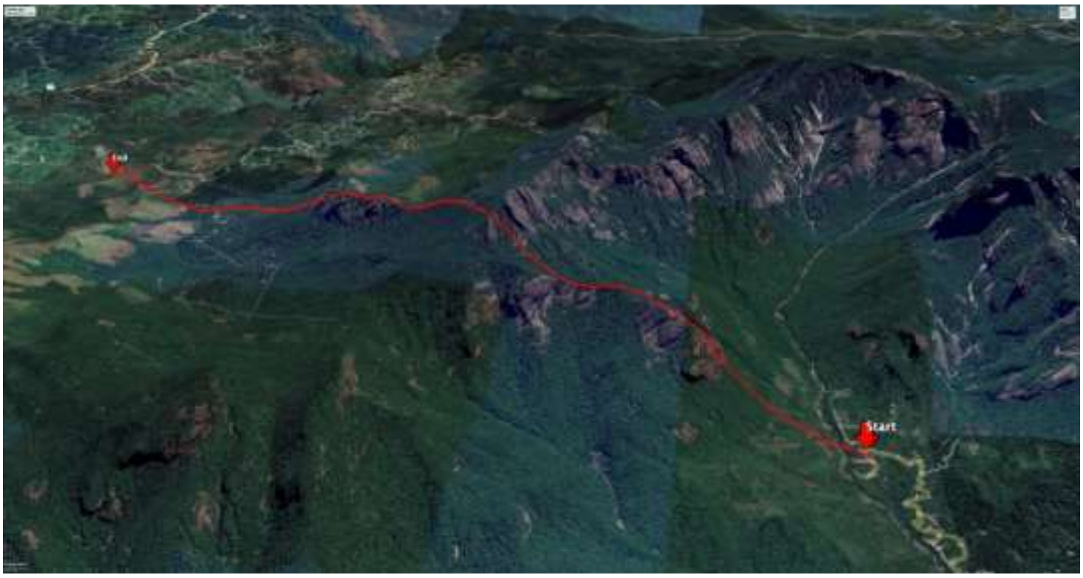


Fig. 5.2: The proposed Tunnel Road direction

Fig. 5.3.: The terrain of the proposed tunnel road area

The construction of the proposed tunnel road would probably have severe impacts basically at the start and end points of the tunnel route. Birds being terrestrial and mobile, may be more adaptable compared to herpetofauna, and can possibly fly away farther from the point of impact to some extent. Even then, clearing of vegetation in these points might lead to destruction of their breeding or nesting grounds, and roosting or resting sites that may be present in these areas. Vibrations induced from boring through or machine-cutting of these huge boulders could also have adverse effects on the overall behaviour and survival of birds. Possible air pollution following the construction activities would also be problematic for the biota of the study region and its surrounding landscapes. Moreover, there are certain species that are habitat specialists, and that are of specific conservation value like the threatened, range-restricted and endemic species that would be the most impacted by such habitat degradation. If these construction activities disturb habitats in the upper parts of the tunnel in any way (which is not possible as per the present plan), it could possibly have huge impacts on the already fragmented populations of the aforementioned Banasura Chilappan (*Montecincla jerdoni*).

The possible impact on the herpetofauna due to the proposed tunnel is unknown at the moment and depends on the method of tunnel construction. However, the two openings on either side of the tunnel might be the area where there are possibilities of negative impact on the herpetofauna in the form of road kills or as fragmentation of habitats. This is especially possible in Meppadi area. Amphibian species like *Clinotarsus curtipes* and *Blaira ornata*, which breed and lay their eggs in the streams would migrate to nearby forest areas once they metamorphosize and the opening areas of the tunnels have streams/rivers in the vicinity. All over the world, amphibians and reptiles are one of the major group of vertebrates that are impacted by linear intrusions (Puky, 2005; Sheperd *et al*, 2008) and one potential recommendation is to provide under-road tunnels or passages for the amphibians. Nonetheless, whether all species use such under passage is unlikely but studies show that a greater percentage of animals use such passages when they are directed to these tunnels by walls which were built higher for them.

5.7.4. Mitigation Measures

In the present EMP, due regard is given to protection of habitats and the life forms, during the entire project. In order to achieve this, a number of recommendations have been made, which are aimed at ensuring that the proponent maintains adequate control over the project in order to minimize the extent of impact during project execution, ensuring appropriate restoration of areas affected by construction and preventing long term environmental degradation. The programmes/measures for sound environment management of the project during construction and operation phases could be summarized as follows.

5.7.5.Management Measures for the Construction Phase

5.7.5.1. Air quality and sound level management during construction

Possibility of significant air contamination and noise pollution are mainly restricted to the construction phase of the project, owing to earthworks and tunneling, use of heavy machineries, transport of materials, crushing of stones, use of cement, crusher, sand, etc. The spread of suspended particulates during construction can be controlled reasonably through intermittent sprinkling of water and use of dust screens. It is also imperative to allow only good quality/fuel-efficient machines in construction which cause minimum emission of pollutants and noise. Adequate cover to vehicles involved in the transport of excavated materials from the sites of generation to muck dump yards shall be ensured. A sizable part of the excavated rock materials can be used for leveling and stabilizing of road bed, construction of bridge, etc. But the excavated rock materials have to be crushed into requisite size before use. However, crushing of rock materials shall be done in the muck dump yard located at a safe distance from the forest boundary, say at least 500 m. Intermittent sprinkling of water also will be of use in controlling the air-borne particulates to certain extent. Further, the crusher will cause noise pollution during its operation and it is important to use good quality machine, which produces less noise; nevertheless, acoustic screen shall be provided.

5.7.3.2. Management of River Water Quality during Construction

Mud and sediments entering the river/stream during construction shall be avoided by regular lifting of excavated materials from the site of generation and disposal at the designated muck dump yards. It is also imperative to avoid unorganised dumping of rejects adjacent to surface flow or within/in the proximity of forestland. In addition, setting up of retention pond in the path of surface runoff shall be made at a safe distance from the river/stream to allow settlement of solid particles and flow of clear water. The sludge from the settling tank must be removed on a regular basis and disposed of in pits prepared in the muck dump yard. The construction camp for workers shall be organised at a safe distance from the river with adequate arrangements for water supply and sanitation.

5.7.3.3. Wildlife Protection during Construction

The tunnel mouths are situated adjacent to forestland. Therefore, construction of the proposed tunnel and adjoining roads will result in repercussions on the forest system and its wildlife content, if not adequately controlled/managed. In the light of this, a set of management measures have been proposed as follows.

The construction activities must be strictly restricted to daytime, and casual entry/ movement of project workers in the peripheral forest areas of development sites must be strictly controlled. Teasing of animals, poaching and collection of firewood must be checked by imposing restrictions to their movement within the forest land. The machines used in construction must be of good quality and in good condition, which produce less noise. Also, vehicular movement during night hours must be avoided in the peripheral areas of forest land. Sprinkling of water must be done intermittently to avoid the menace of dust pollution during earthworks. Use of plastic carry bags and piling up of garbage in the forestland and its proximity must be strictly controlled. To implement the above management proposals, patrolling by Forest Department personnel must be intensified in the area. In view of this, two check posts shall be established, one near the point at Anakkampoil, and the other at Kallady adjacent to the tunnel mouth. Additionally, care should be taken to ensure uninterrupted flow of the streams near the tunnel mouths and maintain undisturbed breeding sites of the amphibians.

A team for monitoring the activities during the construction phase may be formed with representatives of the Tunnel Road Management, Forest Department and a Wildlife/ Biodiversity Researcher. The Team would periodically (at least once in two months) should visit the project site and oversee the activities in relation to environmental matters and advise the management. The tunnel mouth areas should be protected so that no animals will enter the tunnel and get trapped creating also troubles for the management.

5.7.6. Management Measures for the Post-Construction Phase

5.7.6.1. Development of Greenbelt for the Roads

Green belting of the new roads on both ends of the tunnel and the existing roads where widening is proposed shall be done involving indigenous and acclimatized exotic species, which are adapted to stressful environmental conditions and capable of ameliorating air and noise pollution from extended vehicular traffic. The list of trees and shrubs which could be considered as component species in the development of green belt towards improving aesthetics and accruing environmental services (air purification, carbon sequestration, filtering of airborne dust, oxygen replenishment and noise attenuation) is presented in **Table 5.11.**

Table 5.11 List of species to be considered for green belting of roads

Sl. No.	Scientific name	Common/local name	Habit
1.	*Aegle marmelos* (L.) Correa	Koovalam, Bael tree	Tree
2.	*Ailanthus triphysa* (Dennst.) Alston	Matti, Perumaram	Tree
3.	*Alstonia scholaris* (L.) R. Br.	Ezhilam-pala, Devil’s tree	Tree
4.	*Bauhinia purpurea* L.	Chuvanna-mandaram	Tree
5.	*Bauhinia tomentosa* L.	Yellow-bell bauhinia	Shrub
6.	*Canna indica* L.	Vazhachedi, Canna	Herb
7.	*Cassia fistula* L.	Kanikkonna	Tree
8.	*Cassia grandis* L.f.	Kovindaram, Mountain ebony	Tree
9.	*Dalbergia sissoo* Roxb.	Shisham	Tree
10.	*Diospyros buxifolia* (Blume) Hiern.	Elichuzhi, Kattuthuvara	Tree

11.	*Diospyros perigrina* (Gaertn.) Gurke	Panachi, Panacha	Tree
12.	*Ficus benjamina* L.	Vellal, Weeping fig	Tree
13.	*Ficus racemose* L.	Athi,	Tree
14.	*Gardenia jasminoides* Ellis	Gandharajan, Bush gardenia	Shrub
15.	*Gmelina arborea* Roxb.	Kumbil, Kumizhu	Tree
16.	*Heliconia psittacorum* L.f.	Heliconia	Herb
17.	*Justicia gendarussa* Burm.f.	Vathamkolli	Shrub
18.	*Kigelia africana* (Lam.) Benth.	Sausage tree	Tree
19.	*Kopsia fruticosa* (Ker-Gawl.) A. DC.	Kopsia, Shrub kopsia	Shrub
20.	*Lagerstroemia indica* L.	May flower	Shrub
21.	*Lagerstroemia speciosa* (L.) Pers.	Manimaruthu. Pride of India	Tree
22.	*Lawsonia inermis* L.	Mylanchi, Henna	Shrub
23.	*Magnolia champaca* (L.) Baill. ex Pierre	Chempakam, Champak	Tree
24.	*Malpighia coccigera* L.	Barbados cherry	Shrub
25.	*Mangifera indica* L.	Mango tree	Tree
26.	*Melia azedarach* L.	Malaveppu,	Tree
27.	*Murraya paniculata* (L.) Jack.	Maramulla, Honey bush	Shrub
28.	*Nerium oleander* L.	Arali	Shrub
29.	*Nyctanthes arbor-tristis* L.	Pavizhamalli, Night jasmine	Shrub
30.	*Phyllanthus myrtifolius* Moon		Shrub
31.	*Pongamia pinnata* (L.) Pierre	Pongu, Ungu	Tree
32.	*Rhapis excelsa* (Thunb.) Henry	Lady palm	Shrub
33.	*Saraca asoca* (Roxb.) de Wilde	Ashokam	Tree
34.	*Schleichera oleosa* (Lour.) Oken	Poovanam	Tree
35.	*Simrouba glauca* DC.	Lakshmi-taru, Paradise tree	Tree
36.	*Tabernaemontana divaricate* (L.) R. Br.	Nandyarvattom,	Shrub
37.	*Terminala bellerica* (Gaertn.) Roxb.	Thanni, Belleric myrobalan	Tree
38.	*Terminalia arjuna* Wight & Arn.	Neermaruthu, Arjun	Tree
39.	*Terminalia catappa* L.	Nattu badam, Indian almond	Tree
40.	*Vateria indica* L.	Vellapayin	Tree

5.7.6.2. Wildlife Management in the Post-Construction Phase

Minimizing human interference in the forest areas should be given priority during the operation (post-construction) phase. Reckless dumping of plastic and food wastes along the road shall be strictly banned/controlled. As the tunnel entry/exit points are situated adjacent to forest boundary, there may be chances of larger animals, mainly elephants, crossing the road or entering the tunnel to cause casualty. Such danger shall be avoided by creating fences on both sides of the road at tunnel mouths. The two check posts could be moved to a distant location and maintained especially for prevention of entry of animals in to the tunnel.

A Team with proven credibility may be engaged/funded for monitoring the elephant movement/road kills and other related issues. As suggested earlier, actions have to be taken for an under-passage (eg. Box culvert) along the nearby streams to ensure free movement/dispersal of amphibians during breeding season. An expert in the field of herpetofauna may be consulted for the implementation of the programme. Considering the probability of increased human-elephant interaction, especially in the movement paths in Meppadi Range, a corpus fund may be created for possible mitigation measures including ex-gratia payments. The fund may be parked in the accounts of VSS/EDC of the Meppadi Range, who will address the issues in both the Forest Ranges.

5.7.6.3. Compensatory Afforestation[M A16]

The project implementation involves 17.263 ha of forestland; majority of which encompasses underground use in tunnel development except for 0.994 ha within the riverine belt of Iruvazhanjipuzha in Thamarassery Range of Kozhikode Forest Division. Considering this, it is required to accomplish compensatory afforestation in 17.263 ha, involving indigenous species at par with existing rules and regulations. The Indian Forest Conservation Act (1980) stipulates compensatory afforestation for development projects that involves forestland as:

- **if non-forestland is available, compensatory afforestation shall be done over an area equivalent to the forest area that is affected or lost with respect to project execution, and**
- **if no non-forest land/revenue land is available for the purpose, compensatory afforestation shall be done on degraded forestlands, which must be twice the forest area that is affected or lost.**

The forestland involved in the project execution or the surrounding forest areas of the region, within or outside Forest Divisions of Kozhikode and Wayanad South, does not hold any degraded area in terms of vegetation cover. Therefore, an alternative plan has been considered by the project proponent in consultation with the State Forest Department with an outlay of Rs. 1.05 Crores as Compenastory afforestation scheme for 10 years including planting and maintaince. As per the CA plan, non-tribal private land (four plots totaling an area of 17.53 ha) from Wayanad [A17]South Forest Division under Kannur Circle has been identified, which include 1.8 ha in Kollivayal, 4.43 ha in Chullikkal, 10.03 ha in Madaparambu and 1.27 ha in Manaluvayal villages. Such enclosures are being acquired to avoid man-animal conflicts and towards ensuring forest continuity. The following indigenous trees and shrubs may be considered as component species (**Table 5.12.**) in compensatory forest development. The suggested species include conservation significant trees and shrubs found in the nearby areas of the development stretch towards population enhancement of such species.

Table 5.12. List of species to be considered in compensatory afforestation

Sl. No.	Scientific name	Local/Common name	Family	Habit
1.	*Actinodaphne wightiana* (Kuntze) Noltie	Kambilivirinji	Lauraceae	**Tree**
2.	*Aglaia elaeagnoidea* (A. Juss) Benth	Punyava	Meliaceae	Tree
3.	*Aglaia elaeagnoidea* (A. Juss.) Benth.	Punyava	Meliaceae	Tree
4.	*Alangium salviifolium* L.	Ankolam	Alangiaceae	Tree
5.	*Allophyllus serratus* (Roxb.) Kurz.	Mukkannan-pezhu	Sapindaceae	Shrub
6.	*Ancistrocladus heyneanus* Wall. ex Graham	Mothiravalli	Ancistrocladaceae	Climber
7.	*Antidesma montanum* Blume	Thathalamaram	Euphorbiaceae	Tree
8.	*Aporosa cardiosperma* (Gaertn.) Merr.	Vetti, Neervetti	Euphorbiaceae	Tree
9.	*Baccaurea courtallensis* (Wight) Muel.-Arg.	Moottilpazham	Euphorbiaceae	Tree
10.	*Briedelia retusa* (L.) A. Juss.	Mulluvenga	Euphorbiaceae	Shrub/ Tree
11.	*Butea monosperma* (Lam.) Taub.	Chamatha	Fabaceae	Tree
12.	*Careya arborea* Roxb.	Pezhu	Lecythidaceae	Tree
	Casaeria ovata (Lam.) Willd.	Malampavetta	Flacoutiaceae	Shrub
13.	*Catunaregam spinosa* (Thunb.)	Malankara	Rubiaceae	Shrub

	Tirveng.			
14.	*Chassalia curviflora* (Wall ex Kurz.) Thwaites	Nila-amalppori	Rubiaceae	Shrub
15.	*Cynometra travancorica* Bedd.	Koori	Fabaceae: Caesalpinioideae	Tree
16.	*Dalbergia latifolia* Roxb.	Eetti	Fabaceae	Tree
17.	*Dalbergia sissoides* Graham ex Wight & Arn.	Veetti	Fabaceae	Tree
18.	*Diospyros bourdillonii* Brandis	Kakkakarimaram	Ebenaceae	Tree
19.	*Diospyros buxifolia* (Blume) Hiern.	Elichuzhi	Ebenaceae	Tree
20.	*Elaeocarpus serratus* L.	Kara, Perinkara	Elaeocarpaceae	Tree
21.	*Elaeocarpus tubercuatus* Roxb.	Ammakkara, Karamaram	Elaeocarpaceae	Tree
22.	*Flacourtia montana* Graham	Vyamkatha	Flacoutiaceae	Tree
23.	*Glycosmis mauritiana* (Lam.) Tanaka	Panal, Poonippatti	Rubiaceae	Shrub
24.	*Glycosmis pentaphylla* (Retz.) DC.	Panal, Panchi	Rubiaceae	Shrub
25.	*Grewia tiliifolia* Vahl	Chadachi	Tiliaceae	Tree
26.	*Helicteres isora* L.	Edampiri-valampiri	Sterculiaceae	Shrub
27.	*Hopea parviflora* Bedd.	Kambakam	Dipterocarpaceae	Tree
28.	*Hopea ponga* (Dennst.) Mabb.	Irumbakam, Pongu	Dipterocarpaceae	Tree
29.	*Humboldtia brunonis* Wall.	Kattasokam	Fabaceae: Caesalpinioideae	Tree
30.	*Humboldtia vahliana* Wight	Karappongu	Fabaceae: Caesalpinioideae	Tree
31.	*Lagerstroemia macrocarpa* Wight	Vellilavu, Venthekku	Lythraceae	Tree
32.	*Leea indica* (Burm.f) Merr.	Choriyan-thali	Leeaceae	Shrub
33.	*Litsea coriacea* (Heyne ex Meisn.) Hook.f.	Maravettithali	Lauraceae	Tree
34.	*Lophopetalum wightianum* Arn.	Venkotta	Celastraceae	Tree
35.	*Maesa indica* (Roxb.) Sweet	Kattuvihal, Vannathi	Myrsinaceae	Shrub
36.	*Mangifera indica* L.	Mavu	Anacardiaceae	Tree
37.	*Memecylon gracile* Bedd.	Elimaram	Melastomataceae	Shrub
38.	*Memecylon umbellatum* Burm.f.	Kayampoo, Kasavu	Melastomataceae	Shrub
39.	*Monoon coffeoides* (Thwsites ex Hook.f. & Thoms.) B. Xue & R.M.K. Sounders	Nedunar, Villa	Annonaceae	Tree
40.	*Monoon fragrans* (Dalz.) Bedd.	Kodangi, Chella, Nedunar	Annonaceae	Tree
41.	*Olea dioica* Roxb.	Idala, Edana	Oleaceae	Tree
42.	*Poeciloneuron indicum* Bedd.	Poothamkolli	Clusiaceae	Tree
43.	*Psychotria flavida* Talbot		Rubiaceae	Shrub
44.	*Pterocarpus marsupium* Roxb.	Venga	Fabaceae	Tree
45.	*Pterospermum rubiginosum* Heyne ex Wight & Arn	Chittilaplavu, Ellootti	Sterculiaceae	Tree
46.	*Rubia cordifolia* L.	Manchatti	Rubiaceae	Climber
47.	*Salacia beddomei* Gamble	Koranti	Celastraceae	Climber
48.	*Salacia fruticose* Heyne ex Lawson	Ponkoranti	Celastraceae	Climber
49.	*Sarcostigma kleinii* Wight & Arn.	Odel	Icacinaceae	Climber
50.	*Schleichera oleosa* (Lour.) Oken	Poovam	Anacardiaceae	Tree
51.	*Strobilanthes ciliata* Nees	Karinkurinji	Acanthaceae	Shrub
52.	*Symplocos acuminata* (Blume) Miq.	Pachotti, Kambilivetti	Symplocaceae	Tree
53.	*Symplocos macrophylla* Wall ex A. DC. ssp. *rosea*	Malankaruva	Symplocaceae	Shrub/ Tree
54.	*Syzygium cuminii* (L.) Skeels	Njaval	Myrtaceae	Tree
55.	*Syzygium laetum* (Buch.-Ham.) Gandhi	Njaval	Myrtaceae	Tree

56.	*Terminalia bellerica* (Gaertn.) Roxb.	Thanni	Combretaceae	Tree
57.	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Neermaruthu	Combretaceae	Tree
58.	*Terminalia chebula* Retz.	Kadukka	Combretaceae	Tree
59.	*Terminalia elliptica* Willd.	Thambavu	Combretaceae	Tree
60.	*Vateria indica* L.	Vellappayin	Dipterocarpaceae	Tree

5.8. Socio-Economic and Health Environment

5.8.1. Local Community

5.8.1.1. Anticipated Impacts

Construction Phase

During the construction phase, a large labour force, including skilled, semi-skilled and un-skilled labour force, is expected to work in the project area at peak construction activity period. It is expected that 70% of the total work force shall be locally available and manpower to the tune of 30% shall migrate from other parts of the district or adjacent districts of the state. This will lead to a small change in demographic profile of the area albeit during construction phase only. The temporary labour camps will be established at suitable location in the project area. The fuel need of the labourers/ workers shall be attended in an organized manner by providing LPG and safe drinking water so that any altercation between migrated labour and locals' overuse of natural resources and facilities is averted.

During construction phase, migratory population though in limited numbers, is expected from other parts of the state having different cultural habits. However, no cultural conflicts are foreseen due to the migratory population, as they will be largely settled in separate conglomerates having all inbuilt facilities. Since major work force will be drawn from the local populace, which by interaction with outside labour during course of construction, shall develop affinity and friendship with the outside workers, thus, minimizing the chances of conflict.

Construction of the proposed project may cause impacts on health of local residents and the work force. Fuel and dust emission may cause respiratory problems like asthma Migrant workers might act as carriers of various diseases like AIDS, VDS, etc.

The proposed project will generate direct and indirect Employment in the area. In construction phase thousands of temporary working days will be created. Other employment will be in the form of commercial institutions like hotels and restaurants, homestay, resorts keeping etc.

Operation Phase

Various types of business-like shops, food-stall, tea stalls, etc. besides a variety of suppliers, traders, transporters will concentrate here and benefit immensely as demand will increase significantly for almost all types of goods and services. The locals will avail these opportunities arising from the project and increase their income levels. With the increase in the income levels, there will be an improvement in the infrastructure facilities in the area.

5.8.1.2. Mitigation Measures

- Wet excavation of exposed surfaces shall be deployed
- Frequent water sprinkling at least thrice a day shall be carried out on haul roads in the project activity area.
- All approach roads to site shall be metaled.
- The project authority should follow proper quarantine and screening procedures for migrant labours.

5.8.2. Analysis of Positive and Negative Impacts on Present Status of Livelihood

5.8.2.1. Positive Impacts

The main access from Kozhikode district to Wayanad district is Thamarassery ghat road which is having sharp hair pin curves and steep gradients. This ghat road is not highly enduring due to the intensified traffic which causes many accidents at present. It is not technically feasible to improve the width of road since it is going through the forest land and hilly terrain. The search of another alternate route to this ghat road was reached finally at this proposed tunnel road (Churam Badal Road). It is seen that the distance savings between destinations by this road project is very significant. The introduction of this new road will bring drastic development opportunities in industrial, agricultural and tourism sectors not only to the premises, but also to the entire Malabar region and other districts. Consequently it will account for the social and economic growth of the state of Kerala.

The main objective of the project is to provide safe and efficient service levels to growing traffic movements and better connectivity to the region. All road users will be benefited from the proposed improvement on account of comfort, safety and reduced vehicle-operating costs. The proposed tunnel will also become a part of the major road network in the proposed Kochi – Bengaluru Industrial Corridor Region (KBIC Region).[*]

A significant economic benefit of the improvement project is generation of employment opportunities during the construction activities, which will be available to the people, including affected community. Besides, they will also draw benefits from the economic activities as a result of increased traffic flow and movement of vehicles. The project road will help in the economic upliftment of the entire region.

The project will bring revenue to the government as direct and indirect tax from business, employment, contributions from taxes and duties on goods and services supplied and others. Tourism of the area will be improved and will contribute to the revenue generated.

The accessibility and connectivity increases as it is the major connectivity between Kozhikode and Wayanad districts. Thus, the time of travel between these districts shall reduce significantly. With advent of the four-lane tunnel highway, the vehicle operating and maintenance, cost is expected to go down substantially. These benefits can be attributed to smooth and even roads and low congestion.

[*] Kochi Bengaluru Industrial Corridor –Draft Perspective Plan for overall KBIC region – Draft Report, 2019

Savings in fuel consumption can be attributed to low congestion and relatively less travel time due to proposed improvements. The proposed road alignment shall also include general amenities like road signboards, streetlights, medical aid etc. and thus overall facilities to the road users shall improve. The proposed project is expected to improve the quality of life of the people residing in the project zone in terms of their economic, social and health status. Land value in the nearby areas of the proposed alignment will increase substantially.

The overall aesthetics of the area shall improve with proposed landscaping and avenue plantation in the project stretch. Improvement of local tourism is envisaged due to better road infrastructure. During the construction stage of the project, both skilled and unskilled labours will be employed from the local villages to enhance the livelihood and economic standard of the people.

5.8.2.2. Negative Impacts

The Socio economic study shows that around 27 families who are engaged in the above said commercial institutions will lose their land. Here 10 households on the south side and 17 households on the north side, out of which 3 families are absentee landlords.

During operational phase the project will create negative impact on the Churam road who are engaged with their livelihood activity. When majority of transportation passes through the tunnel road and it will result in decrease of income to the business men and street vendors at Churam -Wayanad road.

5.8.3. Land Acquisition

5.8.3.1. Anticipated Impacts

Construction Phase

The proposed project falls in forest area and private land. Hence private land acquisition is required for project activity.The total private land to be acquired for the the project tunnel road is 7.482 Ha. Additionally 10 Ha land is proposed to be acquired for dumping and 2 Ha land for site camp. Loss of productive agricultural land may result from the establishment of construction camps, batch mix plant and WMM plant, quarry and borrow area. This results in minor change in agricultural yield due to project activities. Temporary change in land use at bridge and culvert locations shall be encountered to facilitate the existing traffic by alternate routes.

Operation Phase

No adverse negative impacts are anticipated due to proposed road development during operation phase except conversion of agricultural land to commercial and residential purpose close to project road, especially in rural and urban areas. This leads to decrease in agriculture production and loss of productive land. Land acquisition is inevitable for road projects, however proper care has been taken during design stage to minimise the land acquisition.

Currently the width of the existing road is just six to eight meters. It will necessitate widening of existing roads for approach and separate walk way for pedestrians. This will require acquisition of some commercial buildings (Depending on road [M A18]width) at Meppady junction. Based on survey in the proposed project would affect 27 property holders directly considering both north and south end of tunnel and approach roads as well. It includes four residential buildings, three vacant buildings, one prayer hall , Six commercial institutions and private lands (details of households directly have been added as Annexure 47).

5.8.3.2. Mitigation Measures

- Appropriate rehabilitation action plan as worked out by the socio economic expert[M A19], shall be implemented to mitigate / minimize these impacts.
- If land is required, the proponent will have to adopt principles and procedures in accordance with the provisions of National Land Acquisition, Rehabilitation and Resettlement Act, (RFCTLARR-ACT) 2013 and other relevant policy of the state.
- All the utilities and common property resources being impacted due to the project will have to be relocated with prior approval of the concerned Departments / Agencies before construction starts.
- Compliance to all the State norms towards operation and environmental protection of borrow and quarry areas shall be done by contractor.
- For construction activity local both skilled and unskilled labours should be employed.

5.8.4. Occupational Health and Safety

5.8.4.1. Anticipated Impacts

Construction Phase

Accident risk to workers from construction activities may happen due to poor maintenance of machines and vehicles, poor light conditions.. Contract Workers Health Issues may arise due to unhygienic conditions at work place, campsites and non-availability of good drinking water quality.

Operation Phase

Spillage of hazardous chemicals due to road accidents which may leadas to contamination of soil and water bodies and safety risk to the public residing adjoining to the accident area.

5.8.4.2. Mitigation Measures

Construction Phase

- To ensure safe work environment for contstruction, lighting and safety signal devices shall be installed.
- Traffic rules and regulations to be strictly followed.
- Safety of workers undertaking various operations during construction should be ensured by providing them by helmets, masks, safety goggles etc.
- Regular tool talks, mock drills, training programmes to be organized towards educating workers towards adopting safe working methods.
- The electrical equipment should be checked regularly to avoid risks to workers.
- At construction site, a readily available first aid unit including an adequate supply of dressing materials, a mode of transport (ambulance), nursing staff and an attending doctor to be provided.

- Adequate drainage, sanitation and waste disposal facilities to be provided at workplaces.
- Periodical medical checkup facility to be provided to all the workers.
- At every workplace, good and sufficient water supply shall be maintained to meet the daily chore of the residing population.
- Measures to be implemented so that sewagewater is collected in septic tanks/soak pits. No surface stagnation of water will be allowed to avoid vector outburst.

5.8.5. Cultural Properties

5.8.5.1. Anticipated Impacts

Construction Phase

There are a number of other religious structures present within the 15 km radii of the project alignment. Impacts may be anticipated to the religious structures during transportation of construction materials.. Drilling or blasting activities may affect the structural stability of the cultural properties which are coming within the direct impact zone.

Operation Phase

No impacts are envisages during operational phase hence no mitigation measures is recommended.

5.8.5.2. Mitigation Measures

Construction Phase

- Transporting vehicles are suitably covered with tarpaulins to control the fugitive emission.
- Suitable dust emission control method such as sprinkling of water should be carried out at least twice a day on a regular basis during the entire construction period.
- Construction camps, workshops, material stock yard shall be not established within one km from the protected monument.
- No heavy machinery shall be deployed in the construction process.

5.8.6. Increased Traffic

5.8.6.1. Anticipated Impacts

Construction Phase

Increased use of existing public infrastructure i.e. road due to vehicular traffic involved in transportation of construction materials and muck and earthmovers may cause congestion on roads. However, the state highway and the national highways in the project area in general have been designed keeping in view the futuristic vehicular traffic. The increased traffic shall cause more fugitive dust emission and gaseous pollution, which when added to the existing concentration the resultant concentration shall be within the limits.

Operation Phase

The project area will have access through NH 766. The project area is well connected to network of roads leading to various parts of Kozhikode and Wayanad districts. Adequate measures have been proposed to manage the traffic within and outside the proposed tunnel. Since the flow of traffic increases by tunnel road it maynegatively affect the local businesses of the Churam – Wayanad [M A20]road.

5.8.6.2. Mitigation Measures

- Regular maintenance of road and copious sprinkling of water shall be carried.
- Transport trucks/tippers shall be properly maintained. Only PUC certificate issued vehicles shall be used.
- Avoiding of overloading of trucks beyond stipulated capacity by installing weighbridges at the check posts or near to it.
- Strict compliance of traffic rules and regulations shall be ensured.
- The movement of trucks/trippers/tractors for loading /transportation within the project area and haul road area shall be regulated by a trained supervisor who shall be responsible for the safety of vehicle movement and prevention of accidents or incidents associated with the vehicular movement.

5.9. Solid Waste Management

5.9.1. Solid Waste Collection and Disposal at Construction Camp

5.9.1.1. Anticipated Impacts

Construction Phase

Various construction activities such as demolition of structures, cutting of earth and rock mass, scarification of existing pavement will results to generation of huge quantity of construction waste. Further, substantial amount of domestic waste will also generate from workers camps. Improper disposal of these wastes may obstruct water flow resulting in reduction in water carrying capacity of the water body. Unscientific disposal of domestic waste may cause filthy smell resulting in health problems in workers and local residents. Improper collection waste from construction site may leads to traffic congestion and inconvenience for commuters.

Operation Phase

No impact is envisaged during operation phase of the project and hence no mitigation proposed.

5.9.1.2. Mitigation Measures

Construction Phase

- Dumping of debris in or nearby water bodies shall be strictly avoided. Waste products must be collected, stored and taken to approve disposal sites as per prevailing disposal norms.
- Earth, stone or any other construction material should be properly disposed off so that the flow of water in cross drainage channels is not blocked.
- Construction waste and other materials should be cleared immediately after completing the work so that traffic can move without any constraint.
- Domestic solid waste generated from workers camps shall collected in waste bins and disposed as per the guidelines of Municipal Solid Waste (Management and Handling) Rules, 2016.

- Contractor should strictly adher to other clauses and guidelines detailed out in the EMAP for debris disposal and waste disposal
- The contractor shall follow the construction and demolition Waste Management Rules 2016.

5.10. Impact Matrix

Leopold *et al* were first to devise the use of matrix method for environmental impact assessment. Matrices are particularly useful as they reflect the impacts from series of interactions among the activities and the environmental elements. Although, the Leopold matrix is believed to largely depend on the subjective evaluation of experts that allows the judgments be converted into empirical numbers, but it is still a valid and widely used approach for the assessment of environmental impact. The Leopold matrix is a qualitative environmental impact assessment method pioneered in 1971. It is used to identify the potential impact of a project on the environment. In the matrix, the rows cover the key aspects of the environment and society, while the columns list the project's activities during all stages of the project. Environmental factors must correspond to all those that could be affected by the development of the activity in the project area and the area of influence.

A simplified/modified two-dimensional matrix inspired by Leopold matrix has been adopted for the environmental and social impact assessment of the project. Twenty-three key impact factors have been singled out from a wider list of less significant potential factors.

The interaction of activities and their impacts vary between construction and operational phase. Regarding the tunneling project, major activities occur in the construction phase. Therefore, major impacts are anticipated during construction. Some of the impacts will be of short duration particularly during construction phase, whereas some impacts will be long lasting. Each impact was analyzed under the categories mentioned above and quantified using modified Leopold matrix. Each impact was assigned with a score using a scale of 0-4, (**Table 0.13**) depending on the magnitude and potential. The magnitude, potential and significance of an impact were assessed on the basis of the nature of the impact (short term/long term. reversible/irreversible. local/regional. direct/indirect. minor/major). A positive or negative sign was provided for beneficial and harmful nature of the impacts. The rows' totals of the matrix reflect the total impacts of an action on the various environmental components while the columns' total ls reflect the impact of all actions on one environmental variable.

Table 0.13. Criteria for Evaluation of Impact

Sl. No.	Criteria	Score
1	No impact	0
2	Minor Impact	1
3	Medium Impact	2
4	Significant Impact	3
5	Major Impact	4

Major positive and negative impact factor; major short term and long-term impacts and irreversible and reversible impacts and direct and indirect environmental impacts are interpreted in **Table 0.94** through **Table 0.117** respectively.

Table 0.128 and **Table 0.139** sum up the majority of the impacts during construction and operation phase of the project. Notably, the magnitude of negative impacts decreases considerably in the operational phase of the project. In the construction phase, total score is -33 of which -77 stands for negative impacts and 44 for positive impacts. During the operational phase total score changes to +15 of which negative impacts score are -8 and positive are 23. Considering the project actions during construction phase excavation, quarrying and migrant population are major activities which pose major impacts on the environmental and social components while community development is most positive impact.

Table 0.94. Major Positive and Negative Environmental Impacts

Description	Positive Impact Factor		Negative Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Physical Environment	• No Significant impact	• Improvement in land status of project area • Improvement of drainage of project area.	• Land degradation due to excavation for project tunnelling, approach road • Temporary increase in GLC of ambient air at construction site, approach roads. • Increase in noise levels at construction site and nearby settlement. • Water and soil pollution due to improper disposal of waste and mal- functioning of equipment. • Spread of water borne disease.	• No significant impact.
Biological Environment	• No Significant impact.	• Reduction of anthropogenic pressure on forest resources and wildlife, due to upliftment of rural economy and extended observance	• Loss of trees and ground cover due to road/ tunnel mouth • Loss of habitat due to diversion of forest land. • Increase in temporary stress levels of wildlife. • Impact on free movement of wild life. • Threat due to human interference in the forest area.	• Weed infestation in the peripheral forest areas(in the vicinity of the road and tunnel mouth areas.)
Economic Environment	• Enhancement in Temporary job opportunity. • Increase in demand for fuel and other	• Better opportunities for cattle rearing. Hike in the prices of land in the project area. • Benefits to economy and commerce and better market facilities • Recreation and tourism potential	• The loss of agriculture land and agriculture produce. • Loss of livelihood and income.	• Likelihood of Loss of jobs.

Description	**Positive Impact Factor**		**Negative Impact Factor**	
	Construction Period	**Operation Period**	**Construction Period**	**Operation Period**
	construction material.			
Social & Cultural Environment	• Creation of social unity amongst people of project area.	• Betterment in social welfare of farmers of project area. • Better living Standards for famers of project area. • Preventing migration to other cities for earning livelihood.	• Loss of land assets over which the PAFs have developed affinity. • Increase in pressure on the existing provincial / state road. • Conflict for employment between local people and migratory labor population. • Conflict between beneficiaries and non-beneficiaries.	• Conflict between beneficiaries and non-beneficiaries.

Table 0.15. Major Short-term and Long-term Environmental Impacts

Description	Short- term Impact Factor		Long -term Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Physical Environment	• Land degradation due to excavation for project components, approach road and borrow/disposal area • Temporary increase in GLC of ambient air at construction site, approach roads. • Increase in noise levels at construction site and nearby settlement. • Water and soil pollution due to improper disposal of waste and mal-functioning of equipment. • Spread of water borne disease.	• No significant impact	• Change in the land use of agriculture land and forest land. • Land degradation due to excavation for project components, approach road and borrow area. • Spread of water borne disease due to stagnation of water in pits.	• Decrease in water quality in the local streams due to run off • Improvement in land status of project area fields due to project area development works. • Spread of water borne disease due to stagnation of water in pits
Biological Environment	• Temporary stress on wildlife. • Interruption to free movement of wild life. • Disturbance to wildlife due to construction activities, and also possible human interference in forest land	• No significant impact.	• Loss of micro-habitats and trees due to diversion of forestland. .	• Stress to wildlife due to vehicular movement and noise. • Extended weed infestation in the peripheral forestland. • Reduced anthropogenic pressure on forest resources and wildlife owing to upliftment of rural economy and intensified observance.

Description	Short- term Impact Factor		Long -term Impact Factor	
	Construction Period	**Operation Period**	**Construction Period**	**Operation Period**
Economic Environment	• Increase in Temporary job opportunity • Increase in demand for fuel and other construction material	• Not applicable	• The loss of agriculture land and agriculture produce for PAF. • Loss of livelihood and income for PAF	• Loss of jobs • Better opportunities for cattle rearing. • Employment in other sectors. • Hike in the prices of land in the project area. • Benefits to economy and commerce and better market facilities Recreation and tourism potential
Social &Cultural Environment	• Conflict between beneficiaries and non-beneficiaries. • Conflict for employment between local people and migratory labor population. Increase in pressure on the existing provincial / state road.	• Not applicable	• Loss of assets over which the PAFs have developed affinity	• Betterment in social welfare of farmers of project area • Better living Standards for famers of project area. • Preventing migration to other cities for earning livelihood.

Table 0.10. Major Reversible and Irreversible Environmental Impacts

Description	Irreversible Impact Factor		Reversible Impact Factor	
	Construction Period	**Operation Period**	**Construction Period**	**Operation Period**

Description	Irreversible Impact Factor		Reversible Impact Factor	
	Construction Period	**Operation Period**	**Construction Period**	**Operation Period**
Physical Environment	• Change in the land use of agriculture and forestland. • Land degradation due to excavation for project components and borrow area.	• Decrease in water quality in the local streams and Iruvazhinjipuzha due to run off. • Improvement in land status of project area fields	• Temporary increase in GLC of ambient air at construction site, approach roads. • Increase in noise levels at construction site and nearby settlement. • Water and soil pollution due to improper disposal of waste and mal-functioning of equipment • Spread of water borne disease due to stagnation of water in pits.	• Spread of water borne disease due to stagnation of water in pits
Biological Environment	• Loss of habitat and trees due to diversion of forestland.	• No significant impact.	• Disturbance to wildlife due to construction activities and human interference in forestland.	• No significant impact

Description	Irreversible Impact Factor		Reversible Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
Economic Environment	• Hike in the prices of land in the project area.	• Loss of jobs • Better opportunities for cattle rearing. Employment in other sectors. • Hike in the prices of land in project area. • Benefits to economy and commerce and better market facilities Recreation and tourism potential	• Increase in Temporary job opportunity Increase in demand for fuel and other construction material	• No significant impact
Social & Cultural Environment	• The pang of involuntary acquisition of land shall cause many social pressures and stress on the affected families	• The pang of involuntary acquisition of land shall cause many social pressures and stress on the affected families Betterment in social welfare of farmers of project area • Better living Standards for famers of project area. • Preventing migration to other cities for earning livelihood. • Sustained water availability for agriculture.	• Conflict between beneficiaries and non-beneficiaries. • Conflict for employment between local people and migratory labor population. • Increase in pressure on the existing provincial / state road.	• No significant impact

Table 0.11. Major Direct and Indirect Environmental Impacts

Description	Direct Impact Factor		Indirect Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period

Description	**Direct Impact Factor**		**Indirect Impact Factor**	
	Construction Period	**Operation Period**	**Construction Period**	**Operation Period**
Physical Environment	• Land degradation due to excavation for project components, and borrow/disposal area • Temporary increase in GLC of ambient air at construction site, approach roads. • Increase in noise levels at construction site and nearby settlement. • Water and soil pollution due to improper disposal of waste and mal- functioning of equipment.	• Change in the land use of agriculture and forest land. • Improvement in land status of project area fields due to increased traffic in the region.	• Spread of water borne disease due to stagnation of water in pits.	• Spread of water borne disease due to stagnation of water in pits
Biological Environment	• Loss of trees and ground cover in the development sites of road / tunnel mouths. • Hindrance to free movement of wildlife. • Impact on wildlife due to human interference in the forest areas.	• Stress on wildlife due to extended traffic and noise.	• Habitat decline/ alteration in the peripheral terrestrial and aquatic systems.	• Extended weed infestation in the peripheral forest areas. • Improved forest cover and conservation of ecologically significant species through compensatory afforestation. • Reduced anthropogenic pressure on forest resources and wildlife.
Economic Environment	• Increase in Temporary job opportunity • Increase in demand for fuel and other construction material	• Not applicable	• The loss of agriculture land and agriculture produce for PAF. • Loss of livelihood and income for PAF	• Loss of jobs • Better opportunities for cattle rearing. • Employment in other sectors. • Hike in the prices of land in the project area. • Benefits to economy and commerce and better market facilities • Recreation and tourism

Description	Direct Impact Factor		Indirect Impact Factor	
	Construction Period	Operation Period	Construction Period	Operation Period
				potential
Social &Cultural Environment	• Increase in pressure on the existing provincial / state road. • Involuntary acquisition of land assets. • Loss of assets over which the PAFs have developed affinity	• Betterment in social welfare of farmers of project area • Better living Standards for famers of project area. • Preventing migration to other cities for earning livelihood.	• Conflict between beneficiaries and non-beneficiaries. • Conflict for employment between local people and migratory labor population.	• Betterment in social welfare of farmers of project area Better living Standards for famers of project area. • Preventing migration to other cities for earning livelihood. Sustained water availability for agriculture.

Table 0.128. Modified Leopold Matrix of Environment Impacts in Construction Phase

Environmental Effects →	Physical Environment											Biotic Environment				Economic				Social and Cultural				Total	Total	
Development Activities ↓	Landscape	Hydraulics of	Water pollution	Air pollution	Noise pollution	Vibration	Land degradation	D/s water users	Exploitation of	Spread of Malaria	Ground water	Aquatic life and Fisheries	Fragmented	Ecological balance	Stress on	Employment	Social values	Basic Amenities	Marketing	Cultural conflict	Archaeological	Demographic changes	Business	-ve	+ve	Total
Road construction	-2	0	-1	-2	-1	0	-2	0	0	-1	0	-1	-2	-1	-2	2	0	1	1	0	0	0	0	-15	4	-11
Tunnelling	-1	0	-1	-1	-2	-1	-1	0	0	0	-1	0	0	0	0	2	0	1	1	0	0	0	0	-8	4	-4
Dumping	-1	0	-1	-1	-1	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-5	0	-5
Quarrying	0	0	-2	-2	-1	0	0	0	0	-2	0	-1	0	-1	-2	0	0	0	0	0	0	0	0	-11	0	-11
Colony	-1	0	0	0	0	0	-1	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	-3	0	-3
Diversion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EMP	0	0	1	0	0	0	0	0	0	2	0	0	0	1	0	4	1	0	0	2	0	0	0	0	11	11
Vehicular Movement	0	0	0	-3	-3	0	0	0	0	0	0	0	0	0	-1	0	1	1	0	0	0	0	1	-7	3	-4
Migrant Population	0	0	-2	0	0	0	0	0	-2	0	-1	-2	0	-1	-2	0	-2	4	2	-3	0	-1	4	-16	10	-6
Land assets acquisition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-4	-3	0	0	0	-3	0	-12	0	-12

Environmental Effects →	**Physical Environment**											**Biotic Environment**				**Economic**				**Social and Cultural**				**Total**	**Total**	
Development Activities ↓	**Landscape**	**Hydraulics of**	**Water pollution**	**Air pollution**	**Noise pollution**	**Vibration**	**Land degradation**	**D/s water users**	**Exploitation of**	**Spread of Malaria**	**Ground water**	**Aquatic life and Fisheries**	**Fragmented**	**Ecological balance**	**Stress on**	**Employment**	**Social values**	**Basic Amenities**	**Marketing**	**Cultural conflict**	**Archaeological**	**Demographic changes**	**Business**	**-ve**	**+ve**	**Total**
Comm. Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	3	2	0	0	0	1	0	12	12
Total	**-5**	**0**	**-6**	**-9**	**-8**	**-1**	**-4**	**0**	**-2**	**-1**	**-2**	**-5**	**-2**	**-3**	**-7**	**10**	**-2**	**7**	**6**	**-1**	**0**	**-4**	**6**	**-77**	**44**	**-33**

Table 0.139. Modified Leopold Matrix of Environment Impacts in Operation Phase

Environmental Effects →	**Physical Environment**											**Biotic Environment**				**Economic**				**Social and Cultural**				**Total**	**Total**	
Development Activities ↓	**Landscape**	**Hydraulics of**	**Water pollution**	**Air pollution**	**Noise pollution**	**Vibration**	**Land degradation**	**D/s water users**	**Exploitation of**	**Spread of Malaria**	**Ground water**	**Aquatic life and Fisheries**	**Fragmented**	**Ecological balance**	**Stress on**	**Employment**	**Social values**	**Basic Amenities**	**Marketing**	**Cultural conflict**	**Archaeological**	**Demographic changes**	**Business**	**-ve**	**+ve**	**Total**
Road construction	-1	0	0	0	0	0	-1	0	0	0	0	0	0	0	-1	0	0	2	0	0	0	0	0	-3	2	-1
Tunnelling	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1
Dumping	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colony	0	0	0	0	0	0	0	0	-1	0	-1	0	0	0	0	0	0	0	1	0	0	0	1	-2	2	0
Diversion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EMP	0	0	0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	1	0	0	0	0	0	0	7	7
Vehicular Movement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
Migrant Population	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	-1	0	-1	0	-2	2	0
Land assets acquisition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Environmental Effects →	**Physical Environment**											**Biotic Environment**				**Economic**				**Social and Cultural**				**Total**	**Total**	**Total**
Development Activities ↓	**Landscape**	**Hydraulics of**	**Water pollution**	**Air pollution**	**Noise pollution**	**Vibration**	**Land degradation**	**D/s water users**	**Exploitation of**	**Spread of Malaria**	**Ground water**	**Aquatic life and Fisheries**	**Fragmented**	**Ecological balance**	**Stress on**	**Employment**	**Social values**	**Basic Amenities**	**Marketing**	**Cultural conflict**	**Archaeological**	**Demographic changes**	**Business**	**-ve**	**+ve**	
Comm. Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	3	1	0	0	0	1	0	9	9
Total	**-1**	**0**	**0**	**0**	**0**	**0**	**-2**	**0**	**-1**	**0**	**2**	**0**	**0**	**3**	**-1**	**3**	**1**	**8**	**3**	**-1**	**0**	**-1**	**2**	**-8**	**23**	**15**

Chapter 6. Environmental Monitoring Program

6.1. Introduction

The critical environmental impact due to the project will be the removal of large number of trees. Other issues of concern will be soil erosion, changes in air and water qualities and noise levels during construction stage due to construction activities and due to increased vehicular movements during operation stage. While the impacts are not very severe, care has to be taken to ensure that the ambient environmental conditions do not deteriorate further. The project on the whole will improve connectivity to the region and provide safe and efficient high level of service to the vehicles.

In order to address the impacts predicted in **0** various mitigation measures, monitoring actions and a reporting schedule are suggested in this Chapter in the form of an Environmental Monitoring Programme.

It shall be mandatory for the project proponent to make public the environmental clearance granted for their project along with the environmental conditions and safeguards at their cost by prominently advertising it at least in two local newspapers of the district or state where the project is located and in addition, this shall also be displayed in the project proponent's website permanently.

6.2. Environmental Monitoring Plan for the Subproject

Various physical, biological and social components identified as of particular significance in affecting the environment at critical locations in various stages of the project have been suggested as Performance Indicators (PIs). Performance Indicators listed below shall be the focus for monitoring.

- Air quality along the project road;
- Surface and ground water quality along the project road;
- Noise levels near sensitive locations; and
- Re-plantation success / survival rate.

For each of the environmental components, the monitoring plan specifies the technical aspects of monitoring like locations of monitoring; frequency of monitoring and duration, sampling method, parameters to be monitored, standards to be monitored in analyzing. The monitoring plan also specifies the applicable standards, and implementation and supervising responsibilities. The environmental monitoring plan is presented in **Table 0.1.**

Table 0.1. Environmental Monitoring Plan

Air Quality Monitoring	
Project stage	Construction and operation stages
Parameter	PM_{10}, $PM_{2.5}$, SO_2, NOx, CO and Pb
Sampling Method	High volume air sampler to be located 50 m from the source of pollution in the downwind direction. Method specified by CPCB for analysis shall be

	followed.
Standards	Revised National Ambient Air Quality (NAAQ) Standards set by CPCB
Frequency	Once in every season for three seasons (except monsoon) per year for every year of construction
Duration	Continuous 24 hours / or for 1 full working day
Locations	One monitoring station near each construction related facility namely, WMM plant, labour camp, staff quarters, borrow location, quarry location and at sensitive locations along the project road during construction stage. Monitoring shall be done at each additional construction related facility, if present. At sensitive locations near the project road during operation stage.
Measures	Wherever air pollution parameters increase above specified standards, additional measures as decided by the engineer shall be adopted.
Implementation	Contractor through approved monitoring agencies
Supervision	KPWD Sub consultants appointed by KPWD
Water Quality Monitoring	
Project stage	Construction stage
Parameter	pH, BOD, COD, TDS, Pb, Oil & Grease, Detergents and Faecal Coliforms for Surface water. pH, TDS, Total hardness, Sulphate, Chloride, Fe, and Pb for groundwater.
Sampling Method	Grab sample collected from source and analysis as per Standard Methods for Examination of water and Waste water
Standards	Indian standards for Water quality criteria of CPCB and for Drinking water (IS; 10500, 2012)
Frequency	Twice a year (pre monsoon and post monsoon seasons) during the entire construction period
Duration	One-time grab sampling
Location	At major water bodies along the road
Measures	At locations of increased water pollution towards down stream, all inflow channels shall be checked for pollution loads and channel delivering higher pollution loads shall be terminated from disposal into the water source.
Implementation	Contractor through approved monitoring agencies
Supervision	KPWD (or) Sub consultants appointed by KPWD
Noise Level Monitoring	
Project stage	Construction and operation stages
Parameter	Noise level on dB (A) scale
Sampling Method	Measure equivalent noise levels using an integrated noise level meter kept at a distance of 15m from edge of the pavement
Standards	Noise Pollution (Regulation and Control) Rules, 2000
Frequency	Once in every seasons (except monsoon) for each year of construction.
Duration	Reading to be taken at 15 seconds interval for 15 minutes every hour for 24 hours and then average will be taken.
Location	Near the WMM plant and near sensitive locations such as school hospital etc. along the road during construction stage. Monitoring shall be done at each additional WMM plant, if present. Near sensitive locations such as schools, hospitals etc. during operation stage.
Measures	Incase of noise levels causing disturbance to the sensitive receptors, management measures as suggested in the EMP shall be carried out.
Implementation	Contractor through approved monitoring agencies
Supervision	KPWD (or) Sub consultants appointed by KPWD

Soil Quality Monitoring	
Project stage	Construction
Parameter	Monitoring of Pb, SAR and Oil & Grease
Sampling Method	Sample of soil collected to be acidified and analyzed using absorption spectrophotometer
Standards	Threshold for each contaminant set by IRIS database of USEPA until national standards are promulgated
Frequency	During the pre monsoon and post monsoon seasons in each year for the entire construction period
Duration	One-time grab sampling
Location	At productive agriculture lands/forestland abutting traffic detours and traffic diversions
Measures	At location of increased pollution levels, source shall be identified and shall be diverted from future disposal
Implementation	Contractor through approved monitoring agencies
Supervision	KPWD (or) Sub consultants appointed by KPWD

6.2.1. Air Quality Monitoring and Management

Pollutant which may be generated during the construction phase of the project will alter the local environment temporally and shall subside once the major constructional activities are over. During the construction phase of the project, the ground level concentration of the pollutant like SO_2, NOx and PM_{10} are likely to increase but the resultant concentration shall be within the threshold limit especially in surface excavation areas but may exceed the threshold limit for underground work areas which is to be controlled by use of ventilator fans. It should be made mandatory on the part of the contractors that they use the required equipment for monitoring gaseous pollutants in and around the project and submit a detailed report every fortnight to the project authorities for evaluation and monitoring purposes. The air quality in and around the project area can be improved by the application of following practices/ methods.

- Excavation work may be carried out by pre-splitting and controlled blasting techniques
- Control blasting be carried out as far as possible and use of explosive also be bare minimum.
- The type of explosive used in blasting may be selected as per the requirement.
- To settle down the dust in project area especially around crushing plants, excessive use of water sprinklers is the best method.

6.2.2. Noise Quality Monitoring and Management

The level of noise will definitely rise above threshold level in the project area due to different types of construction activities: blasting for tunnels, etc., movement of heavy and small vehicles and the crushing plants. All these activities will generate high noise and vibrations which can cause health hazards among the labours, local inhabitants and wildlife present in the area. Therefore, it would be most appropriate if following measures are rigorously applied during construction phase of the project.

- Continuous monitoring of sound level within the project area.

- Extensive plantation to be carried out in the project area as plants absorb sound and make a barrier for its travel to long distances.
- Pre-split and controlled blasting.
- Provision of Air muffs to workers working in underground excavation works.
- Compulsory Periodic Maintenance of high earth movers, batching and crushing plants.

6.2.3. Water Quality Monitoring and Management

Water is one of most precious natural resources. the stream water in the project is almost free from major industrial chemical pollutants. Besides this, the catchment is sparsely populated with small chunks of agricultural fields. Due to congregation of labourers during the construction phase, the water quality in this stretch may get deteriorated if proper sanitation facilities are not provided to them. The probable water pollutants which may cause pollution during the construction phase of this project are: - pH, BOD, COD, TDS, Pb, Oil & Grease, Detergents and Faecal Coliforms for Surface water and pH, TDS, Total hardness, Sulphate, Chloride, Fe, and Pb for groundwater.

6.2.4. Soil Quality Monitoring and Management

The transportation of excavated/construction material on unpaved roads and excavation results in land degradation and formation of loose soil particles which are mainly fugitive dust. cause fugitive dust emission. These dust particles are usually blown away along the wind direction and get deposited on the canopy of surrounding vegetation and agricultural crops thereby resu lting in reduced ecological functions of the forest ecosystems as well as economic productivity of the agro- ecosystems. The following measures are, therefore, proposed for soil quality management:

- At the feeding points stone crusher air mist spray shall be carried out.
- Wet drilling shall be carried out
- Copious sprinkling of water on unpaved access/approach roads
- The leakage of POL (presence of leakage) and washings of workshop floors bring oil and grease with it. It shall be collected in oil separators before disposal on land. The soil contamination with oil shall be totally avoided.

6.3. Monitoring Plan for Tunnelling

This plan will provide practical guidance on managing health and safety risks associated with tunnelling work.

6.3.1. Planning and Preparation

6.3.1.1. Ground Support Design

Removing material causes unbalanced soil or rock stresses that reduce the capacity of the tunnel to support itself. Varying geological conditions mean control measures that have worked previously may not be satisfactory under these changed conditions.

The contractor should carry out a detailed analysis of existing geophysical conditions and the design requirements to identify the most suitable temporary ground support that may be installed without requiring workers to work under unsupported ground.

When designing ground support systems, it should be considered structural design and soil and rock mechanics. Ground support designed for the unique circumstances of the tunnel is essential to control the risk of a collapse or tunnel ground support failure.

Design specifications for engineering control measures like shoring support structures should be prepared in accordance with relevant legislative requirements, Indian Standards and codes of practice.

6.3.1.2. Ventillation System Design

The ventilation system should be designed to provide ventilation throughout the tunnel during construction, use and maintenance. This includes providing extra localised extraction ventilation for dust, heat or fumes during excavation, post-blasting, operating large plant or other activities like maintenance.

The design should include to install ventilation equipment or ducting during excavation to maintain air supply to the working face.

Reviewing the Tunnel Design Before Construction

This review should consider a range of tunnelling work issues including the:

- excavation method
- extra excavation for temporary entry
- ventilation systems
- construction phase electrical systems
- materials handling systems including spoil removal; and
- loadings from roof mounted spoil conveyors and ventilation systems,

6.3.1.3. Inspection Planning

Tunnelling work should be inspected regularly to ensure the tunnel and supporting systems remain stable, intact and work can be carried out safely. The inspection should compare the actual conditions with those assumed in the original or amended designs, excavation method or safety management plan and the adequacy of control measures.

Inspection plans should be developed collaboratively with the person conducting the business or undertaking and the principal contractor. The inspection plans should include a section for the principal contractor to confirm support elements have been installed in accordance with the design specifications and the corresponding construction sequences.

A risk assessment should be used to determine how often to inspect the tunnel and what competencies the person inspecting the tunnel should have. When setting how often to inspect the tunnel, whether based on time or on how far the tunnel face has moved, consider the delay due to the assessment and reporting procedures so identified issues are dealt with, before becoming a risk to health and safety.

Table 0.2. Inspection Plan Activities

Activities for inclusion in inspection plan	Extra considerations for open excavations
• mapping and visually assessing actual ground conditions and excavated shape as exposed by the tunnel excavation • monitoring ground support performance including: ○ possible support failures ○ evidence of excessive load ○ anchoring or pulling out tests on rock bolt type supports ○ falling or fretting ground • monitoring time-based deterioration, like spalling or slaking from weathering through temperature and humidity changes or exposure to air • monitoring water entry quantity, quality and location • measuring closure or subsidence of roof or walls by installing extensometers or by regular survey and testing core rocks • measuring in-situ ground stresses • reviewing results of the most recent monitoring of: • tunnel atmosphere • surface settlement	• excavated and other material being placed within the zone of influence of the excavation • plant operating within the zone of influence of excavations causing weight and vibration influences • surface soil falling into the excavation • water seeping into excavations from side walls or base • changes to soil and weather conditions • surface water or run-off entering the excavations or accumulating on the surface near the excavation • subsidence alongside the excavations

Review and if necessary modify the inspection plan after tunnel inspections, collapses, material falls or changes in weather conditions which may increase groundwater levels or groundwater inflows into the tunnel.

6.3.1.4. Planning and Preparation Specific to the Construction Site

The contractor must ensure, so far as is reasonably practicable:

- the provision of adequate facilities for workers including toilets, drinking water, washing facilities and eating facilities, and
- the facilities are maintained in good working order, clean, safe and accessible

In minimising risks to the health and safety of a worker associated with remote or isolated work, the contractor must provide a system of work that includes effective communication with the worker. It is important for people working above and below underground to be in contact with each other. People above ground should know where underground workers are in case an incident occurs.

A system should be in place to quickly and accurately determine the names and working locations of each person in the tunnel. This can be done by a tag board checked by supervisors at the start and end of every shift and by using shift timesheets. For large complex tunnelling work tag boards should be located at sections or branches of the tunnel.

The presence or absence of tags or missing or incomplete timesheets can help determine search and rescue criteria for tunnel rescue teams. If the system is not used properly or maintained it will not be of use in an emergency as it can lead to wasted resources looking for people who are not in the tunnel and overlook someone who is missing. The system should be checked regularly to ensure it is being used properly.

In an emergency, it may be necessary to implement a procedure for people exiting from an alternate exit so they can tag out or be accounted for.

6.3.1.5. Emergency Planning

An emergency plan must provide for:

- emergency procedures including
  - an effective response to an emergency
  - evacuation procedures
  - notifying emergency service organisations at the earliest opportunity
  - medical treatment and help
  - effective communication between the person authorised by the person conducting the business or undertaking to co-ordinate the emergency response and people at the workplace
  - testing emergency procedures including the frequency of testing, and
  - information, training and instruction to relevant workers about implementing the emergency procedures.

All types of emergency and rescue scenarios should be considered when developing emergency procedures. Information from a risk assessment will help in this task and will depend on control measures implemented. **Table 0.3** sets out some questions to consider when establishing emergency procedures.

Table 0.3. Developing Emergency Procedures

Considerations	**Questions**
Coverage of plan	How will the safety of people at the workplace including visitors or people who need help to evacuate in an emergency, be considered in the plan?
Emergencies	What emergencies could happen with the tunnelling work? How will you respond to emergencies like collapse, fire, flood or failure of ventilation systems? **Table 0.4** below lists more examples of possible tunnelling work emergencies. What control measures can be implemented to reduce the severity of the emergency, like self-closing bulkheads to eliminate or minimise, so far as is reasonably practicable, the risk of water inrush? What equipment will be needed to deal with emergencies, like: spill kits • fire extinguishers • early warning systems like fixed gas monitors or smoke detectors, and

Considerations	Questions
	• automatic response systems like sprinklers. Should there be specific procedures included in the plan for critical functions, like a power shut-off?
	What triggers for an evacuation, like a confirmed or suspected underground fire, should be considered in the plan? **Table** 0.4 below lists more examples of possible evacuation triggers. How will the controlled evacuation of people from the workplace be handled? Are there planned regular evacuation drills at least every 6 months or as soon as practicable after the plan is changed?
Workplace location	Is the tunnelling work carried out in a remote or isolated place? How accessible is it in an emergency and how far away is it from medical facilities? Can a person be rescued immediately without relying on emergency services? Are there areas where special emergency provisions like emergency rescue cages and the means to extract people from difficult locations like the base of a shaft needed? Have safe places and assembly points been identified?
Escape routes	**Table 0.5** lists questions and information on escape routes.
Roles and responsibilities	Who should be allocated roles and responsibilities in an emergency e.g. area wardens? Who has the relevant skills for specific actions in an emergency?
Training	Who requires regular and on-going training? When should this be provided? Does the training include an understanding of the emergency plan and actions to be taken in an emergency, escape options and emergency equipment? How will workers who enter the tunnel be trained in entrapped procedures, like remaining calm, alert and making conservative decisions?
Communication	How: • can workers doing tunnelling work communicate in an emergency • will clear lines of communication between the person authorised to co-ordinate the emergency response and people at the workplace be maintained, and • will alarms be activated and who will notify people at the workplace? Is there a system in place to identify who is underground, like tag boards or electronic tagging? Have you clearly displayed the workplace site plan showing where fire protection equipment is stored, the location of emergency exits, assembly points and emergency phone numbers?
Rescue equipment	Has rescue equipment been selected based on the nature of the work and the control measures used? Can it carry out the planned emergency procedures? Is rescue equipment kept close to the work area so it can be used quickly?
Capabilities of rescuers	Are rescuers properly trained, fit to carry out their task and capable of using rescue equipment? Have emergency procedures been tested to demonstrate they are effective?
First aid	Is first aid available for injuries associated with falls, cuts and crush injuries? Are trained first aiders available to use the equipment?
Roles for the local emergency services	Can you rely on local emergency services for rescue? Other arrangements should be made if they cannot respond within a suitable time.

Considerations	Questions
	How will the local emergency services be notified of an incident? Are there entry issues for emergency services like ambulances and their ability to get close to the work area? Are there ways to ensure accurate information is available on: • site location • entry problems • personal details of the casualty including relevant medical history • time of the incident • treatment given, and • any chemicals involved?
Consulting, co-operating and co-ordinating with local emergency services	Have emergency services been consulted when preparing, maintaining and implementing the emergency plan? Has a copy of the emergency plan been provided to the emergency services before starting work or after revising the emergency plan? Does the emergency plan include the emergency services involvement in a trial rescue early in the construction? Is there is a role for the emergency services in the emergency plan? If not, did a risk assessment document why?
Administration, maintenance and review	Does the emergency plan contain instructions on how it is to be administered, maintained and reviewed and how workers will be involved in these reviews?

Table 0.4. Emergencies and Evacuation triggers to be Considered in an Emergency Plan

Types of emergencies	Triggers for an Evacuation
• treating and evacuating seriously injured people • sudden flooding like inrush from an underground water feature • underground: ○ fire including plant fires ○ explosion through methane ignition or other airborne gases, vapours and dusts • harmful concentrations of airborne contaminants or an unsafe atmosphere • tunnel collapse resulting in people being trapped • power or water failure • above ground emergencies compromising tunnel safety like a fire or chemical spill	• confirmed or suspected underground fire irrespective of size • ineffective primary ventilation system including fans, intakes and ventilation controls which impact on the effectiveness of emergency procedures • failure of fire fighting systems like the loss of water supply, even through maintenance, if the tunnels partly rely on sprinkler systems • a surface fire or chemical spill which could affect fresh air intakes • ineffective emergency system equipment like communication equipment, breathable air systems, emergency lighting, recall of self-rescuers • major water inrush • seismic event • imminent weather event which could impact on the tunnel

Escape Routes and Safe Places

The remote nature of tunnelling work should be considered when establishing emergency procedures. A risk assessment including the implemented control measures will help in this task.

Table 0.5 sets out questions and information to consider when including escape routes and safe places in emergency procedures.

Table 0.5. Escape Routes and Safe Places

Considerations	Questions
Identifying escape routes	Have all: • possible escape routes like parallel tunnels, shafts or other connections to the surface been identified • escape routes been marked including travelling in parts of the tunnel not normally used by some workers • floor openings been fenced, and • escape routes that maintain fresh air flow during a fire emergency been identified? Have you considered control measures to ensure the integrity of escape routes or safe places in an emergency? Are escape routes dimensions suitable for stretchers and rescue teams using breathing apparatus? What is the impact of low visibility during an emergency? Should there be strategic placement of lighting, ropes or chains to guide workers?
Securing an immediate supply of respirable air and SCSRs	How will an immediate supply of emergency respirable air for workers be provided? Have the supply and use of oxygen-generating self-contained self-rescuers (SCSRs) which allow a person to travel from an endangered position to the surface or a safe place been considered? When developing escape routes while using SCSRs have you considered how far a person, in a reasonable state of physical fitness, can travel at a moderate walking pace, using 50 percent of the nominal capacity of the SCSR? Are you aware this capacity should be regarded as an absolute maximum because: • the air supply in the SCSRs will be used more quickly by agitated user's • physical difficulties may be encountered while travelling, and • thick smoke may make crawling the only feasible means of movement?
Safe places and refuge chambers	An underground refuge chamber provides a safe place for people if the atmosphere becomes unbreathable. When choosing where to put a refuge chamber and how many to put in, have you taken into account: • the types of tunnelling activity?

Considerations	Questions
	• how long it will take workers to get to the chamber from where they are working and your evacuation procedures and routes? • whether it can fit everyone in and is there an effective communication system inside? • how long the air will last based on a risk assessment? Does the risk assessment take into account types of emergencies e.g. fire as well as equipment, accessibility, alternative air supplies and how long it takes to get above ground? What else can be put in place to allow longer stays? Does induction training and emergency procedures: • tell workers whether to go to a refuge chamber or an escape route if there is a fire, and • include instructions for people in refuge chambers or fresh air bases to remain there and to communicate if their safety conditions change or other people arrive?
Vehicles and plant in the tunnel	How: • have the risks of vehicles and plant blocking escape routes in an emergency been addressed in the emergency plan? • will workers be provided with information, instruction • and training for operating plant within the tunnel including to keep escape routes and emergency entry clear?
Escape route signage	Are emergency escape route signs in places everyone can see? Are they near ground level so they are more visible in smoke?

Rescue Measures in the Emergency Plan

Rescue procedures including self-rescue and where rescue is assisted from outside the tunnel should be described in detail in the emergency plan and be practiced by workers. Self-rescue is important where it may take too long and be very difficult for emergency services to reach people.

When selecting which self-rescue measures to include consider the expected maximum time between the incident and when emergency services can reach the incident site. Consider the maximum number of people who may be in the tunnel when planning and providing safety equipment and facilities. It is important there are enough breathing apparatus, sealable self- contained atmosphere refuges and rescue capacity to accommodate them.

6.3.2 Common Hazards and Risks Associated with Tunnelling

Control measures should be identified to eliminate or minimise, so far as is reasonably practicable, risks associated with tunnelling work. These mostly arise from working underground and can be identified during consultation and the risk assessment process.

Table 0.6. Common Tunnelling Work Hazards, Risks and Control Measures

Hazards or risks	Control measures
Confined spaces	• planning and implementing tasks in accordance with Code of Practice:

Hazards or risks	Control measures
with build-up of gas and fumes	Confined spaces and AS 2865-2009: Confined Spaces • using suitable ventilation and dust extraction systems • monitoring atmospheric conditions • developing rescue procedures including use of self-rescuers • having training and certification for work in confined spaces • using personal protective equipment (PPE)
Rock falls	• inspecting the tunnel regularly and scaling where needed • mechanically scaling and bolting • installing ground support: ▪ as soon as possible ▪ with overhead protection if done manually • changing ground support methods
Failure of floor or roadway	• providing hard floor and roadway surfacing • ensuring drainage
Scaling	• using: ▪ mechanical equipment ▪ overhead protection • working from an: ▪ elevating work platform basket ▪ area of supported ground
High water and mud inflow	• grouting old drill holes • pre-grouting before excavation starts • injecting grouting ahead of the face • probing, drilling and draining • dewatering and pumping from surface bores • using other forms of ground treatment e.g. freezing • installing sump and drainage systems • setting limits on maximum height of water and mud flow during work e.g. less than boot height
Gas inrush	• increasing face ventilation and extraction • probing drill hazard areas through check valves • monitoring for gas • installing automatic plant cut-off and flame-proofing plant in possible flammable atmospheres • restricting smoking to designated areas
Falls from height	• using: ▪ guardrails wherever possible e.g. on maintenance platforms and landings ▪ fall-arrest systems ▪ PPE

Hazards or risks	Control measures
Loss of lighting	• providing emergency lighting and cap lamps
Moving plant	• isolating and restricting contact with moving plant • using: ▪ audible plant reversing alarms ▪ spotters for vehicle movements ▪ a system to warn workers when plant is reversing or special loads like explosives are being moved • providing lighting for safe movement • planning vehicle and pedestrian movements
Manual tasks like handling air tools, drill rods, supports, cutters	• planning and implementing tasks in accordance with Code of Practice: Hazardous manual tasks • selecting lighter plant and equipment • using: ▪ mechanical equipment with automatic feed like drilling jumbos ▪ lifting aids ▪ vibration insulation on handles • implementing ▪ lifting procedures ▪ engineering and ergonomic solutions ▪ manual handling procedures and training
Heat stress	• reducing use of high heat output plant • increasing ventilation • providing: ▪ air conditioned offices and meal rooms ▪ cool water • using: ▪ cool suits ▪ heat acclimatisation strategies • scheduling frequent rests
Noise	• insulating plant • using hearing protection • silencing engines to achieve a noise level not exceeding LAeq 85 dbA at a distance of 1 metre
Dust, hazardous chemicals	• increasing face extraction ventilation • using water sprays on cutting equipment or over muck heaps and spoil conveyors • providing: ▪ information like safety data (SDS) sheets ▪ spill kits • using PPE

Hazards or risks	Control measures
Electricity	• planning and implementing tasks in accordance with the Code of Practice: Managing electrical risks at the workplace • installing: ▪ hazard reducing devices like cut-out, earth-leakage and isolating devices ▪ back-up power supplies in case of power loss to critical systems like ventilation, pumping, emergency lighting and fire fighting systems • inspecting equipment before use • implementing lock-out procedures
Fire or explosion, flammable gases and vapours	• eliminating ignition sources underground where practicable • isolating fuel sources from remaining ignition sources • removing potential fuel sources from the work area • monitoring atmospheric conditions • storing only necessary fuel underground • implementing fire fighting training and procedures • ensuring availability of fire fighting resources • restricting smoking to designated areas • using a hot work permit system
Workplace security and visitors	• implementing security measures like immobilising plant and locking fuel dispensers • erecting signs showing the name and contact telephone numbers of the principal contractor • locating offices, parking and delivery areas away from hazardous areas • isolating hazardous areas with perimeter fencing, barricades, screens, barriers, handrails or covers • installing hazard warning lights, signs, markers or flags

6.3.3. Controlling Risks in Tunnelling Work

Safe systems of work and effective control measures should be put in place for tunnelling work. The system of work and control measures should be determined through consultation and the risk management process.

Using the drill and blast method for tunnelling work is often limited by environmental constraints characteristic of many tunnel locations. In particular dust, noise and vibration concerns often limit blasting activities. The person undertaking has responsibility for the control, safe and secure storage, use and handling of the explosives. A blasting plan should be drawn up before blasting is carried out. Only enough explosives for immediate use should be transported to the working face. Explosives should be transported in containers and vehicles specially designed for the purpose. They should be clearly marked and should always be accompanied by a competent person. Vehicles should be checked regularly to ensure they do not present a risk when transporting the explosives.

Charging should not start until drilling is completed and electric plant like water pumps are switched off and removed from the area. In the threat of a thunderstorm, charging with electric detonators should be stopped immediately and the workg force shall be evacuated. Control measures should be implemented to eliminate or minimise, so far as is reasonably practicable, the risks associated with excavation by drill and blast. Some control measures to consider are provided in Table 0.7.

Table 0.7. Specific Hazards, Risks and Control Measures - Drill and Blasting

Hazards and risks	Control measures
• storage, transport and use of explosives • unsupported ground including ground support requirements • ground vibrations and overpressures from blasting • fly rock • competence of explosives contractors and operators • effect on surrounding strata • face instability • injury from drilling and charging faces • firing times and preventing entry to firing areas • blasting fumes and dust • misfires • plant hitting people, plant or structures, like muck out loaders • water entry including flooding and collapse	• providing: ○ a coating of shotcrete, known as a 'flash coat', for immediate ground support ○ protection exclusion zones and safe places ○ engineered ventilation ○ geotech inspection and mapping ○ defined procedures for explosive handling • undertaking: ○ scaling to minimise risk of rock fall ○ drilling of lifter holes first where necessary ○ vibration monitoring ○ smooth blasting ○ muck out using operators and spotters with traffic management plans ○ gas monitoring • controlling entry to the face • using: ○ mechanical scaling ○ explosive management systems including computer control electronic blasting, blast and initiation design and approval processes ○ dust suppression sprays ○ competent, experienced and licenced workers ○ re-entry procedures ○ lighting ○ deck loading ○ using split face excavation - heading and bench ○ PPE like hearing protection

6.3.3.1. Portal Protection

Before tunnelling work starts portal entries not constructed in a permanent way—for example the final concrete structures are not in place—need support and protection from vehicles.

This support and protection will vary but should at a minimum include:

- ground support for the high wall above the portal entrance
- support for the portal brow or lip

- protecting the portal so it protrudes far enough out from the tunnel to protect people entering or leaving the tunnel from being hit by material falling from the high wall above the portal entrance, and
- diverting surface water from the portal and providing dewatering resources.

A fence or other barricade should be provided above the portal to stop entry above the portal.

Where the risk assessment has identified overheight vehicles, like dump trucks with tubs or trays up that may enter the tunnel you:

- should install clearance and advance warnings signs, and
- consider installing advance protective barriers and warnings, like ‘dangle bars’, to warn users that a vehicle will not fit under the structure or tunnel ahead.

6.3.3.2. Inspection and Scaling

The roof and walls should be inspected immediately after blasting or a short section has been excavated and scaling loose rock carried out.

As rock surfaces deteriorate over time, regular follow up inspections and scaling should be conducted on unlined tunnel areas. A risk assessment with ongoing revisions based on the inspection results should be used to determine a suitable period for initial and regular inspection and scaling.

At shift changes there should be a handover discussion about the status of inspections and scaling including the areas not yet inspected and where drummy ground has been identified as this will require scaling or ground support.

Scaling should take place:

- for drill and blast excavation after each blast when the face, roof and wall areas and spoil heap have been washed down, and
- for other excavation methods
- at times determined by the risk assessment
- during the ground support cycle if more loose rock is revealed and as the ground support installation moves forward from supported ground, and
- whenever the inspection shows there could be loose rock on a wall or roof.

The excavation should be washed down, for example with high pressure water before the initial inspection. Regular inspections should continue in the unlined tunnel areas to a schedule determined by the risk assessment.

Inspections and scaling should be conducted from supported and scaled areas. Where possible machine scaling is preferred to hand scaling. Hand scaling at heights should be from an elevated work platform (EWP).

Where hand scaling is done from beneath partially completed ground support, the EWP and people working on it should be protected from falling rocks. Where ground support is needed it should always be installed immediately after an inspection and scaling.

Table 0.8. Specific Hazards, Risks and Control Measures - Inspections and Scaling

Hazards and Risks	Control Measures
• rock falls • tunnel collapse in unsupported ground • access	• working in towards the face • scaling 'down dip' • always standing beneath supported ground • ensuring tools and materials are kept out of walking and working areas • inspecting with trained and experienced people

6.3.3.3. Ground Support

The tunnel needs permanent ground support. The permanent lining can be installed as the excavation progresses or temporary support installed followed by a permanent lining. A second lining may also be installed.

Extra ground support or overhead protection may be needed to provide protection during the construction phase. Often the planned ground support varies as the tunnel dimensions or ground conditions change. The locations of changes should be included in the design documentation.

The ground support installed as a tunnel progresses will often alter with exposure. This change may be from actual ground conditions or experience gained from monitoring the performance of the supports.

Installing ground support should be done from areas where ground support has already been installed or using equipment which provides overhead protection for the operator or installer. Control measures should be implemented to avoid ground or materials like shotcrete falling on people. Risks from falling objects should be minimised, so far as is reasonably practicable, by providing effective barricading to stop people from accessing high risk areas. The potential for serious injuries from falling shotcrete is equal to those from falling rock.

The ground conditions should be inspected in line with the inspection plan as the excavation progresses. The results should be assessed and if conditions have changed from the original design the ground support control measures may need to change. A competent person should inspect, test and assess the ground support system including anchor testing of rockbolts, strength tests for shotcrete and concrete linings so necessary changes can be made to the specification. Each ground support method or type has its own hazards and risks during the installation process which must be eliminated or minimised, so far as is reasonably practicable

Table 0.9. Specific Hazards, Risks and Control Measures - Ground Support

Hazards and risks	Control measures
• rock falls or tunnel collapse when installing ground support • dust from drilling • mobile plant • collapse of fresh shotcrete	• providing: ○ a coating of shotcrete, known as a 'flash coat', for immediate ground support ○ exclusion zones under freshly sprayed shotcrete • undertaking: ○ wet drilling of holes for dust suppression ○ daily checks of the condition of drill sets and tools and carrying out relevant maintenance

Hazards and risks	Control measures
	• using: ○ procedures for flushing holes with water or air including keeping hands and face clear of pressurised water and air ○ procedures when working around plant ○ suitable PPE

6.3.3.4. Sprayed Concrete

Sprayed concrete—known as shotcrete—uses high-powered hydraulic, pneumatic or electric plant to apply concrete by projecting it through the air.

Shotcrete application should only be carried out by a competent person. Shotcrete mixture should be designed to meet the strength and workability specified and to minimise dust levels. A wet mix shotcrete should be used along with non-caustic accelerators.

Surfaces contaminated with oil, dust or mud should be cleaned before shotcrete application and water entry is diverted.

During shotcreting no other activities should be carried out.

Control measures should be implemented to eliminate or minimise, so far as is reasonably practicable, the risks associated with sprayed concrete.

Table 0.10. Specific Hazards, Risks and Control Measures - Sprayed Concrete

Hazards and Risks	Control Measures
Transporting concrete in large plant, usually in confined spaces with poor lighting	• providing: ○ exclusion zones and traffic management planning ○ lighting on the plant and at the work face ○ plant reversing alarms • using suitable PPE including high-visibility protective clothing
Transferring the concrete to the conveyor	• providing guarding to prevent entry to the conveyor unit • using suitable PPE including splash protection for eyes
Conveying the concrete	• providing: ○ regular servicing of the plant according to the maintenance plan including checking conveyor tubes and hoses ○ relevant training to plant operators and mechanics
Applying concrete	• providing exclusion zones and restricting entry to only workers involved in the concrete application • using suitable PPE including impact-resistant goggles, helmet, gloves, breathing apparatus, hearing protection, safety boots and full body clothing
After applying concrete	• ensuring no entry to unprotected, unstabilised freshly sprayed areas

6.3.3.5. Shafts

Shafts are constructed to provide entry for people, materials, equipment and ventilation to a tunnel. Shaft construction methods and excavation techniques vary depending on conditions and their purpose. Shafts may be vertical or inclined and lined or unlined of various shapes.

A protective barrier should be erected around the shaft top to prevent people or materials falling into the shaft. The barrier should also prevent surface water draining into the shaft. When the shaft is unattended protective covers or a suitable fence should be used to prevent unauthorised access.

Access to the shaft bottom should be provided by either ladders, hoist or skip riding. If access is provided by ladder then landings are required at not more than 10 metre intervals. Ladders should be inclined and secured. If ladders are vertical they should be provided with safety cages.

Conveyances for people should be of substantial construction, prevent any part of a person therein protruding and be provided with a proper roof and inward opening doors that cannot open unintentionally. The conveyance should be clearly marked with its safe working load determined using a safety factor of ten.

An alternative means of access should also be provided for use in an emergency. For deep shafts a winder with its own power supply should be considered.

Materials transport should be separated from personnel transport with a suitable barrier. When units are used to transport personnel as well as materials and equipment the simultaneous transport of the two should not be carried out. Only an authorised person like a dogger should be allowed to travel in a personnel conveyance with material, with the exception of a person transporting explosives. Equipment and materials should not protrude above the sides of the skip or kibble unless properly secured. Specially designed lifting units should be considered.

The safe working load of a headframe or lifting device must be clearly indicated. Conveyors should be guarded and provided with an audible prestart alarm.

6.3.4. Air Quality and Ventillation Systems

The workplace must be ventilated to enable workers to carry out work without risk to health and safety. The consequences of poor ventilation include:

- exposure to:
  - excessive heat
  - fumes, substances or mixtures which can lead to unconsciousness, acute or long-term health problems and even death
- oxygen depletion, and
- fatigue and impaired judgment

The quantity of air supplied or extracted from the face should be so the average air velocity at a full cross section of the tunnel or shaft is between 0.3 m/s and two m/s at all times.

Mechanical Ventillation

Mechanical ventilation is one way to:

- ensure oxygen is available for respiration from fresh air
- dilute and transport harmful atmospheric contaminants away from work areas
- have enough air flow to eliminate or minimise contaminants, so far as is reasonably practicable, and
- provide cooling for people working in warm and humid environments.

The ventilation design should check there is:

- no dead spots
- no low air speed areas
- no flow reversals
- no areas of dust concentration
- no recirculation, and
- inspection points are fitted where blockages are likely to occur.

When a mechanical ventilation system is used to eliminate or minimise, so far as is reasonably practicable, the risk of exposure to a contaminated atmosphere the system should be:

- located as close as possible to the source of the contaminant to minimise the risk of inhalation by a person at work
- used for as long as the contaminant is present
- kept free from accumulation of dust, fibre and other waste materials and maintained regularly, and
- designed and constructed to prevent the occurrence of fire or explosion if the system is provided to eliminate or minimise, so far as is reasonably practicable, contaminants arising from flammable or combustible substances

Atmospheric Contamination in Tunnelling Work

Atmospheric contamination in tunnelling work can occur because:

- excavations can be a receptacle for gases and fumes heavier than air
- gases and fumes like methane, sulphur dioxide, carbon monoxide and carbon dioxide leak from gas bottles, fuel tanks, sewers, drains, gas pipes and LPG tanks into the tunnel particularly when other work is taking place nearby
- oxygen in a non-ventilated area can be depleted due to internal combustion plants, oxidation or other natural processes, and
- through blasting activities.

The ventilation requirements should be determined through a risk assessment.

Due to the nature of tunnelling work, contaminants generated in one area of the tunnel will move readily to other areas. Protection against airborne hazards should be provided to workers.

Control measures should be implemented to eliminate or minimise, so far as is reasonably practicable, the risks associated with atmospheric contaminants.

Monitoring of Air Quality

Air monitoring must be carried out to determine the airborne concentration of a substance or mixture at the workplace to which an exposure standard applies if:

- it is not certain on reasonable grounds whether or not the airborne concentration of the substance or mixture at the workplace exceeds the relevant exposure standard, or
- monitoring is necessary to determine whether there is a risk to health and safety.

Risks to health and safety associated with a hazardous atmosphere at the workplace must be managed. An atmosphere is a hazardous atmosphere if:

- the atmosphere does not have a minimum oxygen content in air of 19.5 percent by volume under normal atmospheric pressure and a maximum oxygen content of air of 23.5 percent by volume under normal atmospheric pressure
- the concentration of oxygen in the atmosphere increases the fire risk
- the concentration of flammable gas, vapour, mist, or fumes exceeds 5 percent of the lower explosive limit for the gas, vapour, mist or fumes, or
- a hazardous chemical in the form of a combustible dust is present in a quantity and form that would result in a hazardous area.

A risk assessment may be carried out to determine:

- the engineering control measures, work practices and on-site atmospheric or biological monitoring needed, and
- the monitoring program for airborne contaminants like dust and fumes including taking air samples and ensuring the relevant exposure standard is not exceeded or people are not exposed to a hazardous atmosphere.

After blasting, tests should be carried out before people are allowed to re-enter the tunnel. The tunnel should be monitored throughout the work period in accordance with a suitable procedure. The workplace should be examined by suitably qualified people using detection and measuring equipment.

Managing Heat Stress

To determine the level of heat-related risks for a worker the following should be assessed:

- environmental conditions like air temperature, radiant heat, high humidity and air flow
- physical work e.g. strenuous or light work
- work organisation e.g. exposure to heat and time of day, and
- what PPE and clothing like heavy protective clothing, is worn by workers

Control measures should be identified to eliminate or minimise, so far as is reasonably practicable, the risks associated with heat stress and heat stroke. They may include:

- providing extra ventilation in enclosed environments that may become hot
- reducing items of heat-producing equipment in the tunnel
- regulating air flow or modifying ventilation to ensure cooling
- refrigerating the air supply or water supply in extreme conditions
- providing extra ventilation fans to create air flows in low-flow areas

- implementing work and rest regimes relating to the physical fitness, general health, medication taken and body weight of each worker exposed to heat
- providing cool drinking water and suggesting that in line with industry practice workers drink half a litre of water each hour when hot environments cause excessive sweating
- carrying out a risk assessment and determining a monitoring regime
- monitoring air speed, wet bulb humidity and temperature regularly to determine the cooling effect
- rotating people in hot areas
- educating people to recognise symptoms of heat stress and heat stroke
- providing PPE like shade hats or shade structures for surface heat exposure and using cooling vests, either circulating liquid or gel pack style, and
- allowing workers to acclimatise to heat

6.3.5. Other Tunnelling Risks

Fire and Explosion

Risks of fire and explosion during tunnelling work must be eliminated or minimised, so far as is reasonably practicable.

Fire underground rapidly consumes oxygen and produces noxious fumes and gases. The fire will reduce and in some cases eliminate visibility. There is a significant risk the fire will block at least one tunnel exit forcing workers to seek an alternate exit or a place of safety

The following control measures should be considered when implementing fire prevention procedures.

Table 0.11. Specific Control Measures - Fire Prevention and Control

Considerations	Questions
Workplace emergency procedures	Have workplace emergency procedures for the level of fire risk been developed and practiced? Have escape routes, safe places and emergency assembly areas been established?
Removing hazards	Can tunnelling work activities generating flammable or explosive atmospheres be eliminated? Could they be eliminated or minimised, so far as is reasonably practicable, by providing ventilation? Are procedures in place to remove unnecessary flammable substances, dusts or waste regularly? Have flammable goods storage areas, identified with warning signs, been provided? If smoking is allowed are designated smoking areas provided?
Fire extinguishers	Are the required number and type of fire extinguishers strategically located around the workplace including flammable goods storage areas? Are there signs showing where fire extinguishers, fire hoses and hydrants are? Is the equipment easy to get to? Are training programs in place on fire fighting equipment?
Breathable atmosphere	When should self-rescuers, breathing apparatus and sealable, self-contained atmosphere refuge chambers be provided? How will people be trained to use them safely?
Automated fire protection	Has providing automated fire protection been considered? This may depend on the type and size of plant used, the nature of the tunnel, difficulty of exiting underground work areas and the potential for fire.

Hazardous Chemicals

Control measures should be implemented to eliminate or minimise, so far as is reasonably practicable, the risks associated with hazardous chemicals.

When hazardous chemicals are used in tunnelling work care should be taken to minimise the risk of spillage or loss of containment. Only enough hazardous chemicals for use during one day or shift should be held below ground. A risk assessment should be conducted before a new chemical is introduced to the underground workplace. This should show if there is a potential for the chemical to cause hazardous contamination of the air or ground during normal use, storage and if containment is lost.

The Safety Data Sheets (SDS) supplied by the manufacturer or importer will provide information on the hazards associated with the chemical including how to deal with spills, leaks and fires. Written procedures to use and handling chemicals safely including emergency procedures, should be prepared for chemicals posing a significant risk. Training should be given to anyone using these chemicals.

Visibility and Lighting

Lighting should be provided that:

- allows workers and others to move and work safely within the workplace
- does not create excessive glare, and
- allows safe entry and exit from the workplace including emergency exits.

Control measures should be implemented to eliminate or minimise, so far as is reasonably practicable, the risks associated with poor visibility and lighting.

Table 0.12. Specific Control Measures - Visibility and Lighting

Hazards and risks	Control measures
• collisions • people being struck or run over by plant • inability to assess ground and plant conditions and other potential hazards • slips, trips and falls and fatigue	• providing hard-wired lighting at: ○ transformer installations ○ workshops or service bays ○ fuelling points, pump stations or sumps ○ stores areas and meal rooms ○ loading and unloading points ○ shaft and tunnel intersections ○ plant rooms ○ the transition zone some distance into the tunnel. • providing: ○ extra lighting at the face area including lighting on the platform of mobile plant ○ lighting for detailed work, hazardous processes and where plant is being operated ○ emergency exit lighting.

If there is a chance lighting and in particular the emergency lighting may fail then every person entering the tunnel should be issued with a cap lamp.

Electrical Safety

Control measures should be implemented to eliminate or minimise, so far as is reasonably practicable, the risks associated with electrical hazards in tunnelling work.

Electrical equipment in tunnelling work can be damaged from high temperature, pressure, humidity, dust, from hazardous and explosive chemicals and the effects of blasting. Electrical equipment should be protected from these exposures.

Safety critical plant and equipment like fire fighting equipment, pumps, ventilation, communications and atmospheric monitoring should remain operational even in an explosive atmosphere and where there is an explosion.

Falls from Height

Control measures should be implemented to eliminate or minimise, so far as is reasonably practicable, the risks associated with falls from heights in tunnelling work.

Table 0.13. Specific Control Measures – Falls from Height

Hazards and risks	Control measures
• wet, slippery or uneven ground • inadequate lighting • unsecured and unstable ladders • shafts, excavations and elevated platforms • unsuitable PPE	• providing fall protection while working near: ○ shafts, pits, trenches and sumps ○ cuttings and benches ○ elevated structures like ventilation ducts, working platforms, service platforms, ladders, stairs, formwork, lifts and scaffolding ○ bins, roofs, portal walls and batters ○ plant, tanks and loader buckets

Falling Objects

Control measures should be implemented to eliminate or minimise, so far as is reasonably practicable, the risks associated with falling objects in tunnelling work.

Table 0.14. Specific Control Measures – Falling Object

Hazards and risks	Control measures
• shafts including working stages or platforms within them • pits, trenches, sumps and benches • equipment, bins, tanks, kibbles, spoil stackers, lifts and plant • building roofs or walls of the tunnel, cuttings, portal walls or batters • rock and other material falling from passing trucks or during spoil loading and unloading • elevated structures like conveyors, hoisting facilities, bins, tipping	• installing ground support quickly • changing design e.g. including kick and toe boards, chutes and splash plates • installing screens, overhead protection, protected walkways and lock-out danger areas • not allowing work above other people • using lanyards or thongs on tools

Hazards and risks	Control measures
mechanisms for spoil, working platforms, formwork, ladders and scaffolding	

Vibrations

Some types of plant when used in tunnelling can expose people to vibration. Control measures should be implemented to eliminate or minimise, so far as is reasonably practicable, the risks associated with that exposure.

Risk assessments should be prepared and control measures implemented based on the number of workers and work shift patterns, including exposure to the vibration risk likely to occur during the work.

6.4. Monitoring of Erosion & Siltation

During the construction period, the project proponent shall monitor daily the suspended silt load of the Tons. After completion of the project, the project proponent shall monitor the daily suspended silt load.

6.5. Ecosystem Studies

Efficacy of conservation measures to be implemented such as afforestation and soil conservation measures, and their effects on flora, terrestrial fauna, aquatic fauna are the aspects which should be evaluated and monitored under the head monitoring of ecosystem. The findings of this study should be made available to authority implementing restoration of muck disposal and quarry areas so as to make necessary change if need arise and the implementation more meaningful during construction and operation phase of the project. Since, the study is subject specific, services of expert agencies will be required to carry out the same.

6.6. Monitoring of Muck Disposal

It has already been made eloquent in the relevant muck management plan that the excavated material shall be evacuated from site with suitable usable muck to be utilized in project works by the project proponents and also allowed to be used by private users and the non-usable muck is to be disposed of on designated areas so as not be interfere with either environment/ecology. Thus, these is an imperative need to monitor regularly the quantum of muck generated and its disposal for which purpose the project proponent shall furnish monthly statement of muck/debris disposal to project proponent and SPCB.

6.7. Training requirement

For the successful implementation of EMP it is important that the agencies and particularly the officials involved in the Investment Program should have an understanding of the environmental assessment procedures and also of environmental issues of various urban infrastructure components. As far as implementation of mitigation measures on site is concerned the Contractor will be involved. Hence, it is important to orient the contractors and supervisory staff towards the implementation of mitigation measures and their consequences. Hence, considering the existing capabilities of the agencies involved, the following training program is suggested. PC will conduct the training as a part of or during the monthly progress review meeting.

Table 0.15. Details of Training Requirements

Description	Contents	Schedule	Participants
Program 1 Orientation Program / Workshop for Implementing Agency and Executing Agency	Module 1 – Orientation Indian Environmental Laws & Regulations relating to urban infrastructure Investment Program Environmental impacts of urban infrastructure Investment Programs Module 2 Environmental Assessment Process Conducting Field Reconnaissance Identification of Environmental Impacts Identification Mitigation Measures Formulation of Environmental Management Plan Implementation and Monitoring Incorporation of mitigating measures in the Investment Program design and contracts	4 hrs	Officials of Implementing Agency and Executing Agency
Program - 2 Orientation Program / Workshop for Contractors and Supervisory staff	Module 1 Implementation of Mitigation Measures Environmental issues related to urban infrastructure Investment Programs during construction Implementation of mitigation measures Monitoring of implementation Emergency and Safety response for Disaster Management	2 hrs	Contractors Contractors Supervision consultant
Program - 3 Experience Sharing	Module – Experiences and Best Practices Experiences on implementation in terms of environmental concerns of implemented Investment Programs Best Practices followed	4 hrs (every alternative year from the start of Investment Program, i.e. 2008)	Officials of Implementing Agency and Executing Agency Local NGOs

Chapter 7.0. Additional Studies

7.1 Introduction

In order to ensure the comprehensive and effective EIA, it is necessary to conduct various project specific studies, which will help in identifying the probable impacts anticipated on sensitive environmental attributes. Further, it facilitates to propose appropriate measures during design phase to successfully mitigate the envisaged impacts. Additional studies shall be identified based on presence of ecological sensitive features such as protected forests, national park, wildlife sanctuary, biosphere reserves, migratory corridors, nesting and breeding ground, marine park, coral reefs, mangroves etc., critical polluted industrial areas / clusters identified by CPCB, eco –sensitive areas as notified under section 3 of the Environment (Protection) Act, 1986 and flood and landslide prone areas.

7.2. Items Identified by the Proponent

To ensure that people’s concerns are incorporated in the project design and to promote public understanding about the project and its implications information dissemination is treated as a two way process where the information is passed on to public and their feed back is sought to understand their issues. The preparatory stage consultation helps to explore alternative design options, to avoid very adverse social impacts and to reduce the magnitude of the impacts of the project. Hence, project consultant had carried out public consultation through informal interaction during the socio economic survey during 2022 and 2023 to make aware of the local people and stakeholder about the project activity and incorporated there views and suggestions in the alignment design. The additional studies on public consultation are presented below.

7.2.1. Public Consultation and Information Disclosure

7.2.1.1. Definition of Stakeholder

Stakeholders are those who have a direct interest in project development and whose participation needs to be ensured in consultations at various stages. Stakeholders include project affected people, project beneficiaries, elected representatives of legislative assembly, parliament and local self government bodies and officials of various Government departments.

To ensure that stakeholders’ concerns are incorporated in the project design and to promote public understanding about the project and its implications public consultation and information dissemination is treated as a two way process where the information is passed on to public and their feedback is sought to understand their issues. The consultative process is continued throughout the project period – design preparation, implementation and post implementation periods. The preparatory stage consultation helps to explore alternative design options, to avoid very adverse social impacts and to reduce the magnitude of the impacts of the project, while consultations during implementation stage helps to facilitate a smooth resettlement of the PAFs thereby enabling speedy implementation of the project.

7.2.1.2. Types / Categories of Stakeholders

For consultation and participation, primary and secondary stakeholders have been identified. The following are the major stakeholders consulted:

- All Project Affected Persons (PAPs) and Households, Beneficiaries of the Project, including representatives of Vulnerable Households;
- Elected representatives, Community leaders of PAPs, representatives of CBOs;
- Representatives of local NGOs
- Officials of Forest Department and Public Works Department

7.2.1.3. Details of Stakeholder Consultations

7.2.1.3.1. Objectives of Stakeholder Consultations

The overall goal of the consultation programme is to disseminate project information and to incorporate PAPs views in the road design and Resettlement Plan. The specific objectives of the consultations are to:

- Improve project design and lead to fewer conflicts and delays in implementation;
- Facilitate development of appropriate and acceptable entitlement options;
- Increase long-term project sustainability and ownership;
- Reduce problems of institutional coordination;
- Make the resettlement process transparent; and
- Increase effectiveness of sustainability of income restoration strategies and improve coping mechanisms.

7.2.1.3.2. Stages of Consultations and Information Dissemination

The consultation process formulated for the project employs a range of formal and informal consultative methods including in-depth interviews with key informants, focus group discussions, and public consultation meetings. The consultation programmes are scheduled for several stages of the project, which can be broadly classified as:

- Project preparation phase
- Project initiation phase
- Project implementation phase
- Post implementation phase

Project Preparation Phase: At this stage, following methodologies were used for public consultation and information dissemination.

- Reconnaissance survey
- Focus Group Discussions
- Census surveys

EIA was prepared in close consultation with the stakeholders and involved public consultations, FGDs and meetings, particularly with affected households. Consultations with PAPs ensured that views of PAPs are fully incorporated in finalizing the highway alignment and formulation of compensation and rehabilitation measures.

7.2.1.4. Summary of Stakeholder Consultation

Stakeholders groups participated in public consultation meetings, focus group discussions and interviews included land and building owners, tenants, employees, politicians, peoples' representatives and government officials etc. A large number of potentially affected persons expressed their views about the proposed project.

All the relevant stakeholders such as primary and secondary stake holders were consulted in a collective manner at this stage, hence separate minutes has not been prepared. However, the Consultants have consulted all the District Collectors, MLAs and government officials of revenue, forest and other departments along the stretch at different stages of the project study, apprised about the project, and collected their opinion about the project.

7.2.1.5. Details of Focus Group Discussions

Focus Group discussions (FGDs) were conducted wherein each PAF falling within 500 m radii of the project alignment is identified and contacted and document the status of potentially affected population within the project impact area. It will provide a demographic overview of the population served and profiles of household assets and main sources of livelihood. The questionnaire documents the socio-economic status of the PAF to a limited extent. This survey process also serves as a tool to disseminate information about the proposed project and helps PAF to be clear about the extent of losses.

Main objective of the FGDs is to assess the perception of the people about the proposed project. The stakeholders selected included shop keepers, local residents, owners / workers of local commercial establishments, etc. Issues and concerns of the people pertaining to the project were discussed including their perception on the project.

Opinion on Project: People are aware about the limitations of the existing road and also believe that this project is a very much required to improve the infrastructure services in the region so that it can attract more investment in various fields and develop. They are willing to part with their land for the project purpose provided they receive adequate and timely compensation for the losses they incur. In all the places where FGDs were conducted people expressed their willingness to part with their land for the project. The location wise public gathering and discussed issues are presented in the following table. Details of persons contacted and photographs of Focus Group Discussion are given in Figure 0-1.

Table 0.1. Details of Focus Group Discussion

Location: Anakkamppoyil Side	
Date: 05.08.2021	Subjects and issues discussed
Type of Participants: Businessmen, land cum building owners, farmers, local representatives, etc.	All the consulted people welcomed the project, since the people think that the project will bring the development to the area. One of the respondent informed that there were 47 families lived in the region. Most of them left the place due to the lack of transportation facility, human-animal conflicts etc. They told that they have to cross the Iruvazhinjipuzha to access road facility. Many
Total no. of participants: 31	

	of the consulted people conveyed that they had stopped agriculture activity due to the wildlife attack. There are people residing in the proposed project site, where the land to be acquired for the project, don't have proper ownership details. They informed that government has issued the land as pattayam. Those who are going to be affected due to the project demanded adequate R&R packages and market value for losing assets.
Location: Meppadi Side	
Date: 07.08.2021	Subjects and issues discussed
Type of Participants: Businessmen, land cum building owners, farmers, local representatives, etc.	All the consulted people welcomed the project, since the people think that the project will bring the development to the area. Elephant, leopard etc. were observed in the forest area near to the project site and attacking cattles and pet animals of the PAPs. Those who are going to be affected due to the project demanded adequate R&R packages and market value for losing assets. They also requested proper safety measures like road signing or signboards should be adopted. They also demanded employment opportunities created for semi-skilled and unskilled labours during the construction phase.
Total no. of participants: 22	

Table 0.2. Details of Focus Group Discussion

Sl No	Name & Address with Contact Number
Southern Region	
1	Philip, Puliyilitheth, 9745618847
2	Augustin, Pullikkal, 9048564097
3	Ponnappan, Vellippuredathil, 9645828115
4	Bunu kurian, Puthanpurayil, 9562196502
5	Thankachan, Kudiyanikkal, 9544691991
6	Baby, Kakkarakkunnel, 8606831590
7	Bino, Nedukkandathil, 9846689396
8	Joy, Kakirakudiyan, 96450399365
9	Varghese, Puliyanakunnel, 9544295518
10	Poulose,Choorathakkil, 8157831456
11	Francis, Padinarakkatle, 9946254000
12	Shibin, Kuriyilkkattil. 8606486066,
13	Joseph Augustin, Kunnappilli, 7591923441
14	James, Mathottummal, 9546657611
15	Sunny Joseph, Anakkallunkal, 9846559008
16	K.C.Joseph,Kurumbalakkattil,9946591663
17	Mathew kunnappil, Kunnappil,9048648728
18	Johny, Anakkallinkal, 9495232901
19	Sunny Poul, Koottiyazhikkal, 9895173413
20	Jijo Gerge, Vadakkekkalathil, 9946442345
21	Renju Joseph, Naduvilambath, 8547301316

Sl No	Name & Address with Contact Number
22	Saji Mathew, Choorathakkezhil, 9495862619
23	Babu, Charukara, 9400676941
24	Gerge, Anakkallunkal, 9544309081
25	Joseph, Kilivallikkal, 9745814658
26	Mathai, Puthettu, 9207603363
27	Mathew, Choorathakkezhil, 9497694185
28	Saji, Parakkal, 9447314962
29	Karunakaran, Poolakkuzhiyil, 9495369067
30	Jose A.M, Anakkudiyil, 9605224847
31	Mary Jacob, Pichappillil, 9605024068
Northern Region	
1	Balan, Aranamala Kattunaika Colony
2	Ramu, Aranamala Kattunaika Colony
3	Abdul Khadar, Andhoor Padikkal
4	Sures, Arunamala Kattunaika Colony
5	Ravi,Aranamala Kattunaika Colony
6	Khasim, Allur, 9605740812
7	Ravi, Kunnathumanakkal, 9947676635
8	Raghu.C, Kunnathumankkal, 9048084678
9	Sainul Hameed,Kuzhikkandathil,
10	Abdulssalam, M S Store,7907763550
11	Yokesh, Namdhatil
12	Baby, Perumalil, 04936281921
13	Santhosh, Puthamkottil, 9778008160
14	Kalyani Amma, Puthankottupulliyil, 9778004160
15	Usuf, Kozhissery, 8590727053
16	Junais, Cherupparambu, 9072337672
17	Rajendran, Chulika Estate, 9349009891
18	Ayisha, Pullipparamban, 9544859966
19	Habeeb, Pulikkal, 9747586410
20	Ayishamma. P V, Kulathottummal
21	Mushthak, Commercial building
22	Jaffer Ali, Nelliparambil, 9747867017

Figure 0-1. Photographs of FGDs Conducted in DIZ

7.2.1.6. Institutional Level Consultations

Various State Government Officials and Officials of local bodies were consulted during the screening exercise of the project. Various Forest Department Officials were consulted to collect their opinion about widening the project passing through forest areas, collect details about wildlife present in the forest areas present along the alignment and to identify the boundaries of forest areas along the road. Joint inspections were carried out with the forest officials to mark the forest boundaries on road and to number the trees which are proposed to cut for project.

Table 0.3. Details of Institutional Level Consultation Conducted

<table>
<tr><th>Sl No</th><th>Contacted Officials</th><th>Discussed Points</th></tr>
<tr><td>1</td><td>Divisional Forest Officer,
Kozhikode Forest Division</td><td rowspan="2">• Wildlife/eco sensitive protected area within 15 km radius of the proposed project
• Information on presence of forest land along the project road and Flora of the area
• Presence of Notified Protected Area (covered under Wildlife Protection Act, 1972)
• Record of sighting of Endangered/Migratory species in the vicinity of Project Area
• Forest Map showing the alignment
• Wildlife crossing/ corridor crossing the project area
• Endemic / Keystone Species
• Project impact</td></tr>
<tr><td>2</td><td>Divisional Forest Officer,
Wayanad South Forest Division</td></tr>
<tr><td>3</td><td>Thahasildar,
Thamarassery Taluk and
Vythiri Taluk</td><td>• Project Impact
• Disscussion on Land records and ownership details of affected survey nos.</td></tr>
<tr><td>4</td><td>District Collector
Kozhikode District and
Wayanad District</td><td>• Project Impact
• Assistance for conducting Socio-Economic Survey</td></tr>
</table>

Figure 0-2. Photographs of Joint Site Inspection with Forest Officials

7.2.1.7. Community Participation in Project Implementation

To implement the EMP in a proper way, it is essential to provide scope of involving communities and affected persons in the process. Stakeholder's participation throughout the stages of project implementation and early operation (or the defects liability period) will be integrated in the project.

It has been fully realized that, to redress the environmental issues likely to surface during construction and operation phases, a constant communication is needed to be established with the affected communities and the project proponents. This has been ensured by regular progress monitoring of the construction and with co-operation of the NGOs. Meetings will be organized with the project affected people and various other stakeholders at regular intervals at the potential hotspot / sensitive locations before and during the construction period.

7.2.2. Land Acquisition and R& R Action Plan

The details of land acquisition, its impact on structures as well as the livelihood of affected people and appropriate compensation packages and rehabilitation measures will be presented in the Rehabilitation Action Plan (RAP), which is under process.

7.2.2.1. R&R Policies and Entitlement Framework

This Resettlement Action Plan (RAP) document describes the principles and approach to be followed in minimizing and mitigating negative social and economic impacts of the project. The RAP has been developed based on applicable acts/policies viz. National Policy on Resettlement and Rehabilitation-2007 (NPRR) and following are the main R&R Policy Principles:

Compensation and Assistance: In general terms, the PAPs under the project will be entitled to five types of compensation and assistance: (i) Compensation for loss of land, crops / trees; (ii) Compensation for structures (residential / commercial) and other immovable assets; (iii) Assistance for loss of business / wage income; (iv) Assistance for shifting; and, (V) Assistance for re-building and / or restoration of community resources / facilities.

7.2.2.2. Assessment of Resettlement Impacts

RoW Status Verification

Existing RoW of the approach road has been estimated based on the revenue records.

Loss of Land

The additional land required for the approach road was estimated based on the land acquisition plan prepared by design consultant. Accordingly, an additional private land of 7.482 Ha is to be acquired for the project. Also an area of 10 Ha land is to be acquired for muck disposal.

Loss of Structures

The are 9 structures and one open well are identifies as the afftected structures.

7.2.2.3. Public Consultations and Information Dissemination

To ensure that people’s concerns are incorporated in the project design and to promote public understanding about the project and its implications, public consultation and information dissemination is treated as a two way process where the information is passed on to public and their feed back is sought to understand their issues at different stages of the study . The major key stakeholders who participated in consultations at various stages include all Project Affected Families/Persons (PAF/Ps); elected representatives, Community leaders of PAPs, DC / officials from DC’s office and local Revenue officials; and representatives of local NGOs.

The consultative process is continued through out the project period – design preparation, project initiation, project implementation and post implementation periods. In the project preparation stage the information gathered from field surveys are incorporated in the design phase of the project and preparation of RAP. At this stage methodologies used for public consultation and information dissemination includes reconnaissance survey; Focus Group Discussions; census of PAFs and public consultations along the road side while conducting the census survey in various locations.

7.2.2.4. Institutional Framework

KPWD would be the executing agency of this project. KPWD has an organizational set up with professional engineers at various levels from junior Engineer to Chief Engineer and administrative wing attached to the respective offices. KPWD will be coordinating the project activities such as carrying out Social Impact Assessment (SIA) and preparation of RAP through DPR consultant and land acquisition through competent authorities (Special land acquisition officers), would be appointed for land acquisition.

Implementation Schedule: Implementation of RAP will include land acquisition, and resettlement and rehabilitation (R&R) activities. The implementation process will cover (i) identification of cut-off date and notification; (ii) verification of properties of PAPs and estimation of their type and level of losses and distribution of identity cards; (iii) preparation of PAPs for relocation through consultation, however, the process of consultation will continue throughout the RAP implementation and (iv) Relocation and resettlement of the PAPs. It is assumed that implementation will take minimum 10 months to hand over land for civil works. Training for income restoration, if proposed, however shall continue for another month, estimating a total period of 11 months for RAP implementation. No civil works should begin until all PAPs receive the approved compensation package. Civil works should therefore be linked with the completion of land acquisition.

Monitoring and Evaluation: RAP implementation will be closely monitored to provide Project Implementation Unit (PIU) with an effective basis for assessing resettlement progress and identifying potential difficulties and problems. For monitoring and evaluation (M&E), PIU will appoint an independent agency to undertake external monitoring of the entire project. The independent agency will monitor the project on a half-yearly basis and submit its reports directly to the PIU. This monitoring will include, administrative monitoring, socio-economic monitoring and impact evaluation.

Internal monitoring will track indicators such as the number of families affected, resettled, assistance extended, infrastructure facilities provided, financial aspects, such as compensation paid, grant extended etc. R&R Cell at PIU will carry out internal monitoring, who will report to the Project Director on monthly basis in prescribed monitoring formats. These formats, to be filled by District Resettlement and Rehabilitation Officers (DRROs) at R&R Cell, will indicate actual achievements against the targets fixed, and reasons for shortfall, if any. Based on the reports, the PIU will monitor and evaluate every three months the overall progress on each R&R component within the project and determine actions to be taken by the PIU in situations where the set objectives are not being met.

7.2.2.5. R & R Budget

R & R budget can be broadly subdivided into four subsections such as; 1) Assistance for Loss of Land, 2) Assistance for Loss of buildings and Structures 3) Other assistance and 4) Contingency items and RAP Implementation.

7.2.2.6. Assistance for Loss of Land

Assistance for land has been prepared based on the design proposals where the extent of land area that needs to be acquired. Based on the land use of the area to be acquired along the existing road and the bypasses, unit rates of land are applied to get the total assistance for loss of land. The land value includes 15% additional increase (considering the interest for the period –one year- of preliminary notification to award) and registration and stamp duty charges (12%).

Details of the same shall be incorporated in the RAP report.

7.3. Traffic Survey Analysis

A traffic study has been conducted for the project. As the project road is new link, current traffic on the connecting road to the project road is very less. The following primary surveys have been carried out as part of the study.

- Classified Volume Count survey along NH 766 and SH 29
- Origin – Destination survey at Adivaram and Meppadi
- Axle load survey

Table 0.4. Details of Traffic Surveys and Survey Locations

Location	Type of Survey	From Date	To Date
Adivaram in Thamarassary Ghat (On NH- 766)	7-day Classified Traffic Volume count	01/10/2020	07/10/2020
	1-day (24 hours) Axle Load survey	26/09/2020	26/09/2020
	1-day (24 hours)O-D survey	27/09/2020	27/09/2020
Near Meppadi Junction (On SH-29)	7-day Classified Traffic Volume count	01/10/2020	07/10/2020
	1-day (24 hours) Axle Load survey	27/09/2020	27/09/2020
	1-day (24 hours) O-D survey	28/09/2020	28/09/2020

7.3.1. Analysis of Classified Volume Count Surveys

The survey data is analysed to arrive at peak hour traffic, mode-wise traffic composition, hourly and daily variations, directional split of traffic at the survey locations. The daily traffic volume counts is averaged and mode-wise (vehicle type) Average Daily Traffic (ADT) is presented in tabular and graphical forms. Effective indicators for seasonal factors are drawn out from the secondary data to arrive at the Annual Average Daily Traffic (AADT).

Table 0.5. Location-wise Annual Average Daily Traffic (AADT)

Type of Vehicles	At Adivaram, Thamarassery Ghat	At Meppadi Junction
2 Wheeler	3517	6144
3 Wheeler	363	2979
Car / Jeep / Van/Taxi	6871	4726
Bus (Govt.)	384	65
Bus (Pvt.)	332	36
LCV/ Tempo	1596	780
2 Axle	852	124
3 Axle	542	17
Multi-Axle	108	2
Tractors	0	17
Ambulance	12	23
Cycle	27	17
Others	3	5
Total Vehicles	**14607**	**14935**
Total PCUs	**18955**	**12129**

Based on the above, it is observed that the present traffic at Adivaram along NH-766 is coming to 18955 PCU per day, however as per ‘IRC-73-2018’, four laning is required for traffic is 8500 PCU per day and more for level of service (LOS) ‘B’ in Rolling Terrain. Hence, at present 4 laning of NH-766 is required in this stretch.

Thamarassery Churam of steep gradient with sharp hair-pin bends and through Forest land. Each year, as the monsoon gathers strength, earth slips from the fragile slopes cause traffic snarls to blockages and causes accidents. Extensive Studies have revealed that it is not feasible to improve the width or geometry of this Ghat Section of the NH 766 to cater to the ever-increasing traffic on the already saturated route. Therefore, there is significant necessity for an alternate road.

Hence, the Government of Kerala (GoK) has approved the construction of a four-lane Anakkampoyil-Kalladi-Meppadi tunnel road to ease the congestion of the Thamarassery Ghat road and to provide reliable, safe all-weather road connectivity between Kozhikode and Wayanad.

The present traffic along SH-29 at Meppadi junction is 12129 PCU per day. In future, major part of this traffic will be diverted along new link i.e. Anakkampoyil-Kalladi- Meppadi tunnel road which will offer great relief at Thamarassery Churam.

7.3.2. Origin-Destination (OD) Surveys

The Origin-Destination survey data is analysed to arrive at mode-wise trip matrices, mode-wise commodity distributions for different type of trucks and purpose of travel for cars. Considering the

OD Survey, the expected traffic may divert on proposed new connectivity from Meppadi to Anakkampoyil are as follow.

Table 0.6. Diversion of Traffic on New alignment of NH-766 Traffic (at Adivaram)

Type	ADT	Type of Traffic	Avg. % from OD Survey	Approx. Traffic on New Alignment (ADT)	PCU Factor	Approx. Traffic on New Alignment (PCU)
2 Wheeler	3517	P	24%	845	0.50	423
3 Wheeler	363	P	24%	88	0.75	66
Car / Jeep / Van/ Taxi	6871	P	24%	1650	1.00	1650
Bus (Govt.)	384	P	24%	93	3.00	279
Bus (Pvt.)	332	P	24%	80	3.00	240
LCV/ Tempo	1596	G	7%	112	1.50	168
2 Axle	852	G	7%	60	3.0	180
3 Axle	542	G	7%	38	4.50	171
Multi-Axle	108	G	7%	8	4.50	36
Ambulance	12	P	24%	3	1.00	3
Cycle	27	P	7%	2	0.50	1
Others	3	P	7%	1	1.00	1
Total	**14645**			**2980**		**3218**

Table 0.7. Diversion of Traffic on New alignment of SH-29- Traffic (at Meppadi)

Type	ADT	Type of Traffic	Avg. % from OD Survey	Approx. Traffic on New Alignment (ADT)	PCU Factor	Approx. Traffic on New Alignment (PCU)
2 Wheeler	6144	P	43%	2642	0.50	1321
3 Wheeler	2979	P	43%	1281	0.75	961
Car / Jeep / Van/Taxi	4726	P	43%	2033	1.00	2033
Bus (Govt.)	65	P	43%	28	3.00	84
Bus (Pvt.)	36	P	43%	16	3.00	48
LCV/ Tempo	780	G	26%	203	1.50	305
2 Axle	124	G	26%	33	3.0	99
3 Axle	17	G	26%	5	4.50	23
Multi-Axle	2	G	26%	1	4.50	5
Tractors	17	G	26%	5	1.50	8
Ambulance	23	P	43%	10	1.00	10
Cycle	17	P	26%	5	0.50	3
Others	5	P	26%	2	1.00	2
Total	**14935**			**6264**		**4902**

Therefore, the overall traffic may be diverted from both locations are as follows –

Table 0.8. Diversion of Traffic in ADT (PCU) on New Alignment

Type	Approx. Traffic from Loc-1	Approx. Traffic from Loc-2	Total Traffic on New Alignment in ADT	PCU Factor	Total Traffic on New Alignment in PCU
2 Wheeler	423	1321	3487	0.50	1744
3 Wheeler	66	961	1369	0.75	1027
Car / Jeep / Van/Taxi	1650	2033	3683	1.00	3683
Bus (Govt.)	279	84	121	3.00	363
Bus (Pvt.)	240	48	96	3.00	288
LCV/ Tempo	168	305	315	1.50	473
2 Axle	180	99	93	3.0	279
3 Axle	171	23	43	4.50	194
Multi-Axle	36	5	9	4.50	41
Tractors	0	8	5	1.50	8
Ambulance	3	10	13	1.00	13
Cycle	1	3	7	0.50	4
Others	1	2	3	1.00	3
Total	**3218**	**4902**	**9244**		**8120**

7.3.3. Traffic Growth Rate and Forecast

Based on the analysis of the above mentioned survey data and secondary data, it has arrive at the traffic growth rate considering both diverted traffic and generated traffic.

Table 0.9. Summary of Traffic Forecast on Proposed New Alignment

Type of Vehicle	2030	2040	2049
Two Wheeler	5,245	7,519	10,252
Three Wheeler	2064	2963	4045
Car/ Van/ Jeep	6,870	11,898	19,106
Bus (Govt.)	186	308	482
Bus (Pvt.)	147	247	388
LCV (4 and 6 Tyre)	635	1,169	1,981
2-Axle Truck	171	311	527
3-Axle Truck	82	142	226
MAV	22	45	79
Tractor/ Trailer	15	33	59
Ambulance	31	60	102
Cycle	17	27	43
Other	13	31	62
Total Vehicles	15,498	24,753	37,352
Total PCUs	**14,027**	**23,183**	**35,992**

Projected traffic at completion of the project (i.e.2025) will be 10692 PCU per day. Hence, to maintain the level of service B, Four lanning is required in the year 2025. Therefore, Four Lanning has been proposed in entire section.

7.3.4. Axle Load Data Analysis

The Vehicle Damaging Factor (VDF) represents the number of Equivalent single Axles (ESA) that would cause the damage to the road pavement. VDF values for various categories of vehicles are furnished in table below.

Table 0.10. VDF Factor

Location-1- Adivaram on NH-766 in Thamarassery Ghat

Sl. No.	Type of Vehicle	Mode	Direction		Average of Both Direction
			Kozhikode to Kalpetta	Kalpetta to Kozhikode	
1	2	LCV	0.53	0.65	0.59
2	3	2 Axle	2.19	2.99	2.59
3	4	Truck (3 Axle)	3.38	3.91	3.64
4	5	4 Axle Vehicle	2.60	3.41	3.01
5	6	5 Axle Vehicles	0.00	0.00	No Vehicle seen

Location-2- Near Meppadi Junction on SH-29

Sl. No.	Type of Vehicle	Mode	Direction		Average of Both Direction
			Meppadi to Kalpetta / Kozhikode	Kalpetta / Kozhikode to Meppadi	
1	2	LCV	0.47	0.67	0.57
2	3	2 Axle	3.54	3.08	3.31
3	4	Truck (3 Axle)	3.83	3.30	3.56
4	5	4 Axle Vehicle	3.04	3.22	3.13
5	6	5 Axle Vehicles	0.00	0.00	No Vehicle

The vehicle damage factor for different type of commercial vehicles is determined from the Primary survey data. This is the major input for calculating the number of million standard axles, likely to be using the Project Road. Axle load spectrum is also derived shall be used for MSA calculation which is used the design of pavement.

Table 0.11. Projected Traffic Load on Project Road in MSA

MSA	In 2020+15	In 2020+30
1	1.32	2.95

7.4. Geological and Geomorphological Study Conducted

This study is part of the EIA consultancy work undertaken by M/s. KITCO for the proposed tunnel from Anakkampoyil in Kozhikode district to Meppadi in Wayanad district. This study contains the geological and geomorphological features of the tunnel alignment and its impact area.

Geological map of the region (10 km buffer zone of the project alignment), comprising Wayanad, Kozhikode and Malappuram districts, was compiled using inputs from available published maps of the Geological Survey of India, as well from their digital library. Description of regional geology is based on the compiled map.

Available core samples from bore holes were documented. With the help of borehole lithologs and with observation inputs from exposures of rock outcrops in the study area, and with literature inputs, lithological sequence of the tunnel corridor impact area was synthesised. Field observations, litholgs, literature inputs , lineament map and petrographical investigations indicate the complex nature of the geology of the study area. Perceived geological impacts due to tunnelling have been included in the report together with suggested EMP measures.

Geomorphological features were elucidated through preparation of TIN (Triangulated Irregular Networks) terrain model using Arc GIS based on 20m interval contours. A slope map was derived from TIN terrain model using slope classification adopted for erosion proneness studies by the ITC, Netherlands.

The section has been structured as (1) “Geological sequences of Kerala” to offer a general idea about the geological sequences of Kerala, (2) “Regional Geology” to elucidate the geology of the districts that constitute parts of the impact area that influences the geology and structure of the tunnel corridor and (3) “Geologic and Geomorphic Setting of the Project Impact Area”. Tunnel overburden sketch and seismicity record are also included in this section.

7.4.1. Geological Sequence of Kerala

The Kerala region is an important segment of the South Indian Precambrian terrain, where major units of the Archaean continental crust, such as granulites, granites, gneisses and greenstones are preserved. Southern part of the State, south of Achankovil shear zone, exposes an assemblage of migmatised metasedimentary and meta-igneous rocks (khondalite-charnockite assemblages). From north of the Achankovil shear zone upto the southern flank of the Palghat Gap, the rocks are predominantly charnockites, charnockitic gneisses and a variety of other gneisses with occasional assemblages of metasediments in the Idukki-Munnar region representing the western continuation of the Madurai block in Tamil Nadu. Within the southern part of the Palghat Gap, charnockitic patches and hornblende- biotite gneisses predominate. Towards the central and the northern parts of the Gap, migmatitic gneisses (hornblende-biotite gneisses) and occasional patches of amphibolites, calc-granulites and granites are observed. Northern flank of the Gap consists of a metasedimentary sequence of khondalite and calc-granulite with crystalline limestone bands that extends to Madukkarai in Tamal Nadu. Granulites, schists, and gneisses, intruded by acid and alkaline plutons, constitute the northernmost parts of the State.

The bulk of the rocks of Kerala, especially the granulites and associated gneisses belong to Precambrian. Sporadic late Precambrian - early Paleozoic granites and associated pegmatites, and Meso-Cenozoicdykes intrude these rocks. The onland sedimentary formations are confined to Neogene period only. This indicates that the geologic column of the region is far from complete, with hardly any representation of rocks of the great periods belonging to Paleozoic, Mesozoic and early Cenozoic eras of the Geologic Time Scale.

A number of radiometric age determinations of rocks from the Kerala region have helped in classifying the rocks into broad age groups. The oldest rocks, so far dated in Kerala, are the charnockites (massive), which yielded U-Pb zircon age of 2930±50 Ma (Odom, 1982). These also happen to be the most widespread rock unit in the State. Charnockites and associated gneisses occupy most part of the Western Ghats and the midland regions of the State.

The largest patch of Khondalite group of rocks is noticed south of Achankovil shear in south Kerala. These rock units occur as a linear belt, wedged between charnockite massifs on both sides. They have recorded ages of ca. 2100-2830 Ma, although there is a whole-rock model age of 3070 Ma reported by Crawford (1969). Therefore, as against the earlier view, khondalite group of rocks are shown above charnockites in the Geologic Time Scale (Table 1). Lower ages have been recorded by cordierite gneiss samples. All these rock units are of granulite grade metamorphism.

Ancient Supracrustals:

The oldest dated rock in Kerala, namely charnockites/charnockitic gneisses, contain several enclaves of schistose rocks. These occur as linear en-echelon bands and enclaves extending from Sultan's Battery, close to Karnataka border through Manantoddy in Wayanad plateau to Taliparamba and Payyannur, and to the eastern parts of Kasaragod district, being the southward extension of the schistose sequence in Karnataka. Lithology of the schistose rocks permits their identification with the Sargur complex of Karnataka, which are considered the oldest rock assemblage there, consisting of a group of sediments and associated intrusives. Field relations and age comparison with the schists of Karnataka further permit to attribute these as the oldest recognizable rock assemblage in Kerala also.

Charnockite-Gneiss Association:

The most widespread rocks in Kerala are charnockites and associated gneisses. These are pyroxene-bearing granulites and gneisses and occupy a major part of the Western Ghats and the midland regions of the State, especially in central and north Kerala. Large bands of charnockites are also observed within the south Kerala Khondalite Belt. In many localities enclaves of mafic granulites also occur within charnockites. Textural, mineralogical and geochemical variations are observed in charnockites from different localities. Field relations, including association with other metamorphic rocks, mineralogical and petrographical features are indicative of the metamorphic origin of the rocks under high P-T conditions (8-10 kb pressure and around 800-860°C) from a diverse source of precursors including igneous ones.

Preponderance of a variety of gneisses, occurring within the granulite terrain, spatially associated with lineaments/faults is a characteristic feature of the geology of Kerala. These are also associated with zones of migmatisation and granite emplacement. Garnet-biotite gneiss, cordierite gneiss and garnetiferous - quartzo - feldspathic gneiss are seen more in association with khondalite, while hornblende-biotite gneiss and biotite gneiss are spatially associated with charnockites. The latter are formed during various episodes of tectono-thermal events including the one at ca. 1550 Ma, discerned in south Kerala. The gneisses often contain enclaves of amphibolites, especially in central and north Kerala.

Khondalite:

Garnet-sillimanite gneiss, containing varying amounts of graphite and some quartz and orthoclase has been termed khondalite. Its occurrences are seen in various parts of the State. The largest patch is noticed in south Kerala in association with garnet-biotite gneiss and garnetiferous-quartzo - feldspathic gneiss. This occurs as a linear belt, wedged between charnockite massifs. Another linear belt is observed in the northern flank of the Palghat Gap, where it is seen in association with calc-granulite and crystalline limestone. Both these belts extend into Tamil Nadu. Minor occurrences have been reported from Idukki-Munnar region and from southeast of Kasaragod. This is basically a metasedimentary sequence belonging to upper amphibolite-granulite grade of metamorphism. Lithological variation of the sequence in different segments may be suggestive of varying depositional/ provenance conditions. According to the available age data, rocks in this group range in age from 2830 to 2100 Ma, although there is an older whole-rock Rb-Sr age of 3070 Ma reported by Crawford (1969). The former also supports the field relation, indicating younger age of the khondalite thanthe charnockites.

Intrusive Rock:

Intrusive phase within the Kerala region includes sporadic occurrence of basic and ultrabasic bodies and dykes belonging to Lower-Middle Proterozoic age (gabbro bodies from Kartikulam, Adakkathodu and Karrang along the Bavali fault zone in Kannur district; perodotite' pyroxenite, gabbro and anothosite along the Attapady shear zone; dunite from Punalur etc), pegmatites of Middle Proterozoic age (phlogopite mica pegmatite from Punalur), a host of younger granites (Ezhimala pluton, Peralimala pluton, Ambalavayal and Kalpatta granites, Pariyaram, Munnar, Chengannur and Angadimogar granites of late Precambrian-early Paleozoic age) with associated pegmatites of early Paleozoic age and later dolerite dykes, contemporaneous with Cretaceous- Paleocene Deccan Basalt Magmatism. Of these, the younger granites and associated pegmatites constitute the bulk of the intrusive rocks, and are contemporaneous with the Pan-African tectono-magmatic event. Within the khondalite terrain, these are white-coloured garnet granites (as in south Kerala), while within the charnockite domain, pink granite, syenite and gabbro-granophyre predominate. Pegmatite phase, closely associated with the younger granite phase is more prominent within the khondalite terrain of south Kerala, where it contains gem-quality chrysoberyl mineralization. Pegmatites in north Kerala (Wayanad) are relatively older and known for their muscovite mineralization.

Dolerite dykes, contemporaneous with the Deccan Basalt Magmatism are the dominant phase, and occur within both charnockites and gneisses and are of different ages ranging from 141 to 61 Ma. Dykes are seen cutting all the penetrative structures in many directions. However, the largest dyke swarm in Kerala oriented in NW-SE direction, is occurring over a 100 x 25 km zone in central Kerala. The dyke emplacement is attributed to the time of the west coast faulting.

Quartz veins, occurring in the Wayanad region is associated with syn or post pegmatite emplacement phase. In Nilambur valley, reef quartz is associated with gold mineralization.

Age Relations:

Rocks of Precambrian age outcrop over large areas of Kerala. Subdivision of the serocks into different time units is difficult because the criteria of superposition, grade of metamorphismetc cannot be applied reliably in a polymetamorphic terrain and the radiometric age data available were also scanty. Thanks to the works of Holmes (1955), Venkatasubramanian and Krishnan (1961), Crawford (1969) and a host of other workers, a number of isotope age data are available now. Geological investigations have brought out the inter-relationship between different lithological units of the Precambrian, their relation to unconformities, to orogenic cycles and to intrusive rocks in many parts of the State. From the available age data, it is seen that there are rocks of ages from 450 to 3070 Main Kerala, and it appears that the area was affected by several episodes of metamorphism and tectono-thermal events. Apart from the significance of the occurrence in Kerala of rocks of about 3000 Ma old,there are also evidences of ca.2700Ma, ca.2100 Ma, ca.1600 Ma, ca.1000 Ma, ca.700 Ma and 500 Ma events. The massive charnockites/charnockitic gneisses which constitute most parts of the State are older than 2900Ma and were affected by the later metamorphic and granitisation cycles. The charnockite samples also give ages in the range of 2155 to 2780Ma by various methods, mostly of whole-rock samples. The latter ages may be an artefact of older protolith ages and subsequent lead loss.

Ages of khondalite and associated gneiss samples are relatively lower, except one determination, than those of charnockites.This would support the view that part of the gneisses were derived from retrogression of the charnockites, and that Khondalite group of rocks were deposited in intracratonic basins, located within the charnockitic provenances. Linking the metamorphic history of the Madurai Block to that of the Kerala Khondalite Belt, Barelett et al. (1994) argued that the Palghat-Cauvery Shea Zone (PCSZ) represents a major geological divide. Furthering this argument Harris etal. (1993) proposed that the Achankovil ShearZone (ASZ) does not represent a major tectonic break, contrary to field, lithologic and P-Tconstraints, and recentseis micrecord. Model Nd ages obtained for a series of samples throughout the Madurai Block and the Kerala Khondalite Belt showed that crustal growth in both the terrains occurredbetween3.0 and 2.0Ga, with the exemption of a small group of metapelite samples along the southern zone of ASZ yielding model Nd ages of 1.3-1.4 Ga (Barelett et al. 1994). However, U-Pb zircon ages from garnet-sillimanite gneiss (Khondalite sensu stricto) from sout hKerala indicate that the upper interceptagesofca.2200 Ma are the oldest Early Proterozoic apparent ages reported from the south Kerala Khondalite Belt (Soman et al. 1995). Lower intercept age of ca. 500-600 Ma, in conjunction with other determination of ca. 550 Ma (Buhl, 1987; Choudhary et al. 1992) may be suggestive of the age of granulite metamorphism, associated with widespread melting affecting the metasediments, retrogression of massive charnockites and the time of formation of arrested charnockite. This is not in full agreement with the suggestion of Harris et al. (1993) that charnockite formation occurred within a Proterozoic mobile belt south of PCSZ during a Pan-African crustalre working event. Late Precambrian-Early Paleozoic granites, granophyres and Phanerozoic dolerite dykes are the major intrusive phases in the region.

Basic and ultrabasic body of Punalur has been dated 1630 Ma (Venkatasubramanian and Krishnan, 1961). Age of the Palachal dyke has been determined at ca.1660±25 Ma (Radhakrishna et al. 1986). Acid and alkaline intrusives are of Late Proterozoic-early Paleozoic age (740-550 Ma). Pegmatites have lower ages ranging from ca.510 to 680 Ma from north Kerala and ca.460 Ma from south Kerala (Soman et al.1990). NE-SW trending dolerite dykes yielded ages of 144 ± 6 Ma (Sinha-Roy, 1983; Radhakrishna et al. 1990). NW-SE trending dykes appear to be younger with ages ranging from 101 to 107 ± 5 Ma.

Tertiary and Quaternary Sediments:

On-land sedimentary formation, belonging essentially to Neogene period and Quaternary period unconformably overlie Precambrian rocks. Both marine and non-marine rocks of the Neogene period fringe the coastal tract in two major basins of deposition: (1) between Trivandrum and Ponnani in the south and central Kerala with a maximum width of 16 km between Quilon and Kundara and (2) between Cannanore and Kasaragod in the north with a maximum width of 10 km at Cheruvathoor. These include rocks of the Vaikom Formation, comprising gravel, coarse to very coarse sand with greyish clay and carbonaceous clay and seams of lignite; fossiliferous limestone, sands and clays of the Quilon formation and the overlying clays with lignite bed, sand, sandy clays and sandstone belonging to the Warkalli bed of late Miocene age.

Sediments of the Quaternary period, consisting of sands, lagoonal clays, shell deposits, teri sands etc. unconformably overlie the Neogene sediments. Total thickness of the sedimentary sequence exceeds 600 m in the Ambalapuzha-Alappuzha region. Mud flats along the Kerala Coast, especially in the central segment are also part of the Quaternary formations. 'Kari' and 'Punja' lands are the occasionally or perennially flooded mudflats of central Kerala, and 'kole' lands in parts of Thrissur district also belong to this category.

Shell deposits occur both in the backwaters, notably Vembanad and Asthamudi lakes, and onland in north Kerala (Payyanrur). In the latter case, the shells are recorded below a depth of 2 m or more under the cover of loose sands and clays, and the thickness of the shell bed attains 0.5-1.0 m. Layers of shells are also seen in the black clays encountered in boreholes.

Offshore Sediments:

The western, Atlantic type, passive continental margin along the Kerala coast has a 50 km wide continental shelf, hosting the Kerala- Laccadive basin. The near-shore shelf part contains a clastic sequence of marine shale and sand with very few limestone interbeds and Cretaceous- Paleocene sediments. The major basin offshore records sediments of over 4000 m thickness of late Cretaceous to Quaternary age, and contains limestone, sandstone and a pile of volcanics. The sediments display two major unconformities during Paleocene-Early Eocene and Middle Eocene- Early Oligocene. The offshore well data also indicate an unconformity at the base of Middle Eocene sediments. Data on offshore sediments have been helpful in reconstructing the geomorphic evolution history of the major landforms of the provenance as well as the evolution chronology of the coast.

Laterite:

Laterite was first reported from Angadipuram by Buchanan during his traverse of Malabar. A weathering product of rocks, rich in secondary oxides of iron, aluminium or both, with or without quartz and clay, it serves as a building material, ore for aluminium/nickel/manganese/iron etc. and is a good aquifer for groundwater. Laterite genesis and landform evolution are interrelated. In Kerala, laterites of more than one generation are present, and are confined to elevations of 600 m and below, over Precambrian and Tertiary sediments. Interface of the coastal plain and lowlands is occupied by laterite. Vast dissected lateritic mesas are present in parts of Malappuram, Cannanore and Kasaragod districts. Two lateritisation cycles are known to exist in Kerala; Pre-Warkalli and Post- Warkalli cycles. Incidence of laterite pebble bed over the consolidated laterite horizons may speak of another possible cycle of lateritisation, age of which may be younger than the other two cycles.

Soils:

Ten broad groups of soils based on morphological features and physico-chemical properties have been identified in Kerala. Spatial distribution and physico-chemical properties of the soils are mostly consistent with the lithological diversities of the rocks, as well as physiographic and vegetational distributional patterns. The most predominant type, however, is lateritic soil, reddish brown to yellowish red in colour, supporting a wide range of crops such as coconut, tapioca, rubber, arecanut, pepper, cashew etc. Properties of the lateritic soil vary depending on the bedrock characteristics.

Field relations and available geological record of the State is suggestive of a protracted history for the region, spanning from Precambrian times onwards to the present. The on land record is, however, one of prolonged periods of erosion and non-deposition. Offshore data indicate that the major geomorphic events took place during Tertiary-Quaternary times.

A number of radiometric age determinations of rocks from the Kerala region have also helped in classifying the rocks into broad age groups. Classification of the Kerala rocks into broad age groups, based on field relations and the available age data is given in **Figure 0-3** (after Soman, 2013).

Foundering of estuaries, and sequential uplift of the coast, it is presumed, must be quite recent events in the geologic history of the region. Continued geological and tectonic activity in the region is discernible from frequent tremors experienced in various parts of the State and from historic record of river course changes.

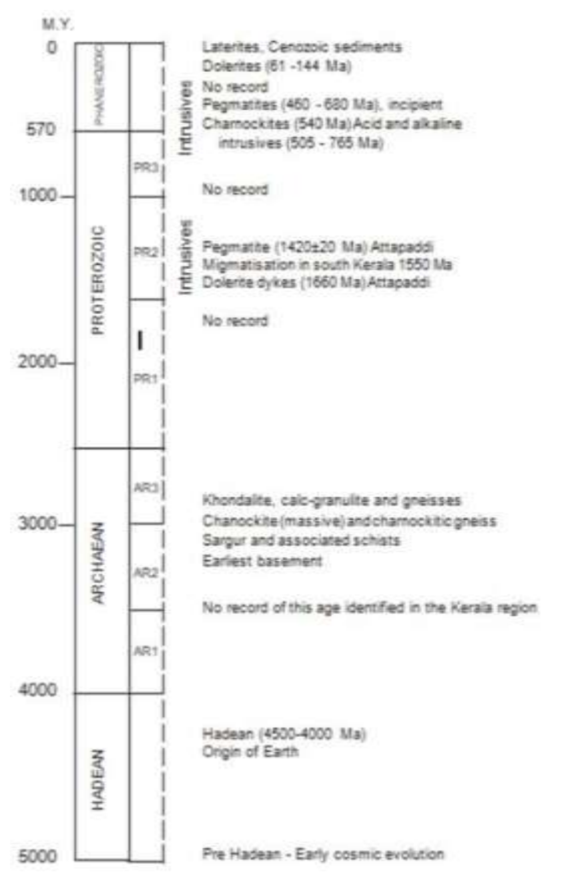


Figure 0-3. Geological Time Scale

7.4.2. Regional Geology

The proposed tunnel alignment (Anakkampoyil-Meppadi) passes through the districts of Kozhikode and Wayanad. The project impact zone is spread over Wayanad, Kozhikode and Malappuram districts (**Figure 0-4**).In the light of the above, description of the regional geology pertains to these districts.

As mentioned in the previous section, the oldest rocks exposed in Kerala are those belonging to the Wayanad Group, being the southward extension in to Wayanad ,Kannur and Kasaragode districts of the corresponding Sargur Comlex in Karnataka. These have good exposures in parts of Wayanad district and are seen in tectonic contact with garnet-silimanite-biotite±graphite gneiss and granite gneiss and engulfed in hornblende-biotite gneiss. Charnockite appears the most wide-spread rock type in the region. Hornblende-biotite gneiss occupies most parts of Wayanad and Kozhikode districts and Nilambur valley in Malappuram district. Intrusives of granite, pegmatites, diorite, gabbro, dolerite and quartz veins have been documented in the region.

Figure 0-4. Project Impact Area

Rocks of Wayanad Group:

This rock asemblage consisting of quartz-mica schist with kyanite, quartz-sericite schist, magnetite quartzites, quartzites and meta ultramafites (talc-chlorite schist, talc-pyroxene-garnet schist) in various stages of migmatization are exposed around Tirunelli in the north-western part of Wayanad district. Together with garnet-sillimanite-biotite ± graphite gneiss, these are seen infolded within the hornblende-biotite gneiss as synformal keels with the garnet-sillimanite –biotite ± graphite gneiss in the core. Their contacts with the gneisses appear concordant possibly due to coaxial folding. The rocks are traversed by NW-SE and NNW-SSE trending fractures/faults and occur in tectonic contact with granulite grade garnet-sillimanite-biotite gneiss±graphite, granite gneiss and diorite intrusive, and are engulfed within hornblende-biotite gneiss. Garnet-sillimanite-biotite gneiss±graphite is also seen containing enclaves of schists of the Wayanad Group. Granite gneiss is seen cutting across hornblende-biotite gneiss and units of the Wayanad Group, and seen engulfed in diorite (**Figure 0-5**). This clearly shows the age relationship of the rocks. Small enclaves/bands of the schists and ultramafites of the Wayanad Group of rocks are seen within hornblende-biotite gneiss in other parts of the study area as well. Prominent exposures are seen to the east and north east of Padinjarathara and in the eastern parts of Wayanad district and in the Nilambur valley in Malappuram district.

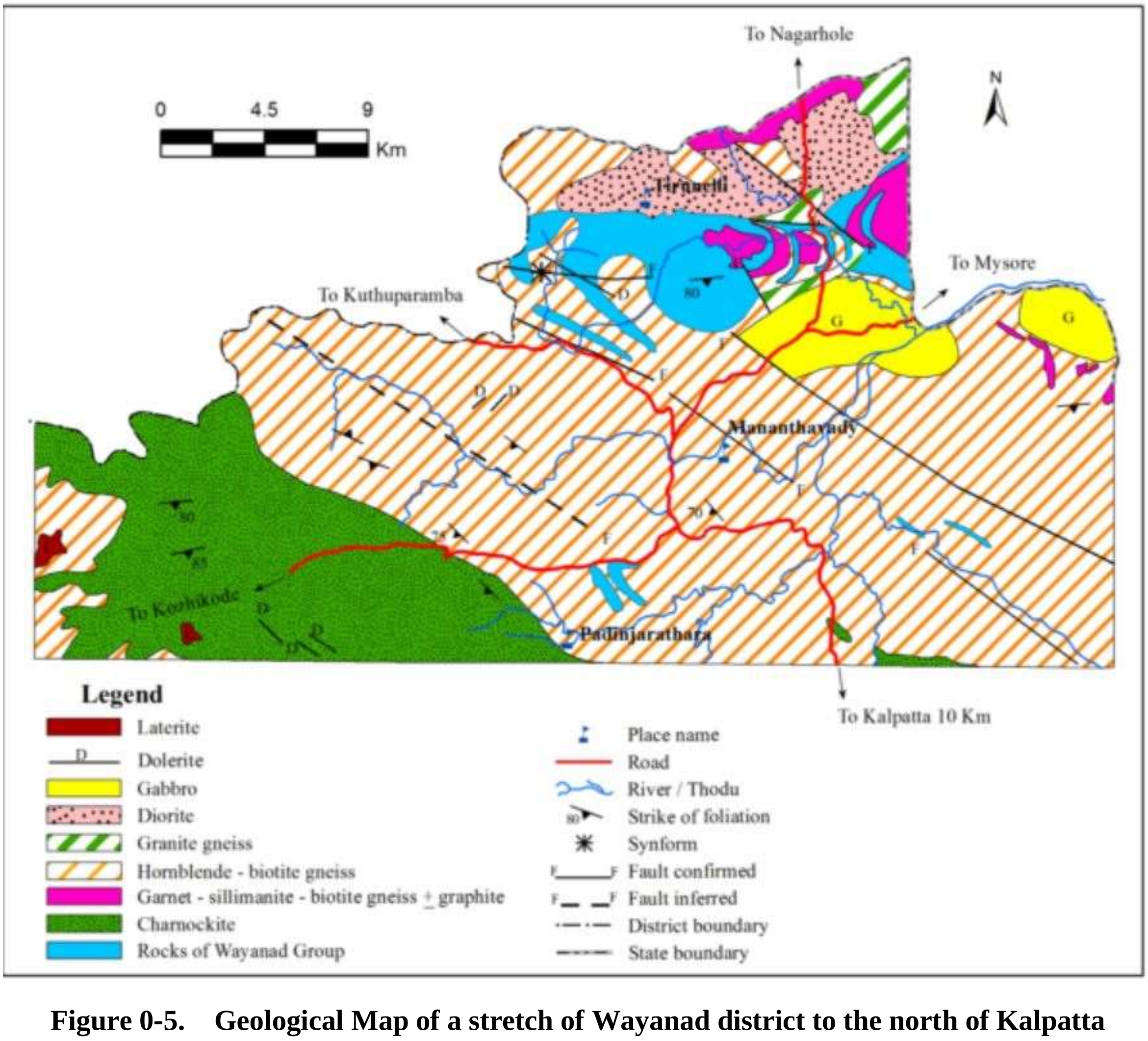


Figure 0-5. Geological Map of a stretch of Wayanad district to the north of Kalpatta
(Simplified from District Resource Map, GSI (1995), geochronologic sequence synthesised from literature sources)

Magnetite quartzite bands are seen in and around Cheruppa, Nanminda and Alampara in Kozhikode distict, occurring both within the charnockites and hornblende-biotite gneiss. The occurrences around Cheruppa, Naminda and Alampara are sufficiently large for small scale extraction. Occurrences of steatite associated with meta ultramafite are observed around Sultanbathery (ref. District Resource Maps, Geological Survey of India, 1992, 1995), where the locals extracted it for pot making.

Spatially associated with the schists are large bodies of garnet-sillimanite-biotite ± graphite gneisses of granulite grade occurring to the north of Kabani river, in addition to their occurrence in the infolded core of the schistose rocks. Small enclaves of it are also seen within the charnockite gneisses.

Charnockites:

These are the most widespread rock type in the region, occupying the higher altitudes of the Western Ghats in Kozhikode, Wayanad and Malappuram districts up to the north of Nilambur valley. Charnockite also occupies parts of the Lowlands (10-300m elevation) and Midlands 300-600m) area approximately from south of Nanminda in Kozhikode district to the southern extent of Malappuram district. The Ghat section from south of Padinjarathara to the north of Vayithiri in Wayanad is occupied by a wide swath of hornblende-biotite gneiss with large enclaves of charnockite in between. Within hornblende-biotite gneiss, bands and enclaves of charnockite are observed. In Wayanad, the intermediate type of charnockite , which is highly garnetiferous and hornblendic is more prevalent, but acid types are also present. In Nilambur valley, pyroxene and hornblende granulites and charnockite gneiss constitute the charnockite group (Sawarkar, 1980). These are dark grey coloured, hypersthene and bluish grey quartz-bearing intermediate to felsic varieties, mostly massive to feebly foliated, and are often intruded by granitic veins and massifs.

Charnockites of north Kerala, especially Malappuram, Kozhikode and Wayanad districts are dark greenish grey in colour, medium-grained, massive or foliated. The mafic minerals include pyroxenes, hornblende and biotite. The most common mineral assemblages encountered are: (1) quartz-plagioclase - orthopyroxene, (2) quartz - plagioclase - clinopyroxene - orthopyroxene, (3) quartz - plagioclase - orthopyroxene - clinopyroxene – hornblende, (4) quartz - plagioclase - orthopyroxene - clinopyroxene - biotite, (5) quartz - plagioclase - clinopyroxene, (6) quartz - plagioclase - clinopyroxene - hornblende, (7) quartz - plagioclase - clinopyroxene-biotite, and (8) quartz - plagioclase - clinopyroxene - hornblende - biotite. Garnet accompanies some of the assemblages occasionally, in parts of Wayanad and Malappuram including Nilambur valley. The retrograded charnockites contain hornblende and/ or biotite, and generally have less orthopyroxene and plagioclase, and a little more clinopyroxene than the charnockite. Hornblende in them is either bluish-green or brown, and biotite flakes cut across all the mafic minerals, indicating their late formation. Magnetite, ilmenite, apatite and zircon are the accessory minerals both in the charnockite and the retrogression products (Soman, 2013).

Charnockite gneisses in Wayanad are conspicuous by the presence of patches of pyroxene granulite (mafic granulite), seen coaxially folded or as thin bands/dykes with thicknesses ranging from 1 to 10 m (ref. **Figure 0-8**). A few outcrops are seen in the north-western part of Malappuram district, and along the Karimpuzha in Nilambur valley. Mafic granulite from Mananthavady area in Wayanad exhibits equigranular granoblastic texture, and consist of plagioclase (An40-60 rarely up to An87), + orthopyroxene + augite ± garnet + hornblende + biotite. Ilmenite, magnetite and apatite are accessory phases. Two generations of orthopyroxene and plagioclase were reported (Ravindrakumar and Srikantappa, 1989). Textural studies by the same authors indicate that the mineral assemblage of garnet+clinoproxene+plagioclase+quartz represents the early mineral phases of granulite facies that formed at a pressure of 10.6 kb (gar-cpx barometer) -7.5kb (gar-opx1 barometer) and temperature of about 790º (gar-cpx)-817º C (gar-opx1). Retrogression mineral assemblages on uplift formed at 6.1 kb and 583º C within 'transitional granulite facies' conditions. Pressure temperature estimates of metamorphism in garnet-sillimanite-biotite gneiss based on garnet-biotite and garnet-plagioclase-sillimanite-quartz thermo-barometers have indicated temperature of 550±50º C and 6.4kb pressure by the same authors. The suggestion of deep burial metamorphism of mafic granulite at crustal depths of about 30 km, followed by uplift and re-equilibration of minerals at transitional granulite facies is consistent with the field relations of mafic granulite, charnockite/charnockitic gneiss and garnet-sillimanite gneiss as core in the infolded schists along fault zones, and subsequent intrusion of diorite and gabbro from deep sources (ref**. Figure 0-5**).

Hornblende-biotite gneisses occupy most parts of the Wayanad plateau, Western Ghats section from the south of Padinjarathara to Vayithiri, the adjoining foot hills, Midlands and Lowlands of Kozhikode district, Nilambur valley and the bordering areas in Malappuram district. They host numerous enclaves of schists/metapelites, ultramafites, charnockite, granite gneiss and are mostly associated with lineaments/faults, zones of migmatisation and granite emplacement. In many places, the boundaries between them are gradational. These gneisses are mostly formed as a result of retrograde metamorphism of charnockites under upper amphibolite to granulite facies conditions (Mahadevan, 1964). The gneisses consist of quartz, plagioclase, K-feldspar, hornblende and biotite as major minerals.

Pink granite gneiss occurs in association with rocks of the Wayanad Group, and seen truncated by/uplifted along faults within hornblende-biotite gneiss as observed to the north-east of Tirunelli. It also occurs as large patch with charnockite enclave within hornblende-biotite gneiss to the SW of Padinjarathara, and as an elongated band towards east of Perintalmanna in Malappuram district.

Quartzo-feldspathic gneiss outcrops are seen as enclaves within charnockite gneiss in the southern border of Wayanad district and in the adjoining parts of Kozhikode district. In Malappuram district, the band is larger with presence of garnet-biotite gneiss and follows a WNW-ESE trend.

Structural setting:

General regional trend of strike of foliation is NW-SE with steep dips. In Nilambur valley, it swings to NE-SW to ENE-WSW directions, coinciding with the direction of the Gudalur pass. Based on swings in the directions of strike of foliation, a ring structure is discerned in between Manjeri and Nilambur. Ring structures, as a rule, are associated with granite emplacement. Occurrence of vast swaths of hornblende-biotite gneiss within charnokcites may be attributed to the granitisation event and the resultant retrogression of charnockite. Another ring structure is inferred to the east of Naduvullur in Kozhikode district, encompassing parts of the tunnel alignment impact area.

Folds identified in the area include NW-SE trending synform and antiform between Perintalmanna and Malappuram within charnockites, WNW-ESE folds to the north-west of Malappuram and NE-SW trending isoclinal antiform structure to the NE of Nilambur. A synform with E-W fold axis is identified to the south of Tirunelli in Wayanad district (District Resource Maps, GSI, 1992, 1995).

A number of lineaments/faults, both inferred and confirmed have been identified in the Wayanad region (also see **Figure 0-5**). NW-SE trending lineaments/faults are concentrated more in the north and north-western parts of the district. One such lineament starting from west of Sultanbathery passes through the north of Manathavady and continues to the south eastern part of Kannur district. Other lineaments/faults either define lithological boundaries or truncate intrusive bodies, as observed to the SE of Tirunelli. A NNW-SSE trending fault to the south east of Tirunelli is very conspicuous in this respect. River courses coincide with the faults, and the latter are identified with the kinks in the river course. In Kozhikode district, two NW-SE trending fractures have been inferred from SW of Alampara, running up to Kannur border and coinciding with dolerite dyke emplacement.

Intrusives:

Intrusive phase in the study area includes occurrence of diorite, granites, pegmatites, gabbro, dolerite dykes and quartz veins.

A large lenticular body of diorite with enclaves of granite gneiss and hornblende-biotite gneiss is seen emplaced within the schistose rocks with concordant contacts in the northern part of Wayanad border with Karnataka. Post-emplacement fault dissects the diorite body and the enclaves.

Large granite bodies are seen around Kalpatta and Ambalavayal in Wayanad district. They are described in **Section 0**.

Pegmatites:

In Kerala, pegmatite veins occur throughout the metamorphic terrain. Mineralized pegmatites are, however, confined to south Kerala (chrysoberyl-bearing and graphite-bearing pegmatites) within gneisses and to parts of Wayanad region (muscovite-bearing pegmatites) within schistose/gneissic rocks. Muscovite-bearing pegmatites are seen more towards the east and north of Sultanbathery and trend NW-SE and NE-SW. Muscovite-bearing pegmatites were formed at P-T conditions of about 400°C and 2.75 kb, and their mineralogy closely corresponds with that of the host schistose rocks. Muscovite-bearing pegmatites from Wayanad are older in age than the pegmatites of Palghat Gap area and of south Kerala, and yielded Rb-Sr mineral ages of ca.680 Ma.

Gabbro:

Two bodies of gabbro are located to the north east of Mananthavady (see **Figure 0-5**). They are seen emplaced in spatial association with the exhumed schist/granulite (garnet-sillimanite-biotite gneiss)/granite gneiss assemblage and truncated by faults. Temporally, their emplacement appears post-dating hornblende-biotite gneiss formation.

Dolerite Dykes:

Bulk of the dyke emplacement in Kerala is contemporaneous with the Deccan Basalt magmatism, although evidences of periodic dyke emplacement phases starting from early Proterozoic time are also known. The dykes occur within charnockites and gneisses, and cut all penetrative structures and they differ from one another in trend, mineralogy, composition and age, and therefore, do not relate to a single swarm (Radhakrishna et al. 1990).

In the study area, dykes have NW-SE and NE-SW trends. The fewer NE-SW trending dykes cut across the schistose rocks. These are medium-grained dolerites which extend for upto 6-7 km along their strike direction with widths ranging from less than 1 m upto 6 m. Two dolerite dykes extend for a few tens of km in a NW-SE direction (District Resouce map, GSI, 1995; Radhakrishna et al. 1999). These dykes always contain fresh ophitic intergrowths of plagioclase and clinopyroxene with subordinate quantities of opaque minerals. Occasionally olivine, and more seldom, garnet are present. The dolerites are olivine/quartz normative and are classified as low K, sub-alkalic, Fe-rich tholeiites.

Dating of felsic dykes from north Kerala by conventional K–Ar method yielded a mean age of 81.7 ± 1.4 Ma, and these dykes possess a normal paleomagnetic vector which is similar to that of the central Kerala gabbros yielding a mean age of 81.3 ± 0.7 Ma. Radhakrishna et al. (1999).

Quartz Veins:

Quartz veins are ubiquitous in the Wayanad region, occurring within the gneisses and schists. They cut across the foliation. The gold-bearing quartz reefs of Nilambur, which are white in colour are often separated from the country rocks by a selvage of talcose-schist, quartz, breccia and limonite. Most of the gold occurs in ferruginous bands of the reefs. In parts of Mananthavady and Ambalavayal, 20-25 m thick, quartz veins are seen to have scores of metres of strike extension. Some of the veins towards depth also contain muscovite and biotite flakes of upto 3 cm across. It is possible that these veins belong to syn or post pegmatite emplacement phase in Wayanad.

Sedimentary Formations:

Within the study region, sedimentaries are confined to the coastal tracts of Malappuram and Kozhikode districts. These include rocks of the Warkalli formation (Mio-Pliocene) exposed in the southernmost part of coastal Malappuram. Other sequnces are pebble beds, strandline deposits with patches of aeolian teri sands, beach deposit, floodplain deposit and tidal flat deposits.

Laterite:

The region underwent two spells of lateritisation process: (1) Pre-Warkalli and (2) Recent. Large patches of laterite exposures in parts of Malappuram and Kozhikode districts and the laterite profiles in Wayanad are Recent in age. Laterite of Pre-Warkalli cycle is at the base of the Warkalli formation.

7.4.3. Geologic and Geomorphic Setting of the Project Impact Area

The proposed tunnel impact area is spread mostly over parts of Kozhikode and Wayanad districts. Its south eastern part falls within Malappuram district.

Physiography: The study area (project impact area) extends between north latitudes 11º21’45” and 11º36’45”and east longitudes 76º0’45”and 76º13’15”. Its western boundary borders Pullurampara, Kodencheri, Adivaram (all in Kozhikode district), Vythiri and Kalpetta (in Wayanad district). Eastern boundary is further to the east of Vellarimala range. Southern extent is further to the south and south east of Pullurampara. The northern border is to the north of Trikkaipetta (Fig.). The highest altitude noticed in the area is 2339 m above MSL to the ESE of Anakkampoyil and the lowest is 34m around Pullurampara.

In tune with the general physiographic classification of Kerala, the study area can be broadly termed as comprising the Midlands (300-600 m altitudinal range), Highlands (600-1800 m) and Mountainous peaks (above 1800 m). Midlands are confined to the south-west of the study area, falling mostly within parts of Kozhikode district and in the eastern parts falling within Malappuram district, and partly extending westward in to Wayanad district. Highlands extend in a north to north-west direction occupying areas of Kozhikode, Malappuram (partly) and Wayanad districts. Mountainous peaks are more prominent in the Kozhikode-Malappuram stretch and less in parts of Wayanad (see **Figure 0-6**.). The most characteristic landscape feature of the Western Ghats east of 75º55'near Kozhikode is the presence of Wayanad plateau at an elevation of 700-950 m above MSL. This surface has a general slope towards east and north east and merges with the Mysore plateau (900-1200 m above MSL). Large part of the study area is occupied by the plateau, especially towards the north, west and east. A small stretch in the south western part of the area belongs to the Lowlands category (10-300m altitudinal range**.**

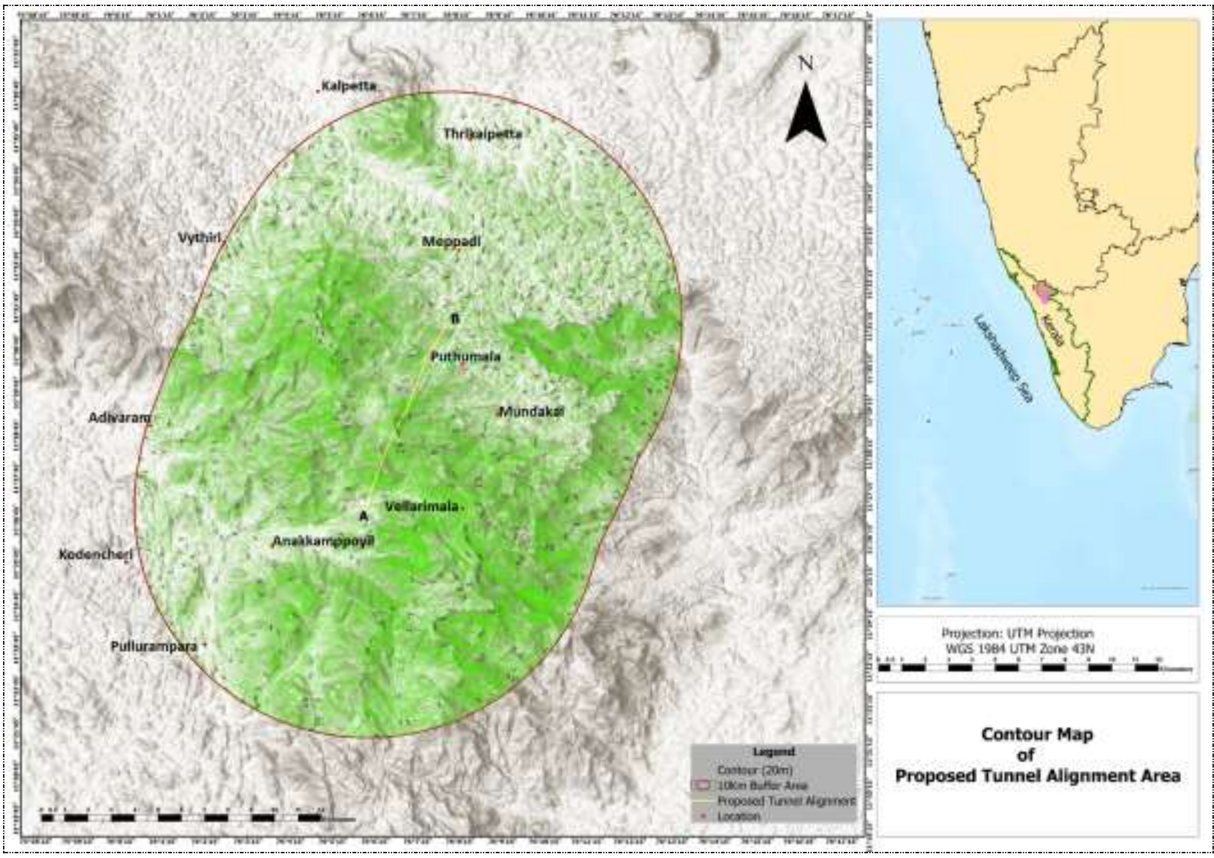


Figure 0-6. Contour Map of the Study Area

Drainage: The study area falls within the Chaliyar and Panamaram puzha catchments. The north to north-west trending Highlands and Mountainous peaks function as the water shed of the study area. Munda thodu originating from Kuratimala and other streams from around flow west and then south west to join Iruvanchipuzha, a mjor tributary of Chaliyar. The east flowing streams (Karadan puzha and Kodinji puzha) in the south east and Kalladi puzha, Minakshi puzha and Nellimunda puzha in the north join Chali puzha, the upstream part of Chaliyar. Streams originating in the northern and north-western parts of the study area drain in to Vayithiri puzha/Pozhutara puzha/ Panamaram puzha. The hilly streams give rise to water falls in many locations on their course.

Drainage patterns observed in the area include dendritic, trellis and rectangular.

Dendritic pattern is more prominent and seen over the higher altitudes. Southern part of the area displays a combination of dendritic and trellis network. Northern part of the alignment, Mundakai-

Puthumala area and the northern plateau area show rectangular drainage pattern, suggesting prevalence of fractured rocks.

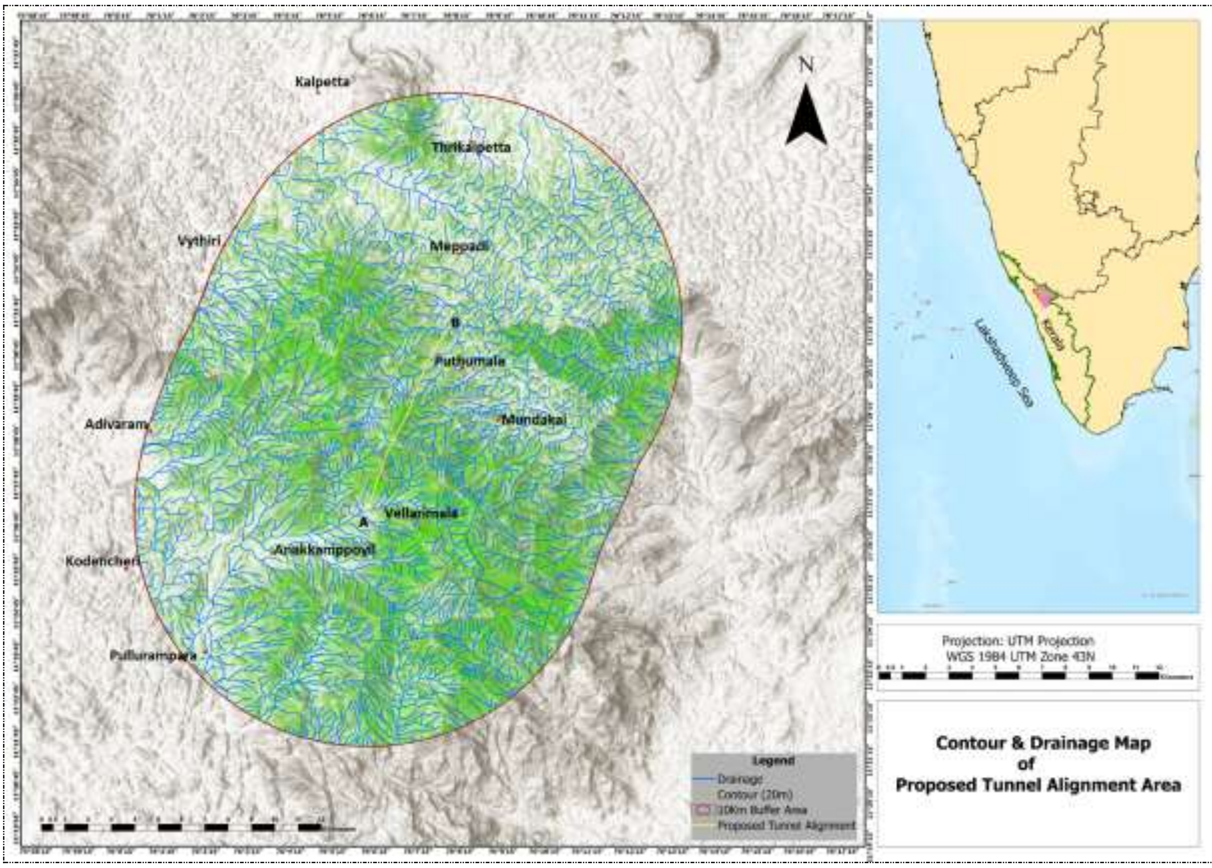


Figure 0-7. Drainage Map of the Study Area

Geological setting: Charnockite and charnockite gneiss constitute most parts of the project impact area. These contain enclaves of pyroxene granulite (mafic granulite), garnet-sillimanite-biotite ±graphite gneiss, quartzo-feldspathic gneiss, and traversed by dolerite dykes. North eastern and south western parts are occupied by hornblende-biotite gneiss. Gauging from regional geology, charnockite and its derivatives are engulfed in hornblende-biotite gneiss. Lenses of magnetite quartzite are seen in the north eastern parts. Thinner bands of it are discerned in the northern portal area. Exposures of Kalpatta granite are observed in the north western part of the study area. Ambalavayal granite is located to the north of the project impact area. Geological map of the area, compiled from District Resource Maps, GSI, 1992,1995 is given in **Figure 0-8**.

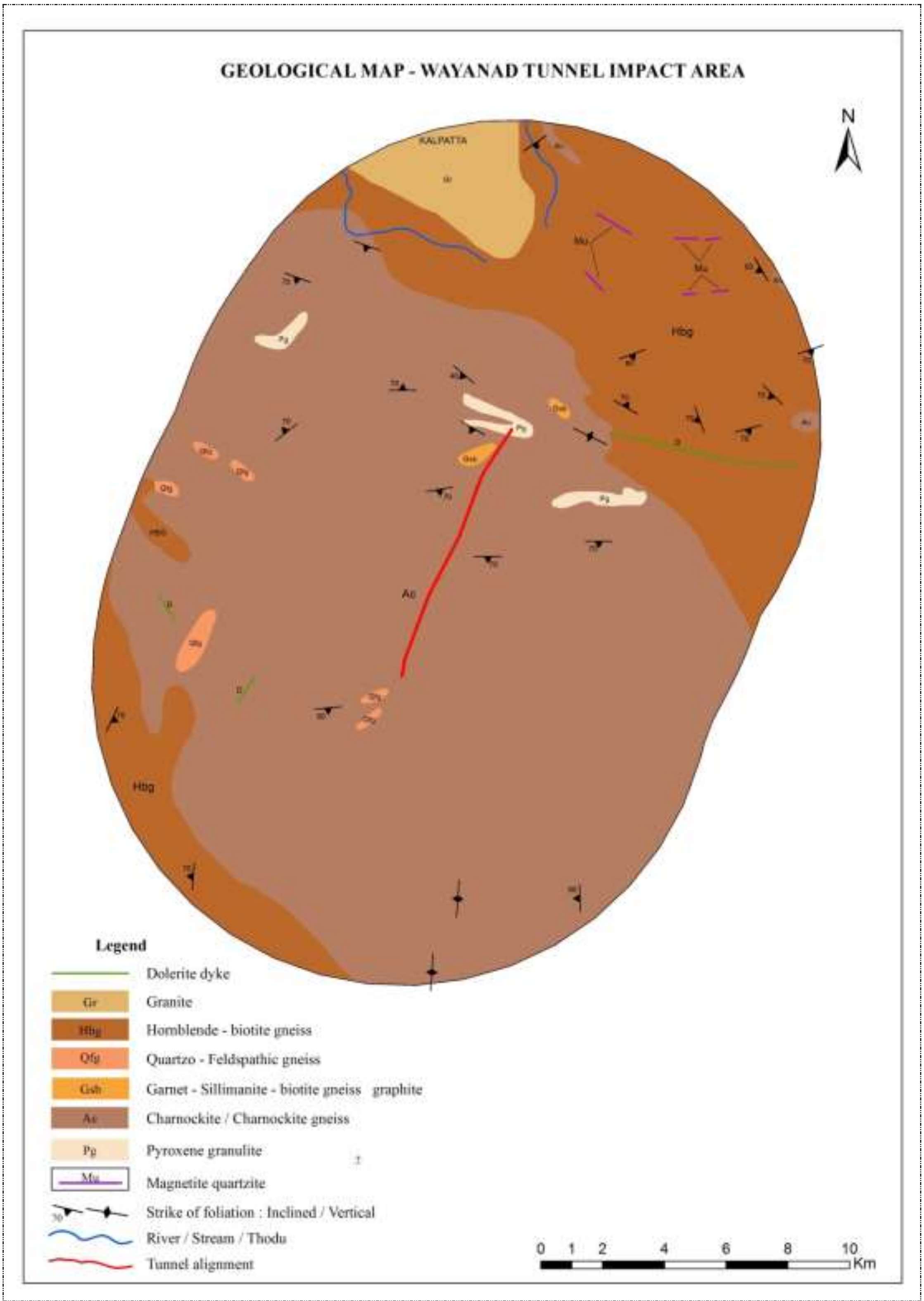


Figure 0-8. Geological Map of the Study Area
(simplified compilation from District Resource Maps, GSI, 1992, 1995).

Description of the lithology is based on field observations, examination of core samples from 8 bore holes drilled in the area as part of geotechnical investigations and their detailed description), literature inputs including material report volume III by M/s Qmax Technoconsultants Pvt Ltd (Design Consultant) and limited petrographic examinations.

A total of 8 bore holes were drilled. Six of them are in the Anakkampoyil portal area. BH-1 encountered only weathering products in its entire depth of 20.00 m. Weathered hornblende gneiss contained pinkish K- feldspar, suggesting proximity of granitic material influx. BH-2 recorded presence of hornblende gneiss, charnockite, fractured gneissic charnockite with evidence of chemical weathering along fracures at depth. Though core recovery attained 60-80% at certain depths, RQD (Rock Quality Designation) values ranged from 10 to 40% only. BH-3 core contains weathered charnockite and weathered pink granite (**Photo 1**). RQD is essentially poor in BH-4, except in intervals 7.00-11.00m.

Photo 1. Weathered Pink Aplite in BH-3

RQD is poor in BH-5 and the samples are fracture-ridden. BH-6 recorded weathering profile development up to 29.50m, followed by gneissic charnockite. BH-7 near Meppadi tunnel portal recorded weathering profile development up to 24.00m, a fracture zone at 24.00-24.20m, charnockitic gneiss-hornblende gneiss transition, granite-pegmatite intrusion and good RQD values.

Photo 2. Massive Charnockite with Occasional Greasy Patches, Fractured . Govt. Polytechnic College Compound, Meppadi

Charnockites occur mostly as medium to coarse grained, dark grey massive rocks with greasy appearance in certain outcrops (e.g. behind the Polytechnic College, Meppadi) (**Photo 2**) and in the core sample of BH-4, 10.00-11.00 interval (**Photo 3**). In certain sections in the bore holes, fine grained charnockite has also been observed. Transition of massive charnockite to charnockitic gneiss and gneissic charnockite is frequent as observed in the field and core samples (**Photo 4, 5**). This is observed in fracture zones and in contact with granitic/pegmatitic intrusions as well as in migmatisation epicentres. Banding in the gneissic variety is defined by parallel arrangement of pyroxene/hornblende/biotite layers and quartz-feldspar layers. Width of foliation layers is less in fine grained/medium grained varieties (up to 10mm apart).

Photo 3. Greasy Patches in Charnockite from Core Sample, BH-4.

Photo 4. Charnockitic gneiss in contact with fracture, Road cut Meppadi-Chooralmala road. Also note the weathered quartzite that has been fractured (post weathering)

Photo 5. Transition of massive charnockite to gneissic Charnockite in contact with neosome along fracture. Core sample BH-3A.

In charnockite-pegmatite interaction zones, large crystals of amphibole (8mm across) are observed in quartz-feldspar matrix (Photo 6). Garnet and specks of muscovite are seen in the gneissic part.

In charnockite, pyroxene is the main mafic mineral. Twinned plagioclase is dominant in charnockite samples. Quartz occurs in lesser amounts and K-feldspar is either subordinate or absent, and seen in contact with the intrusives (e.g.BH-7, 37.00-38.00 m interval). Other mafic minerals include hornblende and biotite. Transition of pyroxenes to hornblende and biotite is observed. Presence of garnet is noticed in outcrops and in core samples. Specks of muscovite have been observed in samples close to pegmatite veins. Coarsening of pyroxene/amphibole grains has been observed in contact with the intrusive phase, and the intrusive phase (neosome aplite veins) itself contains large crystals of hornblende (**Photo 6**).

Photo 6. Large Crystals of Amphibole in Quartz-feldspar Matrix (BH-7)

Mafic granulite: Charnockite gneisses in Wayanad are conspicuous by the presence of patches of pyroxene granulite (mafic granulite), seen coaxially folded or as thin bands/dykes with thicknesses ranging from 1 to 10 m (see **Figure 0-8, Photo 7**). Spatially, the occurrences in the study are located within the plateau landform unit. Investigations of mafic granulites from Manathavady, located to the north west of the study area by Ravindrakumar and Srikantappa (1989) indicated that they are two pyroxene granulites with equigranular granoblastic texture. Consisting of plagioclase (An 40-60 rarely up to An87), + orthopyroxene + augite ± garnet + hornblende + biotite, they formed at a pressure of 10.6 kb (gar-cpx barometer) -7.5kb (gar-opx1 barometer) and temperature of about 790º (gar-cpx)-817º C (gar-opx1). Retrogression mineral assemblages on uplift formed at 6.1 kb and 583º C within 'transitional granulite facies' conditions, followed by 'gradual uplift" that didn't alter core-rim compositions of geothermometer mineral garnet. (Also see **Section 0** for more details).

Photo 7. Two pyroxene Granulite (Darker Portion Close to the Wall) within Massive Charnockite. Location behind Govt. Polytechnic College, Meppadi.

Garnet-sillimanite-biotite±graphite gneiss, popularly known in India geological literature as "khondalite", has its presence as two small enclaves within the plateau region of the study area or in the interface of the plateau and the Highlands (see **Figure 0-8 & Figure 0-9**). Garnet, biotite, feldspars and sillimanite are the major minerals. Graphite and cordierite are also present in certain sections (Rvindrakumar and Srikantappa, 1989). Though this unit occurs as enclaves within charnockite gneiss in the study area, or as enclaves within the infolded core of the rocks of the "Sargur" equivalent Wayanad Group due to complex tectonics of the region, stratigraphically and geochronologically, it is younger than the charnockites as shown in southern Kerala and the Palghat Gap region.

Enclaves of quartzo-feldspathic gneiss in the study area must be related to the granitisation/migmatisation events (ref. **Figure 0-8**). In core samples, neosome injections constitute this unit (e.g. BH-8 ,8.50-9.50m interval, **Photo 8**). Petrographic investigations reveal presence of quartz, feldspars (both plagioclase and K-feldspar) , garnet and biotite in the leucosome. Biotite occurs in more than one generation. It is seen as elongated, mostly altered grains along garnet boundary with well-developed basal cleavage. Quartz occurs as long ribbon like grains showing evidence of corrosion and deformation. Plagioclase is seen as large subhedral crystals with characteristic polysynthetic twinning. Occasionally deformed twin lamellas are also noticed. K-feldspar has large subhedral to anhedral grains with cloudy appearance and undulous extinction (**Photos 9, 10**).

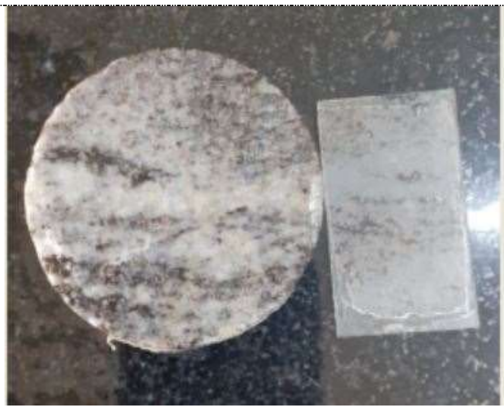


Photo 8. Core sample of Quartzo feldspathic Neosome (white), BH-8. Thin Section on the Right Side

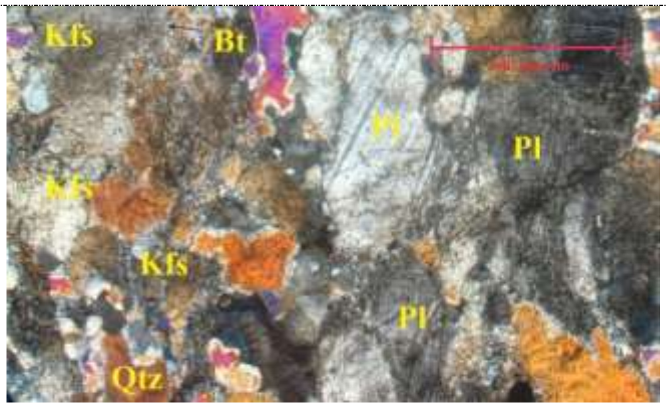


Photo 9. Microphotograph of leucosome, BH-8. Qtz-Quartz, Kfs-K-feldspar, Bt-Biotite, Pl-Plagioclase.

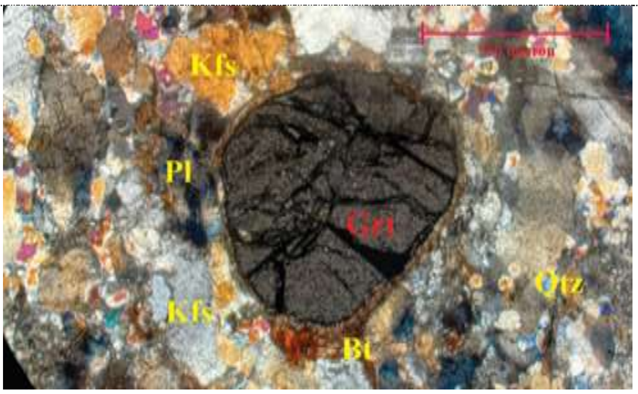


Photo 10. Microphotograph of Leucosome, BH-8. Grt-garnet. Garnet is Severely cracked, Deformed, Crushing of Minerals is also seen.

Garnet occurs as large porphyroblasts up to 12 micron size which is internally fractured and altered. The grains also host mineral inclusions of plagioclase and K-felspar, suggesting that garnet was assimilated from the host rocks (**Photo 10**).

Hornblende-biotite gneiss is the most prominent rock unit in the area after charnockite/charnockite gneisses. It consists of quartz, plagioclase, K-feldspar (pink), hornblende and biotite (**Photo 11**). It is a retrogression product of charnockites resulting from granitisation/migmatisation event in the area.

Photo 11. Transition of Charnockite (dark) to Hornblende-biotite Gneiss, BH-7, 37.00-38.00m Interval, Meppadi Portal.

Strike of foliation of the rocks shows much variation within the study area. It varies from N-S with steep dips to the west and east in the periphery, through E-W, NE-SW and NW-SE with steep dips (ref. Figure 0-8). Such variations are attributed to the inferred presence of a ring structure associated with granitisation/migmatisation event in the area.

Four sets of joints have been identified in tte area: (1) WNW-ESE with steep dips towards SSW, (2) sub-horizontal, (3) NNE-SSW to NE-SW with steep dips towards WNW and NW, (4 NW-SE dipping SW with steep dips. Width of joints space varies from a few mm (ref. **Photo.4 & 14**) to many cms, often facilitating percolation of weathering fluids and soil particles.

Lineament map prepared for the impact area using LISS III imagery indicates that the prominent sets of lineaments belong to NE-SW and NW-SE directions. ENE-SWS shears are also identified (**Figure 0-9**). Indicated fold axes testify to the complexity of folding in the area as manifested in swings of strike of foliation.

Granite:

The study area has outcrops of a granite body, namely the Kalpatta granite (**Figure 0-8**), besides a number of granitic injections noticed in the core samples. It occurs within hornblende-biotite gneisses. It is medium to coarse- grained grey biotite granite with sharp contacts with the country rocks. Enclaves of hornblende gneisses and amphibolites are observed within the granite body, especially towards the peripheries. The general feeble foliation defined by parallel arrangement of biotite is more pronounced near the contacts. Numerous veins of aplite and pegmatite of 5 to 15 cm width traverse the granite. The eastern contact of the granite is faulted, and three textural varieties, viz. porphyritic, coarse and fine-grained are distinguished (Anil Kumar et al. 1992).

The granite is composed of K-feldspar, plagioclase and quartz set in a hypidiomorphic granular texture. The dominant K-feldspar is microcline which is occasionally perthitic. Biotite is the dominant mafic mineral. Occasional grains of hornblende and accessory phases of sphene, apatite and zircon are the other minerals present. Secondary epidote and calcite are also seen (Nair et al. 1983).

This pluton is distinguished by its grey colour and the presence of biotite as the dominant mafic mineral. Age of the granite, based on zircon dating is 765 Ma (Odom, 1982), while K-Ar biotite age is 512±20 Ma (Nair et al. 1985). The latter is thought to be a thermally reset age, correlatable with the 500 Ma regional tectono-thermal event in south India.

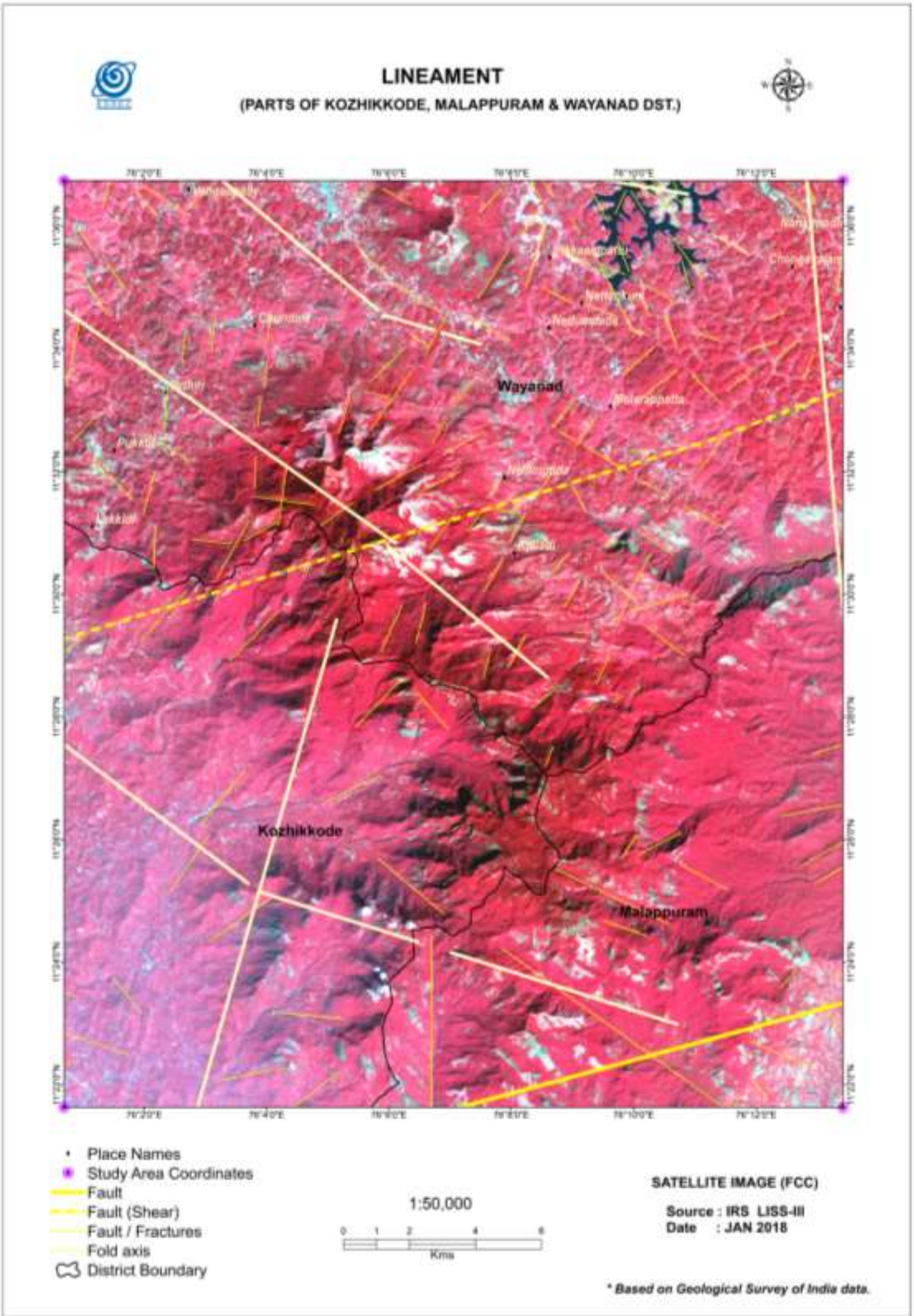


Figure 0-9. Lineament Map of the Study Area
(Source: Kerala State Remote Sensing Centre)

Ambalavayal Granite:

This granite body is located outside, but very close to the northern end of the impact area, and is intrusive into the hornblende-biotite gneiss and is of pink variety. It is spatially related to the Moyar lineament, and occurs as an E-W elongated body, covering an area of about 25 km^2. Perthitic K-feldspar and interlocking quartz constitute the dominant mineral phase, and sodic plagioclase occurs in subordinate amounts. Greenish hornblende and biotite are the mafic minerals. Sphene, epidote, monazite, apatite, calcite and Fe-Ti oxides are the accessory minerals. Disseminations of molybdenite have been reported in the granite, related pegmatites and quartz veins (Nair et al. 1985). Dating of the pluton yielded a Rb-Sr isochron age of 595±20 Ma (Santosh et al. 1986), with an initial 87Sr/86Sr ratio of 0.717±0.0022. This age is broadly correlatable with the K-Ar biotite age of 560±30 Ma (Nair et al. 1985) but higher than the U-Pb zircon age of 505±20 Ma reported by Odom (1982).

Dolerite Dyke:

NW-SE and NE-SW trending dolerite dykes are observed in the area (**Figure 0-8**). Another WNW-ESE to NW-SE trending dyke extending from adjacent Malappuram district appears continuing near the kachha road towards Thottayoram estate to the east of the proposed Meppadi portal area. Presence of large weathered boulders of fractured, fine grained , dark coloured dolerite dyke was observed there. Dolerite dyke is also encountered in BH-5, 13.00-14.50m interval (**Photo. 12**).

Photo 12. Dolerite intrusion in to charnockite, BH-5, depth interval 13.00-14.50m.

Weathering Profile:

Photo. 14. Weathering Profile Over Intensely Fractured Charnockite. Polytechnic College Compound, Meppadi. Note the colour variation from the previous profile.

Deep weathering profiles are noticed in the study area, especially in the northern part. This has reflection in the soil profiles also. Weathering profiles are diverse in appearance and content. Diversity of rock types and their composition, higher incidence of rainfall, intensity of vegetation , flatness of terrain, intense tectonics all have contributed to the above. Weathering profile is 29.50m deep in BH-6 (near the Anakkampoyil portal),

Photo. 13. Weathering Profile of Grey Colour Over Felsic Rock, road cut towards Puthumala.

while it is 24.00m in BH-7, near Meppadi, besides the overlying thick column of soil. Field observation in the Meppadi area suggests occurrence of deep weathering profiles of different hues (**Photo. 13, 14**).

Geomorphic Setting:

The most prominent geomorphological feature of the State is the Western Ghats, which is also one of the important orographical features of Peninsular India. A glaring characteristic landscape feature of the Western Ghats east of 75º55'near Kozhikode is the presence of Wayanad plateau at an elevation of 700-950 m above MSL. This surface has a general slope towards east and north east and merges with the Mysore plateau (900-1200 m above MSL). Landscape of Wayanad is thus important on account of the presence of Western Ghats and the Wayanad plateau. The study area comprises parts of the mountainous Western Ghats as well as parts of the Wayanad plateau, and thus emerges as an object of interesting geomorphic discourse (**Figure 0-10**).

The area is a rugged terrain in the central and southern extents, spreading over parts of Kozhikode, Wayanad and Malappuram districts and comprising Highlands and Mountainous peaks with deep gorges. The peak areas extend in a broad N-S direction, followed to the sides by the Highlands unit, abruptly merging with the plateau region. The plateau has undulations of erosional ouliers, representing another planation surface and indicating a rejunuvation cycle of the plateau. This is also evidenced by the presence of steep and narrow valleys. The plateau descends abruptly towards south west and east before merging with the Midlands topography consisting of a rolling terrain. With high incidence of rainfall, the terrain facilitates fast flowing streams, mostly towards the west.

Slope map of the study area was prepared using a classification by the ITC, Netherlands on the Triangulated Irregular Netwok (TIN) terrain model **(Figure 0-11**). The major landform units identified in the plateau and in the south western midland regions are *flat* surface (0-2% slope) with nil erosion proneness, *gently sloping* areas (2-7% slope) with possibility of low speed mass movement under fluvial conditions and *sloping* terrain (7-15% slope) with chances of severe erosion. Side slopes of ridges in the plateau region belong to *moderately steep* category (15-30% slope) with potential for creep, sheet wash, and occasionally landslips (see **Figure 0-10** & **Figure 0-11**).

The Highlands and Mountainous Peaks areas are characterised essentially by *steep* (30-70% sloe), *very steep* (70-140% slope) and *extremely steep* (>140% slope) categories of landform units. The steep category denotes the possibility of intensive denudational processes leading to creep, landslides and erosion under forest cover. *Very steep* category slope is associated with intense denudational processes, presence of incoherent scree deposits and rock outcrops. *Extremely steep* slope indicates presence of rock outcrops, wall denudation and danger of rolling stone.

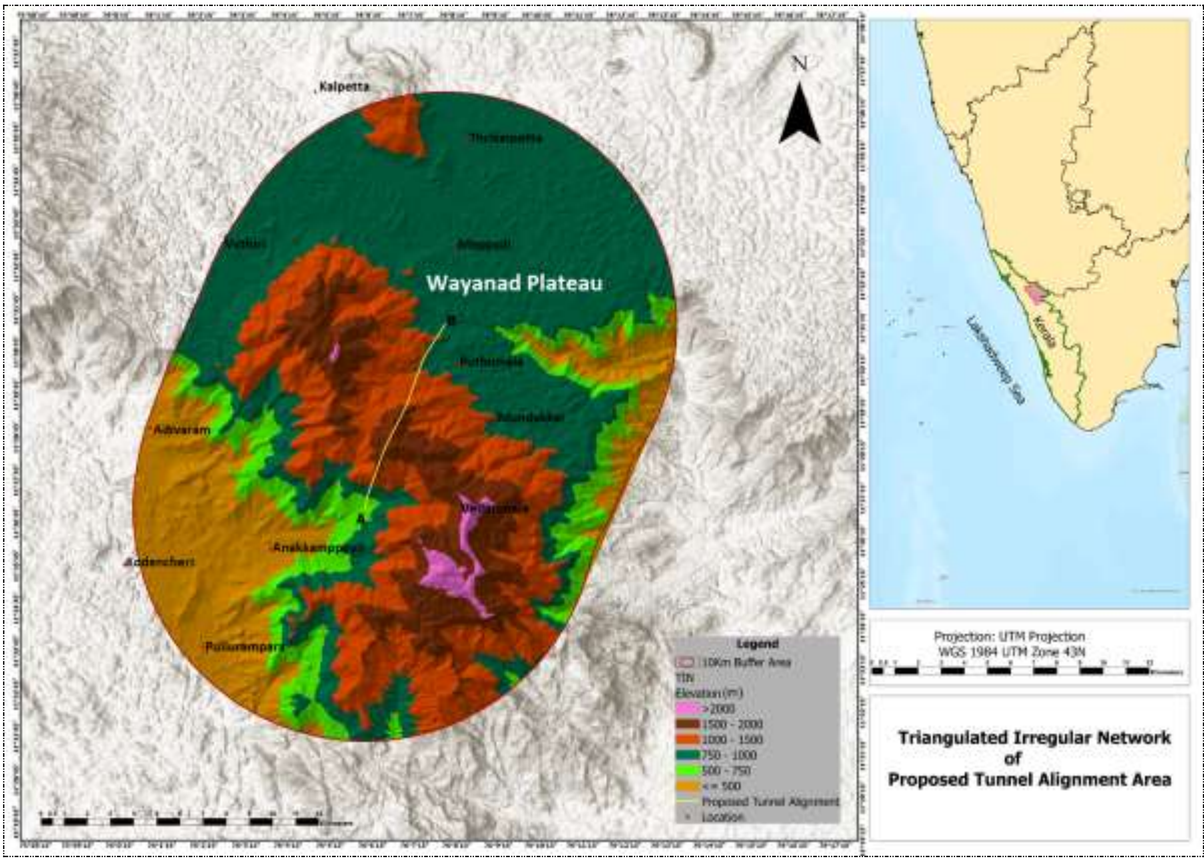


Figure 0-10. Triangulated Irregular Network of the Study Area

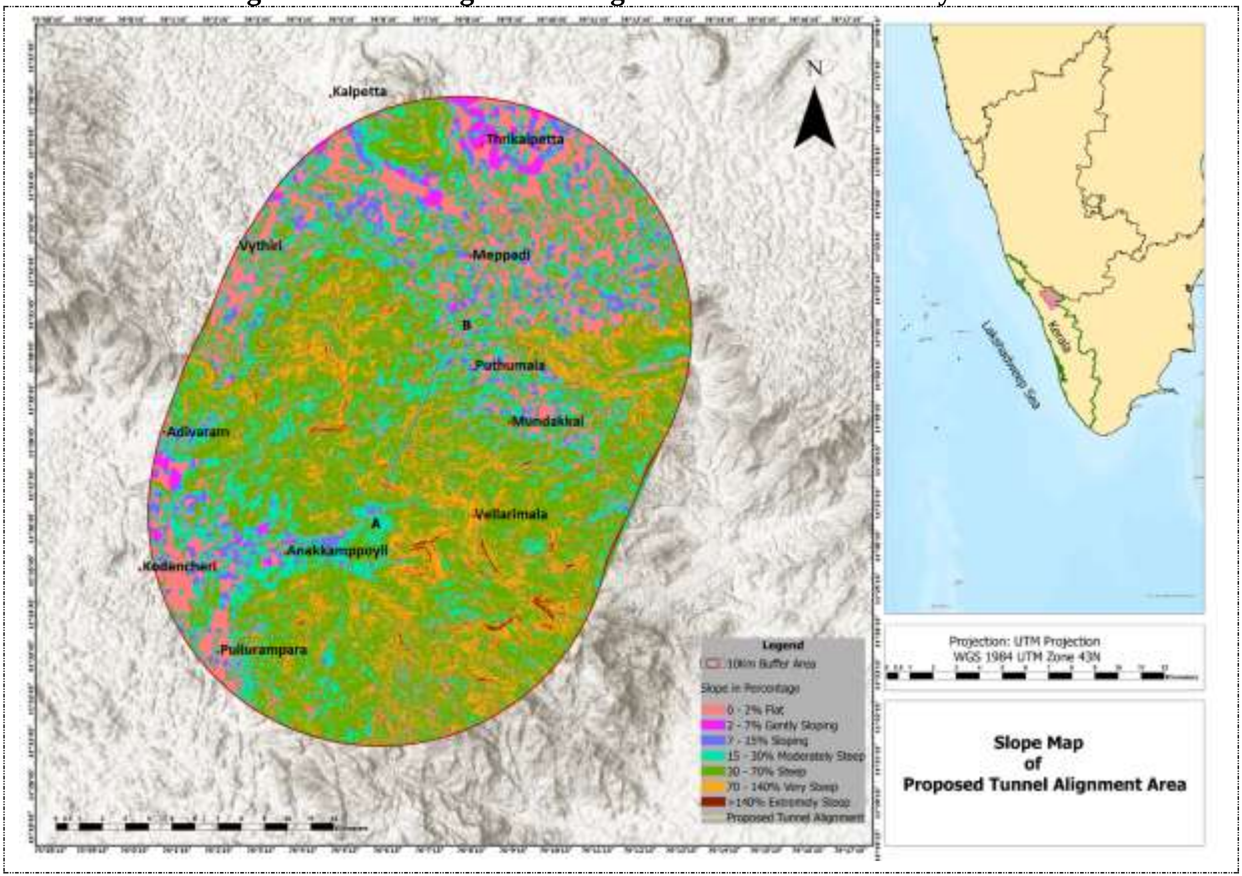


Figure 0-11. Slope Map of the Study Area

The proposed tunnel alignment passes under moderately steep, steep, very steep and extremely steep terrain categories (**Figure 0-11**). In the southern portal area, we could observe very steep slopes of rock outcrops with wall denudation and the potential danger of rolling stones (**Photo. 15**).

Photo . 15. Wall Denudation is Visible with the Potential Danger of Rolling Stones. Location Close to Anakkampoyil-Portal Site. .

The northern half of the tunnel alignment is characterised more by the presence of moderately steep and steep categories of slope, which are more prone to landslides.

Tunnel Overburden Sketch:

As per the Consultant report, the tunnel alignment at Anakkampoyil (A) starts at an elevation of 678.101m, and ends at Meppadi (B) at 851.485 m. Profile A-B was taken from the digitised contour map using GIS tool. Tunnel alignment was plotted on to the cross profile. The hatched area constitutes tunnel overburden. It consists of charnockite, charnockite gneisses, migmatisation products (granite, pegmatite, quartz veins), dolerite and possibly hornblende-biotite gneiss, quartzo feldspathic gneiss and garnet-sillimanite gneiss.. In the absence of subsurface data, it is difficult to speculate about any other rock units encountered in the district or in the region.

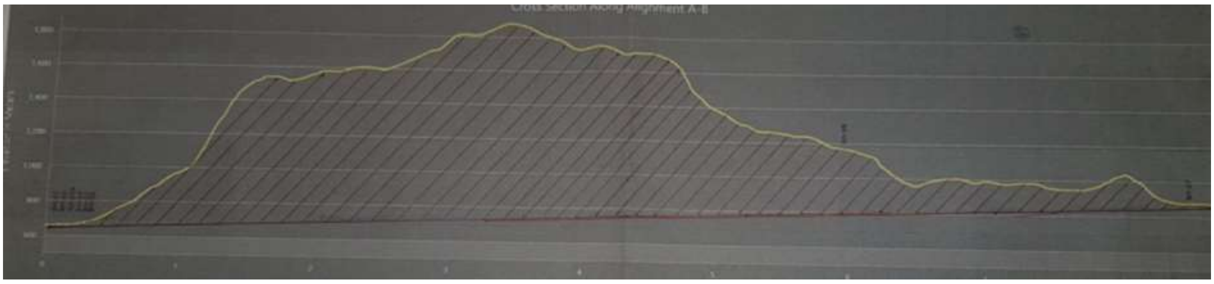


Figure 0-12. Cross-Profile Showing Tunnel Overburden

Seismicity:

According to the seismic zonation map of India, whole of Kerala State falls within Zone III, where earthquakes of magnitude up to 5.7 in Richter Scale and Modified Mercalli intensity up to VII can occur (Rastogi, 2001). The study area being part of the Western Ghats and the Wayanad plateau, tremors are a possibility and need to be reckoned with during and after construction of the tunnel. Seismic records maintained by NCESS, Thiruvananthapuram for the period 2000-2016 indicate that 8 tremors with magnitude ranging from 2.0 to 3.0 occurred in the adjoining areas, mostly in parts of Kozhikode and Malappuram districts, and one in the Kannur-Wayanad border (12/1/2003; magnitude 2.6).

7.4.4. Conclusions

The proposed tunnel passes under the Highlands and Mountainous Peaks physiographic units of the area. The impact area comprises the rugged terrain of the Western Ghats and parts of the Wayanad plateau. Geological features indicate presence of the oldest rocks reported from the State (rocks of the Wayanad Group), presence of mafic granulites metamorphosed under deep burial conditions and their later gradual uplift and charnockitisation. Subsequent granitisation events and associated migmatisation led to the formation of gneisses (gneissic charnockite/charnockitic gneisses), quartzo-feldspathic gneisses, retrogression products of hornblende±biotite gneisses, emplacement of granites, pegmatites, dolerite dykes and quartz veins. All these indicate a very complex and protracted geological history involving tectonic upheavals (at least 6 times or more). This has manifestation in the tectonic/structural features such as multiple folding events and fracture/fault formation. Petrographic investigations substantiate the deformation milieu. Crushing of minerals has been observed. Logging of rock samples from the drilled 8 bore holes indicate that Rock Quality Designation (RQD) values, a major consideration in tunnel design are broadly poor, warranting more detailed investigations of the tunnel overburden through Shallow Seismic Survey for fracture zones identification. Thick weathering profile development is characteristic of the terrain that may hold perched water table on the ground and some water pools feeding the wild life. Extent of that, and the seepage possibility during tunnelling needs elucidation. Electrical Resistivity Tomography survey with appropriate spacing/configuration of electrodes may be thought of.

Geomorphic features, a resultant of the geological processes, bring out the rugged nature of the terrain with steep, very steep and extremely steep slope categories and landform units. requiring precautions during the construction stage to avert vibration induced landslips.

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7.5. Natural Resource Conservation and Optimization

7.5.1. Introduction

As the human population is continuously growing, consumption of natural resources for various development projects is rising. It is essential to minimise the utilisation of natural resources through adopting sustainable development techniques. The objective of the conservation is the proper management of a natural resource to prevent its exploitation, destruction or degradation.

7.5.2. Steps Taken to Conserve the Natural Resource for the Sub- Project

7.5.2.1. Cutting of Tree for the Project

Only 177 trees are required to be felled from both forest land and private holdings for the proposed project. By proposing the alignment through tunnel will be minimum impact on forest flora and land use of the area. Due to proposal of tunnel in forest area help to save many of the well grown trees in forests area.

7.6. Blast Design (Management) Plan

Blast design is not a precise science. Because of widely varying properties of rock, geologic structure, and explosives, design of a blasting program requires field testing. Field testing is the best tool to refine individual blast designs.

Blast design plan should be decided keeping in mind that the following two overriding principles.

- Explosives function best when there is a free face approximately parallel to the explosive column at the time of detonation.
- There must be adequate space for the broken rock to move and expand. Excessive confinement of explosives is the leading cause of poor blasting results such as backbreak, ground vibrations, airblast, unbroken toe, flyrock, and poor fragmentation.

Properties and Geology of the Rock Mass

The rock mass properties are the single most critical variable affecting the design and results of a blast. The rock properties are very qualitative and cannot be sufficiently quantified numerically when applied to blast design. Rock properties often vary greatly from one end of a construction job to another. Explosive selection, blast design, and delay pattern must consider the specific rock mass being blasted.

Characterizing the Rock Mass

The keys to characterizing the rock mass are a good geologist and a good blasting driller. The geologist must concentrate on detailed mapping of the rock surface for blast design. The geologist should document the direction, density, and spacing between the joint sets. At least three joint sets—one dominant and two less pronounced—are in most sedimentary rocks. The strike and dip of bedding planes, foliation, and schistosity are also important to blast design and should be documented by the geologist. The presence of major zones of weakness such as faults, open joints, open beds, solution cavities, or zones of less competent rock or unconsolidated material are also important to blast design and must be considered. Samples of freshly broken rock can be used to determine the hardness and density of the rock.

An observant blasting driller can be of great help in assessing rock variations that are not apparent from the surface. A detailed drill log indicating the depth of these various conditions can be very helpful in designing and loading the blast. The log should be kept by the driller. The driller should also document changes in the color or nature of the drill cuttings which will tell the geologist and blaster the location of various beds in the formation.

Rock Density and Hardness

The density of the rock is a majorfactor in determining how much explosive is needed to displace a given volume of rock (powder factor). The hardness or brittleness of rock can have a significant effect on blasting results. If soft rock is slightly underblasted, the rock probably will still be excavatable. If soft rock is slightly overblasted, excessive violence will not usually occur. On the other hand, slight underblasting of hard rock will often result in a tight muckpile that is difficult to excavate. Overblasting of hard rock is likely to cause excessive flyrock and airblast. Blast designs for hard rock require closer control and tighter tolerances than those for soft rock.

Voids and Zones of Weakness

Undetected voids and zones of weakness such as solution cavities, “mud” seams, and shears are serious problems in blasting. Explosive energy always seeks the path of least resistance. Where the rock burden is composed of alternate zones of hard material, weak zones, or voids, the explosive energy will be vented through the weak zones and voids resulting in poor fragmentation. Depending on the orientation of zones of weakness with respect to free faces, excessive violence in the form of airblast and flyrock may occur. When the blasthole intersects a void, particular care must be taken in loading the charge, or the void will be loaded with a heavy concentration of explosive resulting in excessive air-blast and flyrock.

If these voids and zones of weakness can be identified and logged, steps can be taken during borehole loading to improve fragmentation and avoid violence. The best tool for this is a good drill log. The depths of voids and zones of weakness encountered by the drill should be documented. The geologist can help by plotting the trends of “mud” seams and shears. When charging the blasthole, inert stemming materials rather than explosives should be loaded through these weak zones. Voids should be filled with stemming. Where this is impractical because of the size of the void, it may be necessary to block the hole just above the void before continuing the explosive column.

Alternate zones of hard and soft rock usually result in unacceptably blocky fragmentation. A higher powder factor seldom will correct this problem; it will merely cause the blocks to be displaced farther. Usually, the best way to alleviate this situation is to use smaller blastholes with smaller blast pattern dimensions to get a better powder distribution. The explosive charges should be concentrated in the hard rock.

Jointing

Jointing can have a pronounced effect on both fragmentation and the stability of the perimeter of the excavation. Close jointing usually results in good fragmentation. Widely spaced jointing, especially where the jointing is pronounced, often results in a very blocky muckpile because the joint planes tend to isolate large blocks in place. Where the fragmentation is unacceptable, the best solution is to use smaller blast holes with smaller blast pattern dimensions. This extra drilling and blasting expense will be more than justified by the savings in loading, hauling, and crushing costs and the savings in secondary blasting.

7.6.1. Underground Blasting

Underground blast rounds are divided into two basic categories:

- Heading, drift, or tunnel rounds, where the only free face is the surface from which the holes are drilled
- Bench or stope rounds, where there is one or more free faces in addition to the face where the blast holes are drilled.

Opening Cuts

The initial and most critical part of a heading round is the opening cut. The essential function of this cut is to provide additional free faces where the rock can be broken. Although there are many specific types of opening cuts and the terminology can be quite confusing, all opening cuts fall into one of two classifications—angled cuts or parallel hole cuts. (**Figure 0-13**)

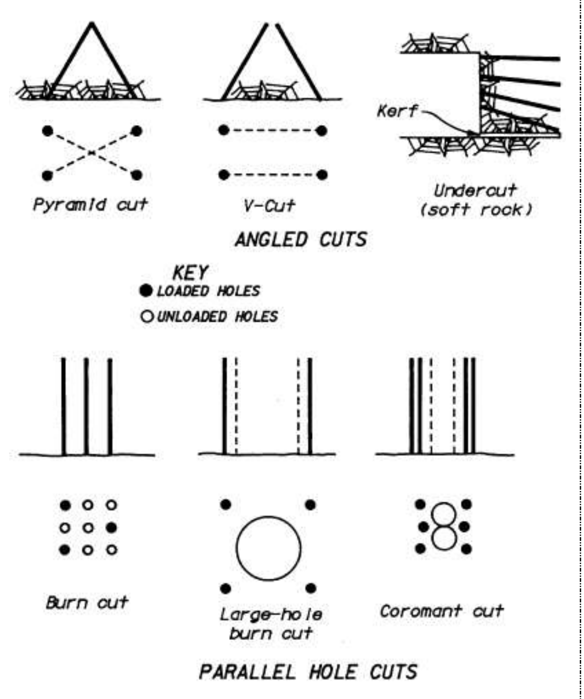


Figure 0-13. Types of Opening Cuts

An angled cut, also referred to as a V-cut, draw cut, slab cut, or pyramid cut, breaks out a wedge of rock to create an opening that the remaining burden can move into. Angled cuts are very difficult to drill accurately. The bottoms of each pair of cut holes should be as close together as possible but must not cross. If they cross, the depth of round pulled will be less than designed. If the hole bottoms are more than a foot or so apart, the round may not pull to the proper depth. The angle between the cut holes should be 60 degrees or more to minimize bootlegging. One method to ensure getting a standard angle cut is to supply the drillers with a template with the proper spacing and angles for the angled holes. The selection of the specific type of angled cut is a function of the rock, the type of drilling equipment, and the philosophy of the blasting supervisor. A considerable amount of trial and error usually is involved in determining the best angle cut for a specific site. In small diameter tunnels with narrow headings, it is often impossible to position the drill properly to drill an angled cut. In this case, a parallel hole cut must be used.

Parallel hole cuts, also referred to as Michigan cuts, Cornish cuts, shatter cuts, burn cuts, or Coromant cuts, are basically a series of closely spaced holes, some loaded and some unloaded (**Figure 0-14**) that, when fired, pulverize and eject a cylinder of rock to create an opening where the remaining burden can be broken. Because they require higher powder factors and more drilling per volume of rock blasted, the use of parallel hole cuts usually is restricted to narrow headings where there is not enough room to drill an angled cut.

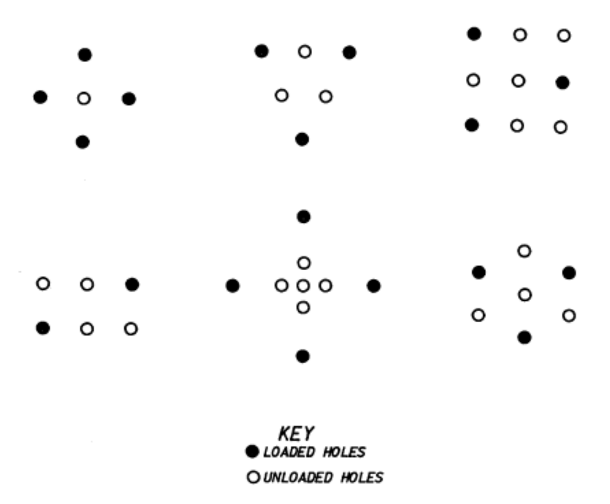


Figure 0-14. Six Designs of Parallel Hole Cuts

Parallel hole cuts involve more drilling than angled cuts because the closely spaced holes break relatively small volumes of rock. Parallel cuts are relatively easy to drill because the holes are parallel. Like angled cuts, accurately drilled parallel hole cuts are essential if the blast round is to be effective. Some drill jumbos have automatic controls to ensure that holes are drilled parallel. Drill jumbos of this type are a good investment where parallel hole cuts will be drilled routinely. A template also may be used in drilling a parallel hole cut. The selection of the type of parallel hole cut also depends on the rock, the type of drilling equipment, and the philosophy of the blasting supervisor. As with angled cuts, trial and error usually is involved in determining the best parallel hole cut for a specific site.

All types of opening cuts must pull to the planned depth because the remainder of the round will not pull more deeply than the opening cut. In blasting with burn cuts, care must be exercised to prevent overloading of the burn holes because overloading may cause the cut to "freeze" or not pull properly. The design of the cut depends on the type of rock and often must be designed and refined by trial and error.

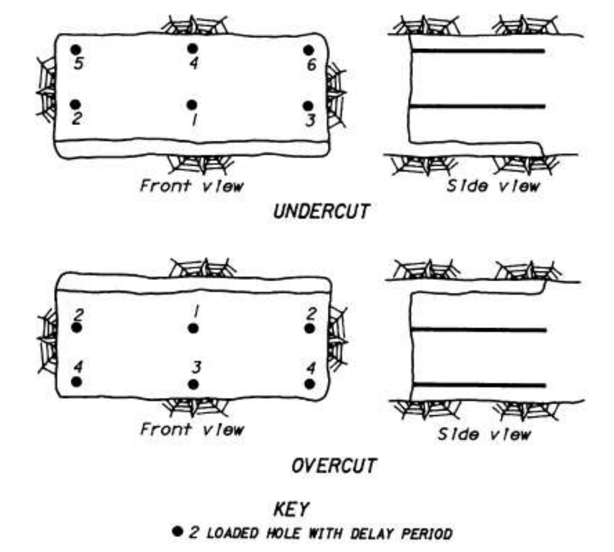


Figure 0-15. Blast Round for Soft Rock using Sawed Kerf

The advantage of a large central hole is that the hole gives a dependable free face where succeeding holes can break. This free face is not always obtained with standard burn cuts. The large central hole ensures a more dependable and deeper pull of the blast round. The disadvantages of a large central hole are the requirements for the proper equipment to drill the large central hole as well as extra time. Intermediate-sized holes, usually 4 to 5 inches (100-130 mm) in diameter, are sometimes drilled using the standard blast hole equipment as a compromise.

In some soft materials, particularly coal, the blasted cut is replaced by a sawed kerf, usually at floor level (**Figure 0-15**). In addition to giving the material a dependable void to break into, the sawed cut ensures that the floor of the opening will be smooth.

Blasting Rounds

Once the opening cut has established the necessary free face, the remainder of the blast holes must be designed so that the burden successively breaks into the void space. The progression of the blast round should provide a proper free face parallel or nearly parallel to the hole at its time of initiation. **Figure 0-16** gives the typical nomenclature for blast holes in a heading round.

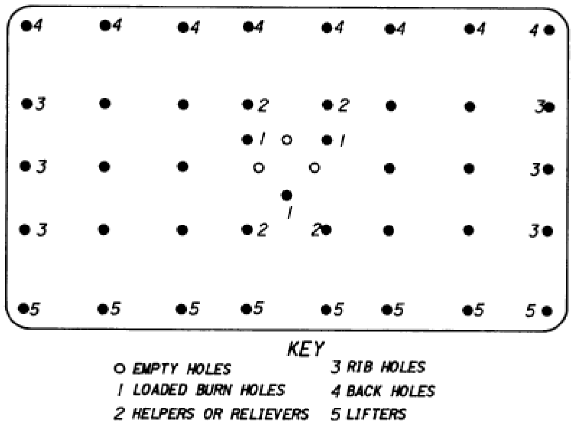


Figure 19-19.—Nomenclature for blast holes in a heading round.

Figure 0-16. Nomenclature for Blast Holes in a Heading Round

The holes fired immediately after the cut holes are called the relievers. The burden between these holes must be planned carefully. If the burden is too small, the charges will not pull their share of the round. If the burden is too large, the round may freeze because the rock will have insufficient space to expand. After several relievers have been fired, the opening usually is large enough to permit the remainder of the blast to be designed, as discussed under "Surface Blasting." Where heading rounds are large, the burden and spacing ratio usually is slightly less than that for surface blasts. In small headings where space is limited, the burden and spacing ratio will be still smaller. Trial and error plays an important part in this type of blast design.

The last holes to be fired in an underground round are the back holes at the top, the rib holes at the sides, and the lifters at the bottom of the heading. Unless controlled blasting is used (discussed below), the spacing between these perimeter holes is about 20 to 25 blast hole diameters. **Figure 0-17** shows two typical angled cut blast rounds. After the initial wedge of rock is extracted by the cut, the angles of the subsequent blast holes are reduced progressively until the perimeter holes are parallel to the heading or looking slightly outward. In designing burden and spacing dimensions for angled cut blast rounds, the location of the bottom of the hole is considered rather than the collar.

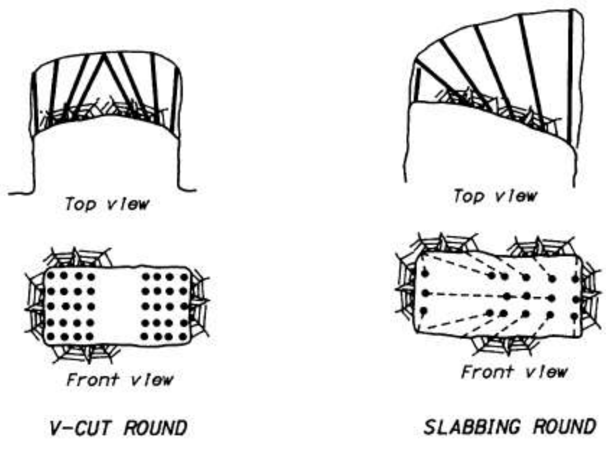


Figure 0-17. Angled Cut Blast Rounds

Figure 0-18 shows two typical parallel hole cut blast rounds. These rounds are simpler to drill than angled cut rounds. Once the central opening has been established, the round resembles a bench round turned on its side. **Figure 0-19** shows a comparison of typical muckpiles obtained from V-cut and burn-cut blast rounds. Burn cuts give more uniform fragmentation and a more compact muckpile than V-cuts. V-cut muckpiles are more spread out and vary in fragmentation. Powder factors and the amount of drilling required are higher for burn cuts.

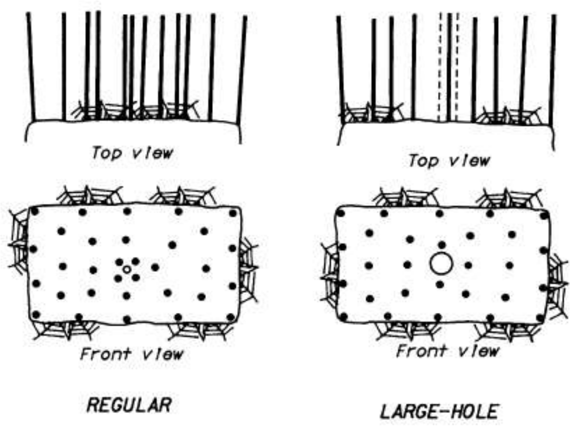


Figure 0-18. Parallel Holr Cut Blast Round

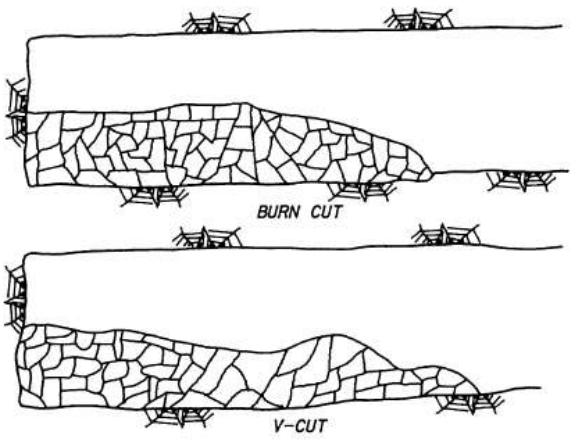


Figure 0-19. Fragmentation and Shape of Muckpile as a Function of Type of Cut

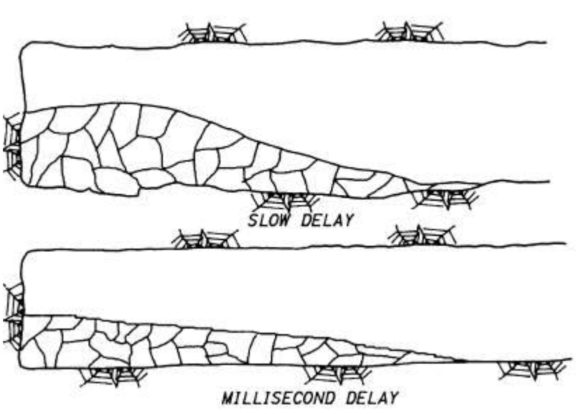


Figure 0-20. Fragmentation and Shape of Muckpile as a Function of Delay

Delays

Two series of delays are available for underground blasting—millisecond delays, the same as those used in surface blasting; and slow, or tunnel delays. The choice of delay depends on the size of the heading being blasted and on the fragmentation and type of muckpile desired. Slow delays give coarser fragmentation and a more compact muckpile. Millisecond delays give finer fragmentation and a looser muckpile (**Figure 0-20**). In small headings where space is limited, particularly when using parallel hole cut rounds, slow delays are necessary to ensure that the rock from each blast hole has time to be ejected before the next hole fires. Where delays intermediate between millisecond delays and slow delays is desired, use millisecond delays and skip delay periods.

In an underground blast round, the delay pattern must be designed so that at the time of firing each hole has a good free face where the burden can be displaced. **Figure 0-21** shows a typical delay pattern for a burn cut blast round in a heading in hard rock. **Figure 0-22** shows a delay pattern for a V-cut blast round.

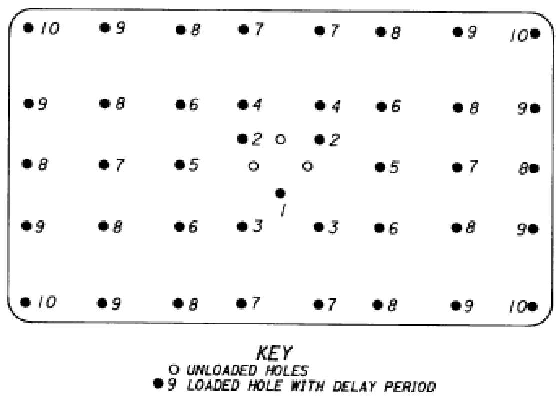


Figure 0-21. Typical Burn Cut Blast Round Delay Pattern

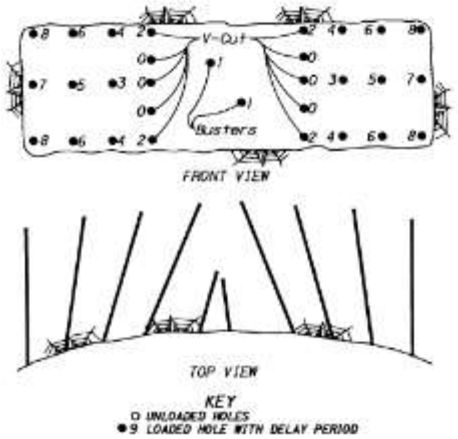


Figure 0-22. Typical V-Cut Blast Round Delay Pattern

Note: Numbers on loaded holes show delay in milliseconds

The shape of the muckpile is affected by the order that the delays are fired (**Figure 0-23**). If the blast is designed so that the back holes at the roof are fired last, a cascading effect is obtained, resulting in a compact muckpile. If the lifters are fired last, the muckpile will be displaced away from the face.

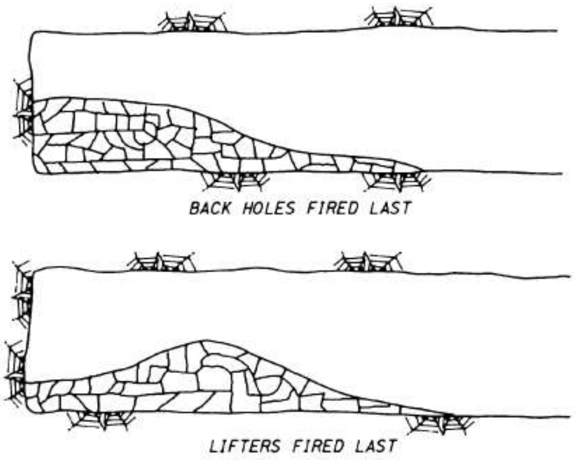


Figure 0-23. Shape of Muckpile as Function of Firing Order

Powder Factor

As with surface blasting, powder factors for underground blasting vary depending on several things. Powder factors for underground blasting may vary from 1.5 to 12 lb/yd^3 (0.7 to 5.5 kg/m^3). Soft, light weight rock, headings with large cross sections, large blast holes, and angle cut rounds all tend to require lower powder factors than hard, dense rock, small headings, small blast holes, and parallel hole cuts.

7.7. Muck Disposal Plan

7.7.1. General

The tunnelling shall result in large quantity of excavated material i.e. muck which shall have to be evacuated, disposed of and roller compacted or laid on mild slopes pari-passu with the excavation work, to such designated areas where the muck piles do not substantially interfere with either environment / ecology or the river flow regime and cause turbidity impairing the quality of water. In the present case, the total quantity of muck / debris, to be generated due to the project, shall be 1879865 Cum, to be disposed-off away so as to make available the clear site for tunnelling activities.

The disposal of muck has to be scientifically planned keeping in view the economic aspects necessitating nearness to the muck generating component of work, which understandably reduce the travel time of dumpers, less interference to surface flow and ground water aquifer and disposition of habitation.

Based on the quantities of underground excavation including 10% over break a muck management plan, therefore, has been formulated to manage the disposal of muck and restore such areas from further degradation of the environment. During construction of the project, huge quantities of excavation will be carried out from the underground and surface components and shall be dumped in designated areas to provide stable slopes.

7.7.2. Selection of Muck Disposal Site

The selection of muck disposal sites was carried out considering the quantity of the muck, landscape, cost effectiveness, nearness to source of generation, relief and scope for afforestation works. All the dumping locations shall be well supported at base and at higher elevation by suitable retaining structures. Subsequently all the spoil tips (muck disposal sites) will be developed by taking up plantation through bio-technological methods to generate a thick forest canopy over them. Three (3) muck dumping sites have been identified matching the criteria.

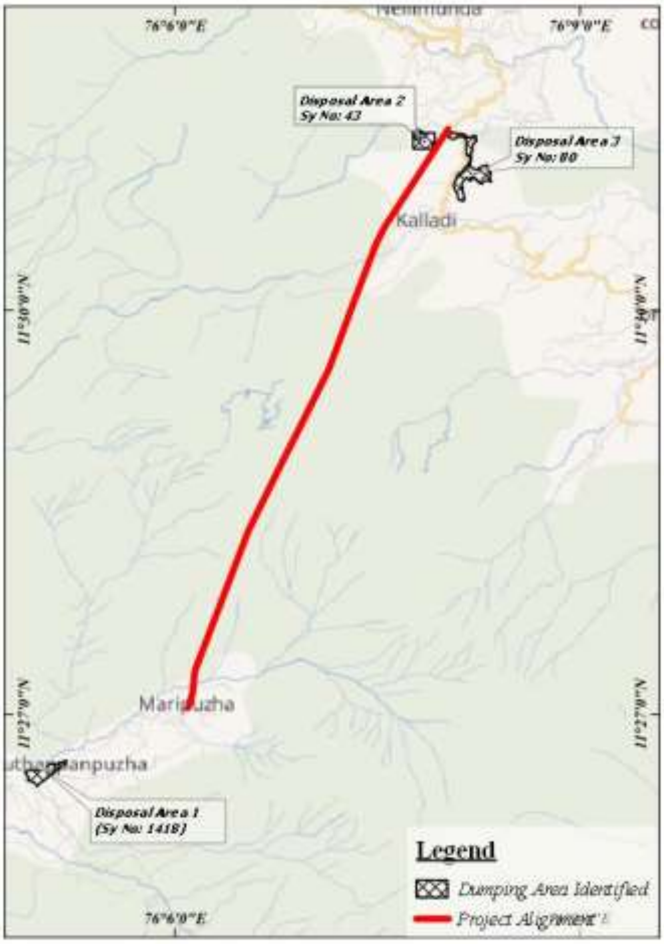


Figure 0-24. Location of Muck Disposal Sites

One site is identified at southern side of the project alignment and other two sites are identified at northern side.

Muck Disposal Site 1:

The proposed muck disposal site 1 is located at around 2 km towards south side of the project alignment. The identified site lies in between Anakkampoyil-Maripuzha road (MDR) and Iruvazhinjipuzha. Geographically the site lies 11°26'32.21"N latitude and 76°4'59.53"E longitude. The site is located approx. 50 m away from the river bank. Identified site is at Sy No. 1418 of Thiruvambadi Village, Thamarassery Taluk, Kozhikode district.

Muck Disposal Site 2:

The proposed muck disposal site 2 is located at around 0.25 km towards north west side of the project alignment. The identified site along the Estate Meenakshivilas Road. A small stream is located near to the proposed site. Geographically the site lies 11°31'15.94"N latitude and 76° 7'50.29"E longitude. Identified site is at Sy No. 43 of Vellarimala Village, Vythiri Taluk, Wayanad district.

Muck Disposal Site 3:

The proposed muck disposal site 3 is located near to the end point of project alignment. The identified site along the Meppadi-Chooralmala road. Meenakshi river is located near to the proposed site. Geographically the site lies 11°31'11.56"N latitude and 76° 8'10.85"E longitude. The site is located adjacent (approx.. 25 m) to the river bank. Identified site is at Sy No. 80 of Kottapadi Village, Vythiri Taluk, Wayanad district.

7.7.3. Implementation of Engineering & Biological Measures

As already explained engineering measures like providing retaining walls and compaction of muck will provide stability to the profile of muck piles. Later on, suitable top soil amended with bio-fertilizers shall be laid on top of muck piles and vegetated.

7.7.3.1. Engineering Measures

It has been observed that after excavation the disposal of muck creates problem as it is susceptible to scattering unless the muck disposal yards are supported with engineering measures such as retaining structures, crate walls and gabions. All the dumping sites need proper handling to avoid spilling of muck either on the adjoining and or into the river water while dumping and in the post dumping stages.

The muck disposal sites shall have to be developed from below the ground level by providing boulder wire crates of 5 SWG wire with 10 cm x 10 cm mesh size and in dimension 2.5m x 2.25 m x 3.0 m. It is proposed to provide three tiers of boulder wire crates with 2.5 m berm width. After placing of first tier of crates at the toe of muck disposal site, the muck brought in dumpers shall be dumped and manually spread behind the crates in such a manner that rock mass is properly stacked behind the crates with minimum of voids.The slope surface shall be developed by turfing. Intermediately wire crates shall also be erected to support dump material at different elevations in case of increased dump height.After construction of retaining wall, the muck brought in dumpers shall be dumped and manually spread behind the wall. The muck shall be laid with vertical angle not exceeding 400 in such a manner that rock mass is properly stacked behind the wall with minimum of voids. The typical cross section of gabion structure is shown in **Figure 0-25.**

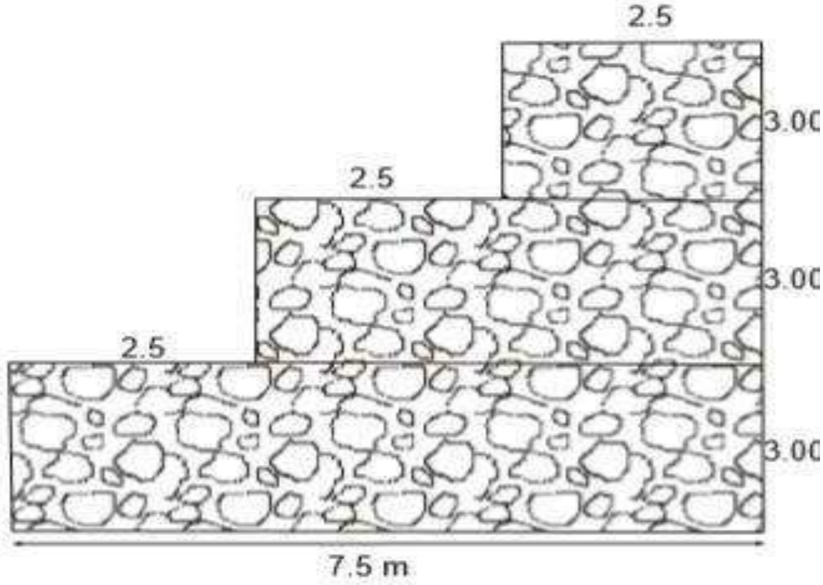


Figure 0-25. Typical Cross Section of Gabion Structure Provided at Toe

7.7.3.2. Biological Measures

Biological measures, however, require special efforts as the muck disposed in disposal yards will in general be devoid of nutrients and soil contents to support vegetation. The selection of soil for spreading over such an area would require nutrient profiling of soil for different base elements. The work plan formulated for revegetation of the dumping sites, through 'Integrated Biotechnological Approach', is based on following parameters: i) Evaluation of dumped material for their physical and chemical properties to assess the nutrient status to support vegetation. ii) Formulation of appropriate blends of organic waste and soil to enhance the nutrient status of rhizosphere. iii) Isolation and screening of specialized strains of mycorrhizal fungi, rhizobium, azotobacter and phosphate solubilizers (bio-fertilizers inoculum) suitable for the dumped material. iv) Mass culture of plant specific biofertilizer and mycorrhizal fungi to be procured from different institutions/organisations which are engaged in the phyto-remediation activity of degraded areas. v) Plantation of dumping sites/areas using identified blend and biofertilizer inoculum. Suitable ad mixture of nutrients would be done before placing the soil on the top surface of muck disposal areas to have administered growth of forest canopy.

7.7.3.2.1. Plantation Techniques

In view of the peculiar site conditions particularly the soil conditions, the planting technique for all the categories of the plants has to be very site specific and suited to the stress conditions as anticipated and discussed above. The planting substrates would need to be considerably improved to support the plants in their initial stages of establishment. The moisture retention capability, availability of nutrients and soil aeration, permeability and porosity would require intervention and assistance.

Multistoried and multipurpose plantations are proposed to be raised on the muck dumping sites as also in road side strips using grasses, shrubs and bushes in the under story and trees in the upper story. Nursery raised grass slips, seedlings of shrubs & bushes and tree species would be planted in the area combined with grass sowing in patches. In addition, cuttings of bushes and shrubs can also be planted to supplement the nursery raised stock but this would substitute requirement of raising the nursery of these species. Intimate mixture of species would be avoided right at the planning stage and would be strictly followed during planting. Each patch should contain maximum of two species. Grasses would be mixed by groups in rows, shrubs and bushes by group again in rows.

Grass slip planting and grass seed sowing would be done in strips at 0.10 m x 0.10 m spacing in the prepared staggered patches of 1 m x 0.5 m with a depth of 0.30 m. Soil mixture would be used while filling the patches. Balance dug up soil/muck will be stacked along the patch on the downhill side for rain water tapping and enhanced percolation in the patch. Number of such patches in each hectare is proposed at 500.

Shrubs and bushes would be planted in elongated strips of 1.5 m x 0.5 m with a depth of 0.45m. Soil mixture would be used while filling the patches. Balance dug up soil/muck will be stacked along the patch on the downhill side for water tapping and better percolation in the patch. These would be staggered throughout the area numbering 500 per hectare. Each patch would have two rows of planting with staggered spacing between plants in a row as 15 cm and distance between rows as 15 cm.

Planting of trees would be done in contour staggered pits of 0.60 m x 0.60 m x 0.60 m size numbering 800 per hectare. Out of these 800 plants, about 200 plants per hectare are meant for planting along the periphery of the area. If the periphery gets filled up with lesser numbers, the remainder would be planted in the core/main area. Soil mixture would be used while filling the pits. Balance dug up soil/muck will be stacked on downhill side of the pit for trapping the rain water and allowing it to percolate in the pit.

It is proposed to use soil mixture in the pits & patches consisting of soil imported from nearby areas mixed with compost or human or vermin-compost or all of these. The ratio for the mix would be 5 parts: Compost/manure 2 parts: Sand 2 part: and humus or vermin-compost 1 part. This will make nutrients really available for the plants in the preliminary stages and also help increase soil aeration, porosity & permeability and improved moisture available for the plants.

The stabilization sites from the time of execution of biological measures would be protected with barbed wire fencing on 2m high RCC posts and provided with inspection paths. Since the muck dumping sites are being provided with either RCC walls or the wire crate (gabion) wall on the valley side (towards river) which is not negotiable by animals and human beings, fencing would not be required along the entire perimeter. Hence, it would be done on the vulnerable sections i.e. towards the hillside only.

The proposed costs include nursery costs for initial planting and also for mortality replacement.

The biological measures shall be taken up towards the end of construction. The plantations would be maintained for a period of 5 years by irrigating the plantation during dry seasons, mortality replacement and repair of fencing & inspection paths within the area. The task of irrigation would be performed by the watch & ward provided in the cost estimate.

7.7.3.2.2. Species for Plantation

The afforestation with suitable plant species of high ecological and economic value and which can adapt to local habitat will be undertaken.

The heaps of spoils dumped at the muck dump yards may be leveled and arranged in a terraced manner; the mounds thus formed at the yards are expected to have an average height of about 5.0 m. Peripheral areas of the mounds may be strengthened by pitching using rubble of convenient size, and to avoid leaching during rains peripheral trenches shall be developed. It is important not to block any natural drainage while designing the above. Though the spoils from construction sites lack nutrients, it is important to grow indigenous/acclimatized species of grasses (e.g. Vetiver/Ramacham; Bermuda grass/Karuka; Sowrd grass/Darbha), legumes (e.g. Thottappayar) and bushes (e.g. Sacred Ixora/Thechi) on them initially with appropriate use of geo-textiles, and introducing saplings of trees subsequently. The trees, shrubs and grasses, which could be considered planting on the mounts are summarized in **Table 0.12.**

Table 0.12. Plants to be Considered Planting on Terraced Mounts of Muck Dump Yard

Sl. No.	Scientific Name	Common / Local Name	Habit
1.	*Ancistrocladus heyneanus*	Mpthiravalli	Climber
2.	*Bauhinia purpurea*	Chuvanna-mandaram	Tree
3.	*Bombax insigne*	Kallilavu, Silk cotton tree	Tree
4.	*Butea monosperma*	Chamatha	Tree
5.	*Cassia fistula*	Kanikkonna	Tree
6.	*Cynodon dactylon*	Bermuda grass/Karuka	Grass
7.	*Ficus callosa*	Kallal, Kadaplavu	Tree
8.	*Ficus racemosa*	Athi,	Tree
9.	*Gmelina arborea*	Kumbil, Kumizhu	Tree
10.	*Impereta cylindrica*	Darbha, Sowrd grass	Grass
11.	*Ixora coccinia*	Thechi, Sacred Ixora	Shrub
12.	*Melia azedarach*	Malaveppu	Tree
13.	*Mucuna brachiata*	Thottappayar	Climber
14.	*Pithecellobium dulce*	Manila tamarind	Tree
15.	*Pongamia pinnata*	Pongu, Ungu	Tree
16.	*Holarrhena pubescence*	Kudakappala	Shrub
17.	*Vetiveria zizanioides*	Ramacham, Vetiver,	Grass
18.	*Cippadessa baccifera*	Kaipanarangi	Shrub
19.	*Helicteres isora*	Idampiri-valampiri	Shrub
20.	*Chrysopogon hackelii*		Grass
21.	*Chrysopogon aciculatus*	Snehappullu, Love grass	Grass

7.7.4. Cost Model for Plantation

The cost model for plantation on muck dumping sites is given in **Table 0.13.**

Table 0.13. Cost Model for Plantation on Muck Dumping Sites (For One-hectare Area)

S. No	Particular	Qty.	Unit	Rate (Rs.)	Amount (Rs.)
A.	**PALANTATION:**				
I	**GRASS SLIP PLANTING AND GRASS SEED SOWING:**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	75	Cum.	850.00	63750.00
2	Digging of staggered patches 1 m x 0.50 m x 0.30 m @ 500 patches/ha.	75	Cum.	50.00	3750.00

S. No	Particular	Qty.	Unit	Rate (Rs.)	Amount (Rs.)
3	Filling of staggered patches with imported soil mixture.	75	Cum.	15.00	1125.00
4	Extraction of grass slips from nursery beds @ 50 slips per patch.	25000	Per Slip	0.12	3000.00
5	Carriage of grass slips from nursery to work site.	25000	Per Slip	0.15	3750.00
6	Planting of the extracted grass slips in above patches @ 50 slips per patch.	25000	Per Slip	0.18	4500.00
7	Cost of grass slips (in nursery).	25000	Per Slip	0.50	12500.00
8	Purchase of grass seeds @ 5 gm. Per patch.	2.5	Kg.	115.00	287.50
9	Sowing of grass seeds in furrows in each patch.	500	Patch.	2.50	1250.00
TOTAL					**93912.50**
(II)	**SHRUBS AND BUSHES PLANTATION:**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	169	Cum.	850.00	143,438.00
2	Digging of elongated patches 1.5 x 0.50 m x 0.45 m @ 500 patches/ha.	169	Cum.	50.00	8,438.00
3	Filling of elongated patches with imported soil mixture.	169	Cum.	15.00	2,531.00
4	Extraction of shrubs & bushes from nursery beds @ 50 per patch.	25000	Per plant	0.15	3,750.00
5	Carriage of shrubs & bushes from nursery to work site.	25000	Per plant	0.15	3,750.00
6	Planting of the extracted shrubs & bushes un above patches @ 50 per patch.	25000	Per plant	0.20	5,000.00
7	Cost of shrubs & bushes (in nursery).	25000	Per plant	1.00	25,000.00
TOATL					**191,907.00**
(III)	**FOUR LINE STRIP PLANTATION (TREE SPECIES):**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	18	Cum.	850.00	15491.25
2	Digging of pits (45cm x 45cm x 45cm) in periphery of area.	200	No.	4.45	890.00
3	Filling of pits (45cm x 45cm x 45 cm) with imported soil mixture.	200	No.	1.27	254.00
4	Extracted of plants from nursery beds.	200	No.	0.25	50.00
5	Carriage of plants from nursery to the work site over average distance of 10 km uphill carriage.	200	Nos. per km	0.17	34.00
6	Planting of extracted plants in above pits including ramming.	200	No.	0.86	172.00
7	Mulching of plants with grass.	200	No.	0.28	56.00
8	Cost of plants (in nursery).	200	No.	1.00	200.00
TOTAL					**17147.25**

S. No	Particular	Qty.	Unit	Rate (Rs.)	Amount (Rs.)
(IV)	**PLANTATION OF TREE SPECIES IN BLANK AREA:**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	55	Cum.	850.00	46474.00
2	Digging of pits (45cm x 45cm x 45cm) for B/L plantation.	600	No.	4.45	2670.00
3	Filling of pits (45cm x 45cm x 45cm) for B/L plantation with imported soil mixture.	600	No.	1.27	762.00
4	Extraction of plants from nursery beds.	600	No.	0.25	150.00
5	Carriage of plants from nursery to the work site over an average distance of 10 Km uphill carriage.	600	No. per km	0.17	1020.00
6	Planting of B/L plants in pits including ramming.	600	No.	0.86	516.00
7	Mulching of B/L plants with grass.	600	No.	0.28	168.00
8	Cost of plants (in nursery).	600	No.	4.00	2400.00
TOTAL					**54160.00**
(V)	**MAINTENANCE:**				
1	1st year maintenance.	1	Ha.	4000.00	4000.00
2	2nd year maintenance.	1	Ha.	3600.00	3600.00
3	3rd year maintenance.	1	Ha.	3200.00	3200.00
4	4th year maintenance.	1	Ha.	2800.00	2800.00
5	5th year maintenance.	1	Ha.	2000.00	2000.00
6	Watch and ward of plantation for 5 years (60 months @ 1000/=) including irrigation during lean seasons.	1	Ha.	1000.00	60000.00
TOTAL					**75600.00**
SUBTOTAL					**432726.75**
B.	**SOIL CONSERVATION:**				
1	**Construction of gulley plugs, small check walls/dams etc.**	**LUMPSUM**			**50000.00**
GRAND TOTAL (A) + (B)					**482,726.75**

7.7.5. Cost Estimate for Muck Management Plan

Since the cost excavation, transportation and dumping of muck at the designated dump yards are envisaged in the project cost, the present cost estimation is restricted to stabilization measures mentioned above, and thus an amount of Rs. 59.27 Lakhs may be set apart. The cost estimate for muck management plan indicating engineering, biological, bio-technological measures and maintenance is provided in **Table 0.14**.

Table 0.14. Cost Estimate for Muck Management Plan

Sl. No	Particulars	Quanity	Unit	Rate (Rs.)	Amount (Rs. lakh)
A. Engineering Measures					
1	Construction of Gabion wall around the disposal site (350m x 300m)	37800	Cum	Included in Engineering Cost	

Sl. No	Particulars	Quanity	Unit	Rate (Rs.)	Amount (Rs. lakh)
Total					
B. Biological Measures					
1	Plantation of muck disposal sites	10	ha	482,726.75	48.27268
2	Barbed wire fencing on 2m high RCC posts	10	ha	50000	5
3	Watch & ward 1 no. @ Rs. 10000 p.m. for 5 years	60	month	10000	6
Total					**59.27**

7.8. Risk Analysis and Disaster Management Plan

The objective of the Risk Analysis Study is to identify potential credible hazards arising out of the facilities that handle, process, store and transport of hazardous substances, to mitigate severity and to aid in preparing effective emergency response plans by delineating a disaster management plan to handle onsite and offsite emergencies. The methodology followed in Risk Analysis for proposed tunnel road is presented in **Figure 0-26.**

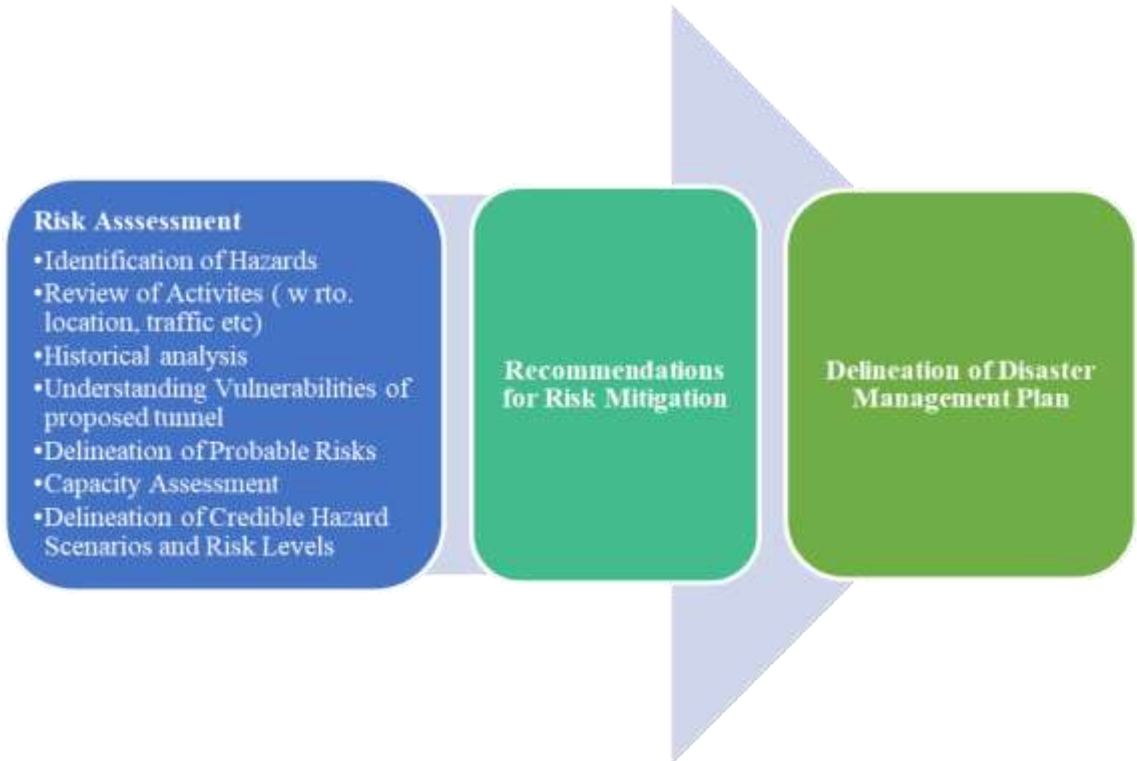


Figure 0-26. Methodology for Risk Assessment for Proposed Tunnel Project

7.9. Risk Assessment

Risk assessment is a process that seeks to estimate the likelihood of occurrence of adverse effects as a result of major road mishaps, gas tanker explosions, fire hazards, floods, landslides. earth quakes etc. at road projects. Fatality rate on Indian highways is very high mainly due to road accidents. The other adverse impacts due to gas tanker explosions, fire hazards, floods, landslides, earth quakes etc. are nominal. Elimination of the risk (avoidance of accidents) is given prime importance and KPWD has introduced road safety provisions during the design of highway with the help of Road Safety Manual.

Contractor shall conduct Risk Assessment for all works to decide on priorities and to set objectives for eliminating hazards and reducing risks.

The project activities involve certain types of hazards, during construction and operation, which can disrupt normal activities abruptly and lead to disaster like fires, failure of machinery, explosion, to name a few. The impending dangers or risks, which need to be investigated addressed, disaster management plan formulated with an aim to taking precautionary steps to avert disaster and to take such action after the disaster, which limits the damage to the minimum. Following problem may be encountered during construction at the project site.

- Accidents due to explosives/blasting
- Failure of stripped slope.
- Accidents due to HEMM
- Sabotage in case of magazine
- In order to take care of above hazards/disasters, the following safety measures will be strictly complied with in the current project:
- Handling of explosives, charging and blasting shall be carried out by competent persons only.
- Provision of magazine at a safe place with proper fencing and necessary watch and ward. Adequate safety equipment will be provided at magazine and project site.
- Regular maintenance and testing of all project equipment/machinery and transport vehicles as per manufacturers guidelines
- Entry of unauthorized persons will be prohibited
- Firefighting and first–aid provisions in the project office/complex and project area and ensuring periodic checking of worthiness of firefighting and first aid provision.
- Training and refresher courses for all the employees working in hazardous points. All employees shall have to undergo the training at a regular interval.
- As a part of disaster management plan, a rescue team will be formed by imparting specialized training to select project staff.

7.9.1. Risk Assessment Process and Hazard Identification

A critical observation/study of the structure/process/site under consideration by the risk assessment team is an essential part of hazard identification as is consultation with the relevant section of the workforce. It is important that unsafe conditions are not confused with hazards, during hazard identification.

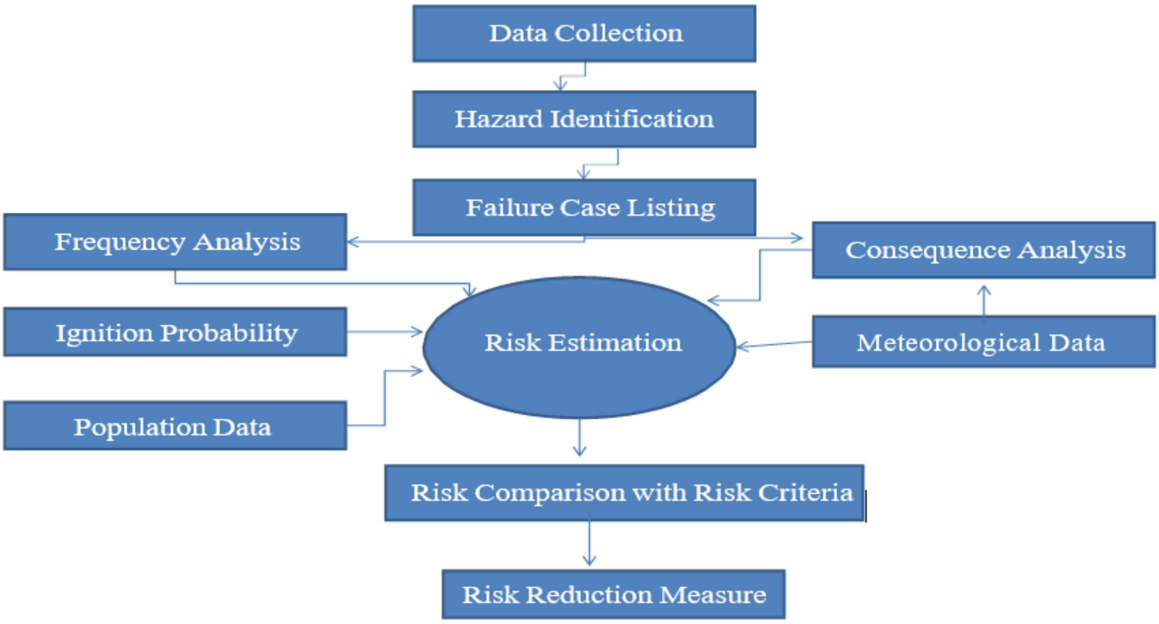


Figure 0-27. Riak Assessment and Hazard Identification for Proposed Tunnel Project

7.9.2. Person(s) at Risk

On a construction / plant area, the persons at risk could be site operatives, supervisors, transport drivers, other visitors and the general public. The risk assessment must include any additional controls required due to mitigate vulnerability of any of these groups, perhaps caused by inexperience or disability.

7.9.3. Risk Control Measures and Hierarchy of Risk Control

The next stage in the risk assessment is the control of the risk. When assessing the adequacy of existing controls or introducing new controls, a hierarchy of risk controls should be considered. The principles are:

- Avoiding risks.
- Evaluating the risks which cannot be avoided.
- Combating the risks at source.

Adapting the work to the individual, especially as regards the design of the workplace, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work rate and to reducing their effects on health.

Adapting to technical progress

Replacing the dangerous by the non-dangerous or the less dangerous. Developing a coherent overall prevention policy which covers technology, organization of work, working conditions, social relationships and the influence of factors relating to the working environment.

Giving collective protective measures priority over individual protective measures and giving appropriate instruction to employees.

In addition to the above the following principles shall also to be employed:

- Eliminating;
- Substitution;
- Applying engineering controls (e.g. isolation, insulation and ventilation);
- Reduced or limited time exposure;
- Good housekeeping;
- Safe systems of work, Method Statement, Permit to work,
- Training and information;
- Personal protective equipment;
- Welfare;
- Monitoring and supervision;
- Review

The purpose of the risk assessment, therefore, is to reduce the remaining risk after taking into consideration of risks already addressed. This is called the residual risk.

The goal of risk assessment is to reduce all residual risks to as low as reasonably practicable (ALARP).

In a relatively complex workplace, this will take time so that a system of ranking risk is required the higher the risk level the sooner it must be addressed and controlled. For most situations, an alliterative risk assessment will be perfectly adequate.

For all high-risk activities, a quantitative risk assessment shall be conducted to quantify the risk level in terms of the likelihood of an incident and its subsequent severity. Clearly the higher the likelihood and severity, the higher the risk will be. The likelihood depends on such factors as the control measures in place, the frequency the exposure to the hazard and the category of person exposed to the hazard.

The severity will depend on the magnitude of the hazard (e.g. voltage, toxicity etc.). A simple of 3 x 3 matrix shall be used to determine risk levels at Construction / erecting sites as given in the Project EHS manual.

7.9.3.1. Matrix for Risk Assessment

Table 0.15. Consultations with Community / Primary Stakeholders

Probability		Consequences				
		1	2	3	4	5
	1					
	2					
	3					
	4					
	5					

7.9.3.2. Severity of Hazard (Consequences)

Severity is the degree or extent of injury or harm caused by the hazards, or as a result of an accident. Severity of hazard is classified as per the table given below.

Table 0.16. Consequence Descriptions

Value	Result of Hazard to personnel	Result of Hazard to Assets/Progress
5	Single or multiple fatality	Catastrophic damage, Critical Delay, May result in fatality
4	Serious Injury requiring hospitalization	Major Damage, Serious Delay
3	Lost time Accident	Serious Damage, Moderate Delay
2	Injury requiring medical treatment but not lost time	Moderate Damage, Minor delay
1	First Aid Treatment Only	Minor Damage, No Delay

7.9.3.3. Likelihood of Occurance (Probability)

Likelihood of occurrence of an accident or incident or ill health is classified as per the table given below.

Table 0.17. Classification of Occurrence of likelihood

Value	Status	Description
5	Inevitable	Happens regularly on this site
4	Most Likely	Known to have occurred on this site in the past
3	Likely	Known to occur on other sites
2	Unlikely	Known to Occur in the industries
1	Most Unlikely	Never known before

7.9.3.4. Hazard Identification Risk Assessment

The procedure for preparing the Hazard Identification Risk Assessment is as follows:

Risk involved in each activity and existing control measures are analyzed and Impact Rating and probability rating are given in Hazard Identification Risk Assessment sheet.

Risk level is identified from the matrix based on the rating given.

Control measures are evolved to bring the risk level to ALARP (as low as reasonably practicable and residual risk is also identified.

If the residual risk is not an acceptable level, then assessment process shall be repeated to bring the residual risk at ALARP.

This activity is done for activities identified as Medium & High Risk.

The lists of control measures for the activities are handed over to the concerned execution engineer for implementation and the HIRA shall be explained to the concerned workmen/supervisors and engineer for implementation.

7.9.4. Emergency Reponse Plan

Concessionaire/Contractor will prepare Emergency Response Plans for all work sites as a part of the Safety procedures. The plan shall integrate the emergency response plans of the contractor and all other sub-contractors.

Each Emergency Response Plan shall detail the procedures, including detailed communications arrangements, for dealing with all emergencies that could affect the site. This include where applicable, injury, sickness, evacuation, fire, chemical spillage, severe weather and rescue. Emergency plans and Fire Evacuation plans shall be prepared and issued. Mock drills shall be held on a regular basis to ensure the effectiveness of the arrangements and as a part of the programme, the telephone number of the local fire brigade should be prominently displayed near each telephone on site.

The Emergency Response Plan is prepared to deal with emergencies arising out of:

7.9.4.1. Fire and Explosion

Fire Safety Procedures will be developed and shall be integrated into Emergency Response Plan.

7.9.4.2. Road Accidents

In case of Road Accident the following contact no should be contacted.

Table 0.18. Helpline Numbers

Description	Help Line No
Police station	100
Police Helpline	0471-324 3000/4000/5000
Police Message Centre	94 97 900000
Police High Way Help Line	9846 100 100
Fire Station	101
Ambulance	108
Women Helpline	1091 , 181
Crime Stopper	1090
Highway Alert	9846100100
Flood / Disaster Helpline	1070 , 1077
DISHA Helpline (Health)	1056
Government Contact Centre-Kerala (Citizen's Call Centre)	0471-155300 0471- 2335523
Kozhikode Rural Police Control Room	0496-2523091
Wayanad Police Control Room	04936-205808
Kozhikode District Emergency Numbers	District Collector - 0495-2371400, 233370582, 238350, 9447171400 District Emergency Operation Center, Kozhikode – 0495 2371002
Wayanad District Emergency Numbers	District Collector - 0493-6202230,6203450,6202300 District Emergency Operation Center, Wayanad – 04936 204151

7.9.5. Operation Control Procedure for Traffic Management

7.9.5.1. Hazards Due To External Traffic

- Construction workers hit by external vehicles while working.
- Injury to Pedestrians:
- Due to fall in excavated trenches.
- Hit by construction equipment / vehicle.
- As they use carriageway due to blockage / absence of footpath.

- Collision due to improper traffic management.
- Between external vehicle and construction equipment / vehicle.
- Between external vehicles.
- External vehicle with other stationery objects in the side of the road

7.9.5.2. Objectives

- Warn the road user clearly and sufficiently in advance.
- Provide safe and clearly marked lanes for guiding users.
- Provide safe and clearly marked buffer and work zones.
- Provide adequate measures that control driver behaviour through construction zones

7.9.5.3. Traffic Control Plan

This plan gives the detailed guideline for traffic management in most of the common situations at our Projects. Traffic Control Plan should be prepared based on this general guideline and applying the following variables, which may vary from project to project. The variables are:

- Average Vehicular Traffic Density in peak and non-peak hours.
- Maximum width of lane required for construction during various activities.
- Availability of standard footpath and its location and dimensions.
- Change in the lane width if any and its location.
- Regulatory and advisory speed limits etc.

Traffic control devices used to regulate the traffic in Road Construction Zones include,

- Road Signs
- Delineators
- Barricades
- Cones
- Pylons
- Pavement markings
- Flashing lights

Cautionary / Warning Signs

In case of divided carriageways, the signs should be provided both adjacent to the shoulder and on the central median so as to be visible from all lanes.

Delineators

Delineators are devices or treatment which outlines the roadway or portion thereof. They include Safety Cones, Traffic Cylinders, Tapes, Drums, Painted lines, Raised Pavement Markers, Guide Posts, and Post-mounted Reflectors etc. They are used in or adjacent to the roadway to control the flow of traffic. Delineators are basically driving aids and should not be regarded as a substitute for warning signs or barriers for out-of-control vehicles.

Guide Post

They are intended to delineate the edges of the midway so as to guide driven about the alignment ahead, particularly where it might be confusing. Guideposts can be of metal, concrete, cut stone, amber or plastic. The posts can be made of Circular, Rectangular or Triangular Cross-section but the side facing traffic should be at least 10 cm wide.

Drums

Drums of height 800 mm to 1000 mm high and 300 mm in diameter can be used as either channelizing on warning devices. Both plastic and metallic drums (e.g. Bitumen drums) can be used for this purpose. Drums need to be filled up with earth or sand to increase its stability.

Safety Cones

Safety cones are 500 mm, 750 mm and 1000 mm high and 300 mm to 500 mm in diameter. They are usually made of plastic, rubber, HDPE, PVC and have retro refectories red and white bands. Safety cones would be displaced or blown unless their bases are anchored or loaded with ballast. This can be avoided by, using sand bag rings to provide increased stability. Using heavier weighted cones. Using cones with special weighted bases. Doubling the cones to provide added weight.

Barricades

Standard barricades are used.

Flagmen

- An authorised personnel at least average intelligence, be mentally alert and good in physical condition be selected, since flagmen are responsible for public and workmen safety.
- Flagmen should be equipped with yellow helmet with green reflective sticker fixed around and reflective jacket along with hand signalling devices such as flags and sign paddles. The typical specification are given below,
- Flagmen need to maintain the flow of traffic continuous past a work zone at relatively reduced speeds by suitably regulating the traffic. He shall stop the traffic for a short while whenever required (e.g. for entry and exit of construction equipment in to work zone).
- Flagman should be positioned in a place where he is clearly visible to approaching traffic and at a sufficient distance to enable the drivers to respond for his flagging instructions. A flagman never leaves his post until properly relieved,
- The standard distance shall be maintained at 60 – 100 m but can be altered depending upon the approach speed and site conditions. In urban areas this distance shall be taken as 20 m to 50 m.

7.9.6. Traffic Management Practices

7.9.6.1. Definitions

Road traffic control involves directing vehicular and pedestrian traffic around a construction zone, accident or other road disruption, thus ensuring the safety of emergency response teams, construction workers and the general public.

7.9.6.2. Working Zone

The plant Site, construction zone of tunnel road etc. at which workmen will be working.

7.9.6.3. Working Space

The space around the works area that will require storing tools, excavated material and other equipment. It is also the space to allow workmen, movement and operation of plant, (e.g. swing of jibs, excavator arms) to move around to do the job. Materials and equipment must not be placed in the zone either. Workmen will only need to enter the zone to maintain cones and other road sign.

7.9.6.4. Safety zone

The zone that is provided to protect workmen from the traffic and to protect from them.

7.9.6.5. Approach Transition zone:

This will vary with the speed limit and the width of the works as given in (diag: Traffic Control zone)

7.9.6.6. Longitudinal buffer zone:

This is the length between the end of the lead-in taper of cones (T) and the working space. It will vary with the speed limit as given in table (Traffic Control zone)

7.9.6.7. Lateral buffer zone:

This is the width between the working space and moving traffic. It will vary with the speed as given in table (Traffic Control zone). The lateral buffer zone safety clearance is measured from the outside edge of the working space to the bottom of conical sections of the cones on the side nearest to the traffic.

7.9.7. Works on Approach Roads

- Approached diversion would be taken out of the works zone for the movement of construction supervision vehicles.
- The construction zone shall be barricaded with standard barricade.
- The ‘works traffic” shall be governed by the location of base camp where workmanship less than 20, a flagman shall be kept for controlling traffic, public and workmen safety or more than 20 in addition to that a safety steward shall be kept for continuous monitoring to identify and removal of unsafe acts and conditions.

7.9.8. Construction Traffic meets Live Traffic from Quarry/Plant/Borrow Pit

- Where vehicles are more to the approach junction from the side road, permission shall be seek for providing speed breaker at junction from local traffic police and road-authority.
- The layout for signs and traffic control devices.
- Flag man shall be kept in the peak time provided with the traffic circle painted with red and white at the corner at a height of 500 mm, clearly visible to approaching traffic for a distance

provided with while gloves and STOP, GO Paddle. And night time flagman should use LED Batons.

- All vehicles from approaching road should be STOP, LOOK and GO.
- Spillage of earth / Gravel / Aggregates / Bituminous mix from the tipper shall be cleaned on regular basis, if required 2 coolies permanently posted for booming.
- All Construction vehicles must follow lane discipline and road signs.

7.9.9. Possisble Hazards

There are various factors which singularly and severally can cause disaster in a tunneling project. The project activity is associated with many hazards which are discussed in the following sub sections:

7.9.9.1. Blasting

The accidents from the blasting are mainly manifest as projectiles which some time traverse beyond the danger zone and trespass the project boundary. It is largely due to overcharging of blast holes and also during secondary blasting. Ground Vibration caused due to blasting lead to displacement of adjoining areas and result in fallout of loose rock-mass if not properly scaled in earlier blasting cycle. The following measures are suggested to avoid accidents due to blasting:

- All blasting operations shall be supervised by a competent person appointed for the purpose and strictly conducted as per guidelines contained
- Danger zone area falling within a radius of 500m from the blast site shall be demarcated;
- Guards shall be posted at all access points leading to the blast area to prevent and control movement of persons/ stray animal;
- All employees and equipment shall be cleared off the blast area to a safe location prior to any scheduled blasting; and
- Audible signals such as sirens whistles and mikes etc., shall be put to use to caution the workers, passer-by about the scheduled blasting events

7.9.2.2. Heavy Machinery

Most of accidents during transport of dumpers, excavators, dozers and other transport vehicles are often attributed to mechanical failures and human errors and can be significantly averted by adapting to following:

- All HEMM and transport vehicle movement within the project area should be carried out under the direct supervision and control of the management;
- All project machinery and vehicles should be periodically maintained and weekly checked by a competent person authorized by the management;
- Conspicuous sign board should be provided at each and every bend for guidance of the operators/drivers during day/night time; and
- To avoid dangers while reversing the trackless vehicles, especially at the embankment and tripping points, all areas for reversing of vehicles should, as far as possible, be made man free, and should be a light and sound device to indicate reversing of trucks/project machinery.

7.9.9.3. Storage of Explosive

The explosive magazine shall be located outside the project area. For the purpose of transportation of explosives, explosive van shall be deployed. The main hazard associated with the storage, transport and handling of explosives is fire and explosion. The rules as per Indian Explosive Act-1984 and Explosive Rules-2008 should be followed for handling of explosives, which includes transportation, storage and use of explosives.

7.9.9.4. Fuel Storage

All project machinery will operate on diesel for which no storage point is envisaged in the project area. It will be stored in the central workshop area of the proponent.

7.10. Disaster Management Plan

7.10.1. Definition of Disaster

The United Nations Office for Disaster Risk Reduction (UNISDR, 2009) defines disaster as:

"A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources."

UNISDR considers disaster to be a result of the combination of many factors such as the exposure to hazards, the conditions of vulnerability that are present, and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injuries, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation.

7.10.2. Scope

This section describes the provisions which have been kept in the project components viz. Tunnels, approach roads and bridges, in order to mitigate the effects of Disaster and also for providing an early warning system to the concerned authority / personnel on occurrence of accidents/impending disaster. In addition, it also describes, in general, the measures and actions which should be incorporated in the Disaster Management Plan for the Project during Construction & Operation phase of the proposed tunnel road. It is imperative that the DMP for the construction and operations phases should be finalized and amended as required, after due consultation with all the stakeholders and agencies involved in Disaster Management. The document also gives the Standard Operating Procedures (SOPs) to be followed during the construction Phase. These (SOPs) are based on the provisions of MORT&H Specifications & IRC Special Publication, which are commonly used for the construction of Highway/Bridge & Tunnel Projects in India.

7.10.3. Types of Disaster

Primarily disasters are triggered by natural hazards or human-induced, or result from a combination of both. In particular, human-induced factors can greatly aggravate the adverse impacts of a natural disaster. Even at a larger scale, globally, the UN Inter-Governmental Panel on Climate Change

(IPCC) has shown that human-induced climate change has significantly increased both the frequency and intensity of extreme weather events. While heavy rains, cyclones, or earthquakes are all natural, the impacts may, and are usually, worsened by many factors related to human activity. The extensive industrialization and urbanization increases both the probability of human-induced disasters, and the extent of potential damage to life and property from both natural and human-induced disasters. The human society is also vulnerable to Chemical, Biological, Radiological, and Nuclear (CBRN) disasters.

7.10.3.1. Natural Hazards

The widely accepted classification system used by the Disaster Information Management System of DesInventar classifies disasters arising from natural hazards into five major categories (DesInventar, 2016):

- **Geophysical:** Geological process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Hydro-meteorological factors are important contributors to some of these processes. Tsunamis are difficult to categorize; although they are triggered by undersea earthquakes, and other geological events, they are essentially an oceanic process that is manifested as a coastal water-related hazard.
- **Hydrological:** Events caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up
- **Meteorological:** Events caused by short-lived/small to meso-scale atmospheric processes (in the spectrum from minutes to days)
- **Climatological:** Events caused by long-lived meso- to macro-scale processes (in the spectrum from intra-seasonal to multi-decadal climate variability)
- **Biological:** Process or phenomenon of organic origin or conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Substances that may cause loss of life, injury or illness

A brief description of these five major categories of the disasters arising from natural factors with the sub-categories is given in Table below. The below classification is not a water tight one. In real life situations, many disasters are a combination of different types of disasters. In addition, secondary disasters may occur after a disaster has occurred.

Table 0.19. Categories of Natural Hazards

Sl. No.	Family	Main Event	Short Description / Secondary Disaster
1	Geophysical	Earthquake / Mass movement of earth materials	• Landslide following earthquake; • Urban fires triggered by earthquakes; • Liquefaction - the transformation of (partially) water-saturated soil from a solid state to a liquid state caused by an earthquake; • Mass movement of earth materials, usually

Sl. No.	Family	Main Event	Short Description / Secondary Disaster
			down slopes; • Surface displacement of earthen materials due to ground shaking triggered by earthquakes.
		Tsunami	A series of waves (with long wavelengths when traveling across the deep ocean) that are generated by a displacement of massive amounts of water through underwater earthquakes, volcanic eruptions or landslides. Tsunami waves travel at very high speed across the ocean but as they begin to reach shallow water, they slow down and the wave grows steeper.
2	Hydrological	Flood, Landslides and Wave Action	• **Coastal Erosion-** The temporary or permanent loss of sediments or landmass in coastal margins due to the action of waves, winds, tides, or anthropogenic activities • **Coastal flood-** Higher-than-normal water levels along the coast caused by tidal changes or thunderstorms that result in flooding, which can last from days to weeksFlash Flood Hydrological - Heavy or excessive rainfall in a short period of time that produce immediate runoff, creating flooding conditions within minutes or a few hours during or after the rainfall • **Flood Hydrological-** A general term for the overflow of water from a stream channel onto normally dry land in the floodplain (riverine flooding), higher-than normal levels along thecoast and in lakes or reservoirs (coastal flooding) as well as ponding of water at or near the point where the rain fell (flash floods) • **Wave Action-** Wind-generated surface waves that can occur on the surface of any open body of water such as oceans, rivers and lakes, etc. The size of the wave depends on the strength of the wind and the travelled distance (fetch).
3	Meteorological	Hazard caused by short- lived, micro- to meso- scale extreme weather andatmospheric conditions that may last for minutes to days	• Cyclone, Storm Surge, Tornado, Convective Storm, Extratropical Storm, Wind Lightning, Heavy Rain
4	Climatological	Unusual, extreme weather conditions related to long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal (long-term)	• Extreme hot / cold conditions • Subsidence

Sl. No.	Family	Main Event	Short Description / Secondary Disaster
		climate variability	
5	Biological	Exposure to germs and toxic substances	• Epidemics: viral, bacterial, parasitic, fungal, or prion infections • Insect infestations

7.10.3.2. Human Induced Disaster

The NPDM (2009) notes that rise in population, rapid urbanization and industrialization, development within high-risk zones, environmental degradation, and climate change aggravates the vulnerabilities to various kinds of disasters. Due to inadequate disaster preparedness, communities, and animals are at increased risk from many kinds of human-induced hazards arising from accidents (industrial, road, air, rail, on river or sea, building collapse, fires, mine flooding, oil spills, etc.). Chemical, Biological, Radiological, and Nuclear (CBRN) hazards rank very high in among the human- induced risks. Terrorist activities and secondary incidents add to these risks and call for adequate preparedness and planning.

7.10.3.3. Levels of Disaster

The disaster management and its planning at various tiers must take into account the vulnerability of disaster-affected area, and the capacity of the authorities to deal with the situation. Using this approach, the High Power Committee on Disaster Management, in its report of 2001, categorized disaster situations into three 'levels': L1, L2, and L3. The period of normalcy, L0, should be utilized for disaster risk reduction.

Level-L1: The level of disaster that can be managed within the capabilities and resources at the District level. However, the state authorities will remain in readiness to provide assistance if needed.

Level-L2: This signifies the disaster situations that require assistance and active mobilization of resources at the state level and deployment of state level agencies for disaster management. The central agencies must remain vigilant for immediate deployment if required by the state.

Level-L3: This corresponds to a nearly catastrophic situation or a very large-scale disaster that overwhelms the State and District authorities.

The categorization of disaster situations into levels L0 to L3 finds no mention in DM Act 2005. Further, the DM Act does not have any provision for notifying any disaster as a national calamity or a national disaster.

7.10.4. Project Specefic Provisions for Disaster Management Plan / Provisions

7.10.4.1. Nodal Operation Control rooms

Nodal Control Canters will be equipped with the latest Communication facilities and will be manned 24 x 7 during the Construction and Operations Phase. During the Construction Phase, these rooms will be manned by the Contractor’s personnel along with the Supervisory staff of the Disaster Management Cell.

These Nodal Operation Control Rooms will maintain effective communication at all times with the various agencies listed in Disaster Management Plan viz.

- Police Commissionerate
- Traffic Police
- Municipal Corporation / Panchayaths
- Home Guards and Civil Defence
- District Collectorates
- Indian Meteorological Department (Regional Office)
- Fire Brigade
- BSNL
- Mobile Service Providers
- Hospitals
- Radio & TV Centre

7.10.4.2. Safety Measures during Construction of Tunnel

The Standard Operating Procedures/Safety practices to be followed during the construction of the Tunnels will be in accordance with the provisions of Clause 6.0 – Safety during Construction of Tunnels – IRC SP: 91 – 2010. A summary of provisions is given below. The Tunnel Contractor will formulate an elaborate Health & Safety Manual covering at least the following aspects before the commencement of construction activities.

Table 0.20. General Requirement of Health and Safety Manual

Sl. No.	Description	Reference Clause No. of IRC SP 91 – 2010 – Tunnel Design
1	General – Background, Applicable Regulations, Project Safety Plan	6.1
2	Basic Aspects – Basic Philosophy, Personal Protective Equipment, Signage, Access Control Systems, Safety Systems	6.2
3	Drilling & Blasting – Drilling Operations, Blasting Operations, Inspection after Blasting, Misfires, Scaling & Mucking, Installation of Supports,	6.3
4	Ventilation & Noise Protection,	6.4
5	Lighting	6.5
6	Communication System – Warning Signs & Notice Boards, Telephone Systems, CCTV System,	6.6
7	Protection against Fire – General, Fire System, Electrical Installations,	6.7
8	Housekeeping – General, Traffic Control, Pipes & Cables, Water Control	6.8
9	Emergency Management System	6.9

7.10.4.3. Supervisory Control & Data Acquisition (SCADA) Control Rooms for Tunnels (Operations Phase)

The tunnel monitoring systems viz. Fire Detection & Fire Fighting System, Ventilation System, Video Camera Control System, Emergency Communication System, Carbon Monoxide Detection System etc. will be housed in the Control Rooms for Tunnels. These Control Rooms will be located at the

Entry/Exit of the Tunnels and will be manned 24 x 7 by the O & M staff. Communication links will be established between these Control Rooms and all the agencies above as well as with the Nodal Control Rooms.

The Tunnel Control Rooms with SCADA will play a vital role in ensuring safe operations in the Tunnel during the Operations Phase. The various provisions to be kept in the instrumentation are described in detail in DPR Volume 2: Design Report.

7.10.4.4. Standard Operating Procedures to be followed during construction

Standard Operating Procedures (SOPs) as stipulated in MORT&H Specifications – Revision 5, a document which is largely used in India for construction of Highways, shall be used during the Construction Phase. These also include precautions to be taken for safeguarding the environment. A summary of provisions is given below.

Table 0.21. SoP Requirement

Sl. No.	Description	Reference Clause No. of MORT&H Specification
1	Borrow Pits for Embankment Construction	111.2
2	Quarry Operations	111.3
3	Control of Soil Erosion, Sedimentation & Water Pollution	111.4
4	Pollution from Plants and Batching Plants	111.5
5	Substances hazardous to health	111.6
6	Use of Nuclear Gauges	111.7
7	Environment Protection	111.8
8	Occupational Health and Safety of the Workforce	111.9
9	Control & Disposal of Waste	111.10
10	Transport of hazardous materials	111.11
11	Emergency Response	111.12

It is expected that the Contractor will prepare an exhaustive project specific Health & Safety Management Plan before commencement of Construction activities and implement the same rigorously.

7.10.5. Highway Traffic Management System (HTMS) during Operations Phase

Highway Traffic Management System will control the traffic monitoring and movements on the Road. The following outdoor units will be installed as a part of HTMS:

- Emergency Call Boxes
- Variable Message Signs
- Meteorological Data Systems
- Close Circuit TV Camera System
- Traffic Counting, & classification and transmission system

Indoor units will comprise of the following:

- Large Display board with Central Computer and Network monitoring system
- CCTV System
- Uninterrupted Power Supply

The system shall meet the following objectives:

- Smooth and uninterrupted Traffic flow
- Enhanced Road SafetyA
- Real-time information and guidance to road users
- Round the clock 24hrs emergency assistance
- Alerts for abnormal road and weather conditions
- Reduced journey time and reduced driving fatigue

7.10.6. Approach to Disater Management Plan

Environmental risks are inherent in design and operation of a complex project. Any major failure in the system could lead to a disaster resulting in loss of human life, loss to property and damage to ecology. Growing concern has resulted Risk Assessment as a mandatory requirement during project reviews of MoEF&CC.

Risk involves the occurance of potential occurrence of some accidents consisting of an event or sequence of events. Maximum Credible Accident (MCA) analysis, Hazard Analysis, Assessment and Evaluation, Disaster Management Plan (DMP) and Emergency Prepardness Plan (EPP).

7.10.6.1. Maximum Credible Accident (MCA) Analysis

The word MCA stands for Maximum Credible Accident or in other words, an accident with a maximum damage distance, which believed to be probable. MCA analysis does not include quantification of the probability of occurrences of an accident. In practice the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgment and expertise in the field of risk analysis especially in accident analysis.

7.10.6.2. Hazard Analysis, Assessment and Evaluation

Less and more hazard prone sections of each unit are decided based on the Fire Explosion Index (FEI), Toxicity Index (TI) and inventory analysis. Safety of less hazard prone section is studied using check list approach while detailed Hazard and Operability (HAZOP) studies is carried out for most hazardous sections.

The purpose of HAZOP analysis is to detect any predictable undesired event in a process to achieve a systematic study of the operations carried out for each process step involved and also the way in which the various components involved interact. This exercise is particularly important in the case of process for which there is no or only limited actual operating experience.

The HAZOP studies indicate all possible events and their consequences. In multi component systems, it is important to analyse the possible mechanisms for failure and to perform probabilistic analysis for the expected rate of such failures. Fault Tree Analysis (FTA) is a technique by which many events that interact produce other events that can be related using simple logical relationships which permit a methodical building of a structure that represents the system. Majority of the primary events that could lead to the failure of a unit (known as top event) could be derived from HAZOP studies.

Applications of reliability engineering especially in the process control instrumentation are of recent origin. System performance can be evaluated by Assessment of Pathway reliability of each vulnerable process section. The quantitative estimation of pathway reliability helps in deciding reliability improvement strategies.Whilst the quantitative assessment of reliability (or for that matter estimation of top event probability of an occurrence of an event using FTA and Monte Carlo Simulation) uses mathematical theories, it is hindered in practice by the lack of failure rate data from chemical-control instruments, equipment. This is of relevance, especially in the Indian context while adopting quantitative risk analysis approach. Generation of Indian Data base on failure rate date is therefore of vital significance.

7.10.7. Disaster Management Plan (DMP) and Emergency Prepardness Plan (EPP)

7.10.7.1. Disaster or Emergency and its Possibility

A disaster, and therefore an emergency, occurring as a result of a malfunction of the normal operating procedures or an intervention of an outside force such as a cyclone, flood or sabotage, that may affect several sections within it and/or may cause serious injuries, loss of lives, extensive damage to property or serious disruption outside the works.

Apart from earthquakes, cyclones, flood, major fire and disruption, serious accidents may take place through explosion in Gas/Fuel Tankers, heavy leakage and subsequent fire in the oil tankers etc. near or inside the tunnel.

7.10.7.2. Objective of the Disaster Management Plan

In order to be in a state of readiness to face any accident or disaster caused during the project operation, a Disaster Management Plan shall be prepared. Such a plan ought to cover possible disaster, on and off-site emergency preparedness plan, establishment of Emergency Control Centres (ECC), location of emergency services, and duties of the officers/staff during emergency.

7.10.7.3. Basic Content of DMP

Basically, the DMP will contain the following aspects:

1. Description of the Site
2. On-site Emergency Plan
3. Off-site Emergency Plan

7.10.7.4. On-Site Emergency Plan

Objective and Contents

The objective is to combat emergency caused by an accident, the effects of which are confined to the Site involving only the people working on the project. This project road especially tunnel section, essentially consists of an action plan which includes identification of key personnel; defined responsibilities of key personnel; designated ECCs and assembly points; declaration of emergency; all clear signal; actions to be taken by non-key Personnel during emergency.

Appointment of Key Persons and their Role

1. Site Controller (SC)

The General Manager (however called) or his nominated deputy will assume overall responsibility for the Site and its personnel.

2. Incident Controller (IC)

A Production Manager or an Officer of similar rank will be nominated to act as the IC. Immediately on learning about an emergency, he will rush to the incident site and take overall charge and report to the SC.

3. Liaison Officer (LO)

Personnel/Administrative Manager or his nominated Officer of deputy rank will work as LO and will be stationed at the Nodal Control Centres during emergency to handle Police, Press and other enquiries.

4. Forward Area Controller (FAC)

Departmental In charge of the concerned area will be the FAC to take care of the respective departments during emergency.

5. Team Leader (TL)

As number of specified activities may have to be carried out, for which specific teams have to be formulated and their roles or duties defined, each of them will be headed by a TL. The following teams are suggested:

- Task Force
- Repair Team
- Fire Fighting Team
- Communication Team
- Security Team
- Manpower Team
- Safety Team
- Transport Team
- Medical Team

<u>Emergency Control Centres Centres (ECC)</u>

Emergency Control Room is to be set up and marked on the site plan for the knowledge of all concerned. ECC is the focal point and it should be well connected with internal and external telephones and furnished with list of personnel and their addresses.

- **Assembly Points**

Assembly points, the pre-determined safe places, where people will be directed after evaluation from the hazardous locality, have to be set up and marked on the site plan. Escape routes from assembly points have to be clearly defined and depicted.

- **Alarms**

Suitable sirens will be provided at Site, which could be operated from the Nodal Control Rooms. The coding of the siren should be as per the standards and well circulated within the facility.

- **Tie Ups for Aid with Institutions (Hospitals, Wards, Police Stations etc.)**

It is essential to have mutual aid arrangements among the industries in the neighbourhood which would help in the case of a major disaster.

- **Training and Mock Drills**

Proper training of the key personnel and other non-key personnel, who will take part in case of an emergency, should be arranged. Mock drills will be performed to test the performance of the procedure laid

7.11. Risk Matrix

Table 0.22. Risk Matrix

Sl. No	Family	Main Event	Short Description/ Secondary Disaster	Probability of occurrence	Proposed Actions
1	Geophysical	Earthquake / Mass movement of earth materials	Landslide following earthquake; Urban fires triggered by earthquakes; Liquefaction - the transformation of (partially) water-saturated soil from a solid state to a liquid state caused by an earthquake Mass movement of earth materials, usually down slopes Surface displacement of earthen materials due to ground shaking triggered by earthquakes	Kerala falls in Earthquake Zone III which is consider moderate risk zone. Earthquakes have not been very frequent in project district.	Structures will be designed considering the seismic provisions as per Codal provisions Mock Drills. Quick Evacuation of Site Workers and Staff Contact to be maintained with nearest hospitals and Fire Stations for taking casualties for treatment and for rescue operations
2	Hydrological	Flood Landslides Wave Action	Heavy or excessive rainfall in a short period of time that produce immediate runoff, creating flooding conditions within minutes or a few hours during or	Flooding: The alignment does not pass through the chronic Flooding spots. Infact, the proposed	Contact to be maintained with the regional office of IMD Early warnings to the project workers/staff to be given, when

Sl. No	Family	Main Event	Short Description/ Secondary Disaster	Probability of occurrence	Proposed Actions
			after the rainfall Flood Hydrological - A general term for the overflow of water from a stream channel onto normally dry land in the floodplain (riverine flooding), higher-than normal levels along the coast and in lakes or reservoirs (coastal flooding) as well as ponding of water at or near the point where the flash floods occurred. Wave Action: Wind generated surface waves that can occur on the surface of any open body of water such as rivers and lakes, etc. The size of the wave depends on the strength of the wind and the travelled distance (fetch).	alignment Road will offer a good and safe evacuation passage for the public, in general. Landslides: There is medium probability of landslides getting triggered due to earthquakes or floods.	applicable. Quick evacuation of Site Workers and staff
3	Meteorolo gical	Hazard caused by short- lived, micro- to meso- scale extreme weather and atmospheric conditions that may last for minutes to days	Cyclone, Storm Surge, Tornado, Convective Storm, Extratropical Storm, Wind Lightning, Heavy Rain	Project district are vulnerable to draught and storms	Contact to be maintained with the regional office of IMD Early warnings to the project workers / staff to be given, when applicable. Quick evacuation of Site Workers and staff
4.	Climatolo gical	Unusual, extreme weather conditions related to long- lived, meso-to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal (long-term) climate variability	Extreme hot/cold conditions Subsidence	Low Probability	Contact to be maintained with the regional office of IMD Early warnings to the project workers/staff to be given, when applicable. Quick evacuation of Site Workers and staff

Sl. No	Family	Main Event	Short Description/ Secondary Disaster	Probability of occurrence	Proposed Actions
5	Biological	Exposure to germs and toxic substances	Epidemics: viral, bacterial, parasitic, fungal, or prion infections Insect infestations	Low probability	Proper hygiene to be maintained in the Worker's Camps, Canteens and Work areas. Close co-ordination to be maintained with the City hospitals and Health Authorities.
6	During Constructi on	Accidents	Accidents during construction of Road / Bridges / Tunnels / reclamation	Medium	Formulation of Safety Policy and strict implementation of the sameduring construction phase. Provision of safety planning and Tool-Box talk before start of any work at sites Provision of First Aid at worksites Arrangements with nearest hospitals for emergency treatment in case of accidents Provision of Ambulances

7.11.1. Approach to Risk Assessment

PHASE I: MCA ANALYSIS

- Process Information Study
- Study of Process Engineering Details
- Detailed Study of Plot Plan/Layout
- Hazard Identification through
- Inventory
- Effects Calculations

PHASE II: HAZARD ANALYSIS, ASSESSMENT AND EVALUATION

- Checklist approach for less hazard prone areas/sections
- HAZOP Studies
- Failure Frequency Analysis
- Data Collection
- Pathway Reliability Approach

- Protective System Hazard Analysis
- Evaluation of Hazards.

PHASE III: DISASTER MANAGEMENT PLAN (DMP)

- Suggest Preventive and Corrective Measure

PHASE IV: EMERGENCY PREPAREDENESS PLAN (EPP)

- Study of EPP
- Emergency Preparedness
- Onsite

7.11.1.1. Risk Analysis Matrix for Proposed Tunnel Road Project

Table 0.23. Risk Mitigation Measures for Tunnels during Operations Phase

Perceived Risks	Occurrence	Risk Mitigation Methods
Environmental		
Area prone to flooding	Once a Year	All entry points to be covered from above to prevent rain water from directly falling on the ramps; Provide efficient drainage system with collection; Provide Sumps to trap any water coming within the tunnel; Provide pumps to transfer any such water to external drains; Install systems to prevent entry of traffic into the tunnel in case of any eventuality; Install emergency communication methods for traffic to organize and evacuate themselves; Install quick evacuation methods for vehicles; Install dedicated emergency communication Systems at every 100 meters.
Earthquake	Once in 20Years	Install systems to prevent entry of traffic into the tunnel in case of any eventuality; Install emergency communication methods for traffic to organize and evacuate Install quick evacuation methods for vehicles; Install dedicated emergency communication systems at every 100 meters.
Internal Air Quality (IAQ)	Daily	Install CO_2 and CO sensors at every 15 meters; Provide sufficient fresh air supply fans and provide effective exhaust fans.
User Related Risks		
Accidents	Weekly	Install cameras at every 30-50meters; Install incident reporting systems with ability to recognize stoppage in traffic flow, reverse traffic flow etc. in lanes; Identify methods to enable emergency services to access accident sites quickly; Install emergency communication methods for traffic to organize and evacuate themselves; Install quick evacuation methods for vehicles; Install dedicated emergency communication system at every 100 meters.

Perceived Risks	Occurrence	Risk Mitigation Methods
Congestion / Breakdown / Stoppage / Lane Changing / Drunk / Rash Driving / Over Speeding	Daily	Install variable message system Install fixed sign system Install cameras at every 30-50meters; Install incident reporting systems with ability to recognize stoppage in traffic flow, reverse traffic flow etc. in lanes and provision of escape routs; Identify methods to enable emergency services to access accident sites quickly; Install systems to prevent entry of traffic into the tunnel in case of any eventuality; Install emergency communication methods for traffic to organize and evacuate themselves; Install quick evacuation methods for vehicles; Install pedestrian exit routes at every 500 meters; Install dedicated emergency communication systems at every 100 meters.
Hazardous/ Poisonous Gases	Rare	Prevent entry of tankers, articulated long trucks and oversized vehicle into the tunnel; Provide margin for vehicular rejection at least 50 meters before tunnel entry to divert these vehicles to other lanes Install sign boards outside the tunnel for vehicles to Organize themselves and move to other lanes. Provide sufficient fresh air supply fans; Provide effective exhaust fans.
Operational / Maintenance Risks		
Fire	Once a Year	Install SCADA systems for monitoring all Equipment installed in the tunnels; Ensure only 'Plug and Play' equipment's are installed; Install quick response fire detection systems in the tunnel; Install cameras with ability to recognize fire hazards every 30 – 50 m; Install Fixed Fire Fighting (FFF) and automatically Systems within the tunnel; Install smoke evacuation systems; Identify methods to enable emergency services to access accident sites quickly; Install systems to prevent entry of traffic into the tunnel in case of any eventuality; Install emergency communication methods for traffic to organize and evacuate themselves; Identify quick evacuation and provision of escape route for vehicles; Identify quick evacuation methods for pedestrians; Install dedicated emergency communication system at every 100 meters.
Power Outage in Tunnels	Once in 6 Months	Provide power supply through HT line for running of all the equipment's like lighting and exhaust system Provide UPS supply to all emergency equipment and at least 1/3 rd. of the lights; Provide secondary source of power supply like DG sets;
Equipment Failure	Monthly	Install SCADA systems for monitoring all Equipment installed in the tunnels; Ensure only 'Plug and Play' equipment are installed;

Perceived Risks	Occurrence	Risk Mitigation Methods
		Ensure adequate spare parts/ replacements to Minimize equipment downtime.
Security Risks		
Terrorist Attacks	Once in 2 Years	Install cameras at every 30-50meters; Install incident reporting systems with ability to recognize stoppage in traffic flow, reverse traffic flow etc. in lanes; Install systems to prevent entry of traffic into the tunnel in case of any eventuality; Install emergency communication methods for traffic to organize and evacuate themselves; Identify quick evacuation methods for vehicles; Identify quick evacuation methods for pedestrians; Install dedicated emergency communication systems at every 100 meters.

7.11.1.2. Risk Assessment for Tunnel

Risk assessment is essential part of tunnel services and structural design. This has been considered in related to various incident scenarios which may occur during operation of the proposed tunnels. Risk analysis is based on risk rating of various incidents and their impact on the proposed tunnel structure and users.

Table 0.24. Risk Assessment for Tunnel

Structural measures	Twin tubes Mandatory where a 15-year forecast shows that traffic > 10000 vehicles /lane.	Two tubes of 2 lane each-unidirectional with same cross section.
		Maximum Tunnel Gradients shall be 2.50%
	Emergency walkways are mandatory where no emergency lane is provided	Provision of emergency walkway is proposed
	Emergency mandatory exits every 500m are	Cross connections proposed at every 300m
	Mandatory cross-connections for emergency services at least every 1 500 m	Cross connections proposed at every 300m
	Crossing of the central reserve outside each portal (mandatory requirement)	It is proposed to provide continuous cut section to adopt the same
	Drainage for flammable and toxic liquids is mandatory where such goods vehicles are allowed	Although such inflammable and toxic goods carrying vehicles will be rejected. Drainage provisions have been made underneath the pavement
	Fire resistance of structures is mandatory where local collapse of structure may have disastrous effect	Complied by making such provisions
Lighting	Normal Lighting	Proposed as per CIE 88, 2004
	Safety lighting	Proposed as per CIE 88, 2004
	Evacuation lighting	Provided over footways
Ventilation	Mechanical ventilation	Proposed longitudinal ventilation by providing jet fans
	Mandatory semi transverse	Provisions made through supply ducts

	ventilation for tunnels of more than 3000m length	and ventilation shafts.
Emergency stations	Mandatory provision of emergency stations at 150m equipped with telephone and two fire extinguishers necessary	Provision to be made at every 200 m.
Road signs	Mandatory	Provided with road signs
Control Centre	Surveillance of several tunnels may be centralized into a single control centre.	Control centres shall be provided to cover two tunnel sections. The Control Centres are located at start of tunnel as well as end of the tunnel and entire stretch with provision of SCADA.
Monitoring systems	Video	CCTV cameras shall be provided along tunnels as well as along Road
	Automatic incident detection and/or fire detection	SCADA system connected to CCTV equipped with automatic incident detection system and response is proposed.
Equipment to close tunnel	Traffic signals before the entrances	The mandatory provision is to be complied by provision of gate controlled from Control centre
	Traffic signals inside the tunnel	It is proposed to provide traffic signals at every 500m before every cross connection to enable traffic diversion to parallel tunnel in case of incident.
Communications system	Radio re-broadcasting for emergency services	Provisions made connected to SCADA system
	Emergency radio messages for tunnel users	Provisions made connected to SCADA system
	Loudspeakers in shelters and exits	Provisions made connected to SCADA system
Emergency power supply	Mandatory	It is proposed to equip control centre with necessary capacity of standby generators with necessary fuel storage
Fire resistance of equipment	Mandatory	All tunnel fixtures and fitting shall be fire resistance compliant.
Additional Provisions	Drainage	Drainage pipe of 400mm dia running along the length of the tunnel has been proposed between chainage 0.51km to 6.65km to account for seepage from Kalladi river flowing above the alignment. Water proofing measures such as PVC water proofing membrane, geotextile and geo composite has been proposed around the tunnel lining to prevent seepage on to the tunnel.
	Environmental monitoring sensors	It is proposed to provide environmental monitoring sensors to monitor visibility levels, air quality and smoke detection
	Linear Heat Detection	Linear heat detection is proposed through adoption of OFC cables cross looped to detect exact location of fire.
	Variable Message signs and panels	It is proposed to provide VMS system

		attached to SCADA at control centre to enable safe tunnel operation.

7.11.1.3. Risk Response Strategies

Vehicle related incidents: Tunnels are designed to carry traffic loading and there are events of varying probability which may affect safe operation of the tunnel.

Fire in the Tunnel

Fires in tunnel are a serious risk and the probability of such incidence is based on likelihood of a serious accident occurring inside the proposed tunnel and the vehicle involved catching fire. Tunnel alignment have been maintained as straight alignment with maximum grade of 4% allowing high visibility distance.

Accidents

Probability of occurrence of accident in a unidirectional tunnel is very unlikely. To reduce the probability of same to extremely unlikely event, alignment of the tunnels has been designed as straights with maximum grade of 4%. This will ensure high visibility to stopping vehicle/ debris on road. It is also proposed to restrict the vehicle speeds to 80 kmph for entire road and enforce the same through speed detection cameras.

Breakdown and debris on road

Risk of occurrence of such event is similar to accidents. Automatic incident detection system shall be implemented to reduce the impact of such event

Oversize vehicles

It is proposed to restrict entry of all oversized vehicles on Road to eliminate such risk. Non Vehicle related incidences

Non Vehicle related incidences

Vandalism

It is necessary to provide for securitization of likely entry points to the tunnels by pedestrians. Such a vandalism event may have very high impact on tunnel services. Therefore control room shall be provided with automatic incident detection system to report stoppage of vehicles and presence of pedestrian inside tunnel. Control rooms shall be manned 24x7 to register and act on such incidence. However to eliminate risk of this high impact event, the SCADA software shall be capable of sending message to enforcement agency automatically with details of location.

Terrorist Attack

Impact of such event on tunnel operation would be disastrous and would require immediate action by local police who would be informed by the personnel manning the Emergency Control Centres. The method of reducing risk of such event shall be discussed with the Authority. System will be provided so that the information will be intimated to the Police within a short period of time.

Traffic Queues

Risk of occurrence of traffic queues is unlikely considering adequate number of lanes has been proposed with adequate distances from tunnel entry/ exit points from proposed interchanges. However, event of traffic queuing is unlikely to impact on tunnel services. Environmental monitoring sensors are proposed to adjust level of tunnel services such as lighting and ventilation.

Chapter 8. Project Benefits

8.1. Introduction

The main objective of the project is to provide safe and efficient service levels to growing traffic movements and better connectivity to the region. All road users will be benefited from the proposed improvement on account of comfort, safety and reduced vehicle operating costs.

Community will accrue the benefit from proposed development project by way of improvement in the physical infrastructure; social infrastructure; development of economy; reduced pollution, vehicle maintenance, fuel saving; employment potential and other tangible benefits.

In general Project will have following benefits at national and regional level:

- **High-speed connectivity and access:** The projected corridor is a proposed 4-lane tunnel road. This will avoid traffic congestion and speed-up the freight movement. It is expected that overall, the proposed Kochi-Bengalure Industrial Corridor will reduce the travel time between the two economic hubs.
- **Aiding economic growth:** The seamless connectivity will provide better access to vehicles as a link to the existing NH 766 (which connects Kozhikode in Kerala with Kollegal in Karnataka via Mysore) and SH-59 (Meppadi - Kalladi - Chooramala on north side of tunnel road). The Project will reduce travel time and provide boost to trade and commerce linked to the regions connected through this highway.
- **Growth of backward areas:** As a result of connectivity and access to other parts of the State, the backward areas in the Malabar region will be aided to integrate with other part of Kerala. Further, freight and passenger traffic on the tunnel road will help promoting ancillary economy of these regions.
- **Decongestion of existing National and State Highways:** The proposed corridor will take away traffic pressures from existing NH-766 passing through various cities. Also, long-distance traffic will shift to the proposed highway, thereby reducing traffic and congestion on the existing NH and SH for regional and local usage.
- **Usage shift:** While National Highway 766 serves as the major connectivity between Kozhikode and Wayanad and to neighbouring States, the project will be an important initiative to provide an alternative route connecting with the existing road network. Long-distance traffic will shift from existing NH to the proposed tunnel road, resulting in lesser congestion leading to higher fuel savings and reduced travel time.
- **Improved safety:** Due to access control, the Roadway & Travel Safety of the traffic will be enhanced as there will be minimum distractions & conflict zones
- **Support to industry:** Different types of industries like Manufacturing, Tourism etc. along the proposed corridor will be facilitated in their business operation and reachability.

Detailed environmental and social benefits associated with the proposed highway development are described in sections below.

8.2. Efficient and Safe Connectivity Option

The proposed tunnel is a 8.735 kms long four-lane Tunnel Road including approaches (from existing roads) for providing connectivity between Anakkampoyil-Kalladi-Meppadi in the Kozhikode and Wayanad Districts in Kerala. The Project is planned as bypass to the existing NH 766 which provides high speed connectivity between Kozhikode and Wayanad districts of Kerala, more importantly giving a reliable access to the country's prominent economic and social hubs like Kochi and Bengaluru.

The proposed tunnel road will provide better connectivity to several towns and cities Kozhikode and Wayanad districts and give an infrastructure boost to the State. The highway will be access-controlled and ensure high speed traffic movement from Kozhikode to Wayanad. The proposed alignment is selected so as to cover one of the most important East-West arterial connectivity in the State, further interspersed with feeder highways on its either sides.

8.3. Saving in Travel Time and Cost

The project tunnel road will be 30 km shorter than the present Thamarassery ghat road. Also, it is expected to reduce the distance to be travelled between Kozhikode and Wayanad district, leading to the following cost savings for users:

- Vehicle Operation Cost (VOC)
- Travel Time (VOT)

8.4. Benefits to Local Trade and Economy

The proposed Project plans to link between Anakkampoyil-Kalladi-Meppadi in the Kozhikode and Wayanad Districts in Kerala. The strong regional connectivity proposed through the Project will further increase regional trade and economic growth. The regions to be connected through the Project have their distinct economic profiles:

- Economy of Kozhikode is mainly business oriented. Kozhikode makes 12% contribution to the State's income.
- Agriculture is the backbone of the economy of Wayanad district. Most of the lands in the district are use for agricultural purposes. More than half of its population are engaged in agriculture in order to earn their livelihood. The chief agricultural crops in the district are Coffee, tea, cocoa, pepper, plantain, vanilla, rice, coconut, cardamom, tea, ginger, etc.

These regions source their raw materials as well as transport their finished goods to various parts of the country. The corridor will boost efficient access to various markets by ensuring smooth flow of goods and services. The highway will also support the local businesses and economy along the project corridor.

8.5. Employment Generation (Direct and Indirect)

The project is expected to generate employment during construction phase. Further, due to ecosystem which will be created during construction and operations phase of the project, the tunnel-road will also create considerable indirect employment opportunities in form of transportation of construction materials, greenbelt development, ancillary facilities like canteens, etc.

During operations phase, the Project will largely have indirect employment benefits in form of amenities and through economic & social hubs developed around the project site. Efficient reach and connectivity to distant markets will further enhance economy of the districts and create employment pportunities.

Chapter 9. Environmental Cost Benefit Analysis

9.1. Introduction

Environmental Impact Assessments (EIA) are crucial tools in assessing the potential environmental, social, and economic consequences of proposed projects, policies, or developments. A comprehensive Cost-Benefit Analysis (CBA) is an essential component of the EIA process. This report aims to provide an overview of the key concepts and considerations in conducting a cost-benefit analysis for EIA.

It is a systematic evaluation of the costs and benefits associated with a proposed project or policy. In the context of EIA, it assesses the economic implications of alternative options, helping decision-makers make informed choices regarding environmental projects and regulations.

9.2. Components of Cost Benefit Analysis

9.2.1. Costs

Direct Costs: These include all expenses directly associated with the project, such as construction, operation, and maintenance costs.

Indirect Costs: These encompass less apparent expenses, such as land acquisition, legal fees, and administrative costs.

External Costs: Externalities refer to costs that are not borne by the project proponents but by society, such as pollution-related healthcare expenses.

9.2.2. Benefits

Direct Benefits: These are the positive outcomes directly attributable to the project, such as increased employment opportunities and enhanced resource availability.

Indirect Benefits: These are the secondary or unintended positive outcomes, such as improved infrastructure or increased tourism.

External Benefits: These are benefits that extend to society, like reduced pollution or enhanced ecosystem services.

9.3. Cost Benefit Analysis

Name of the project: Proposal Name of the Project: Proposal for Diversion of Forestland for "Construction of Twin Tunnel (2+2 lane) with Four Lane Approaches (from existing roads) for providing direct connectivity between Anakkampoyil -Kalladi-Meppadi in Kozhikode and Wayanad Districts of Kerala".

Nature of Proposal: Diversion of 17.263 Ha of forest land under FCA, 1980 for tunnel road construction.

Forest Proposal No. FP/KL/ROAD/148616/2021

Purpose: The Cost of Benefit Analysis is being undertaken for proposed Diversion of Forest land being affected due to the construction of Twin Tunnel (2+2 lane) with Four Lane Approaches (from existing roads) for providing direct connectivity between Anakkampoyil-Kaladi-Meppadi in Kozhikode and Wayanad districts of Kerala.

Total length of the road along the PF/RF: Under Reserve/protected Forest of Kozhikode and Wayanad South forest divisions = 5.78 km approx.

Total Forest area proposed for diversion : Under Reserve/ protected forest Kozhikode and Wayanad South forest divisions 17.263 Ha.

Table 9.1 Guidelines for conducting CBA

[As per MoEF&CC guidelines for conducting Cost Benefit Analysis vide file no. 7-69/2011-FC(Pt.) dated 1st August, 2017]

Sl.No	Parameters	Applicable / Not Applicable	Remarks
1	All categories of proposal involving forest land upto 20 Ha in plain and upto 5 Ha in hills	Applicable	The proposed project involves 17.263 Ha of forest land. Hence the CBA is applicable
2	Proposals for defence installation purposes and oil prospecting (Prospecting only)	Not Applicable	No such area is involved
3	Habitation, establishment of industrial units tourist lodges/complex and other building construction.	Not Applicable	No such activities involved
4	All other proposals involving forest land more than 20 ha in plains and more than 5 ha in hills including roads, transmission lines, minor, medium and major irrigation projects, hydel projects, mining activities, railway lines, location specific installation like micro-wave stations, auto repeater controls, towers etc.	Applicable	The proposed project involves 17.263 Ha of forestland. Hence, the CBA is applicable. 4 Hill 17.263 Ha Plain Nil Ha

Table 9.2 Estimation of cost of forest diversion

[As per MoEF& CC guidelines for conducting Cost Benefit Analysis vide file no. 7-69/2011-FC(Pt.) dated 1st August, 2017]

S.No	Parameters	Remarks
1	Ecosystem services losses due to the proposed forest diversion	The proposed forest area to be diverted is mostly characterized by Tropical Wet Evergreen Forests / Tropical Semi Evergreen Forests. According to MoEF&CC Guidelines for diversion of forest land for non-forestry purposes under Forest (Conservation) Act, 1980-and Guidelines for collection of Net Present Value (NPV) dated 05.02.2009, the area comes under Class I type of forest. Considering Eco average value of R. 10,43,000.00 can be considered per Ecosystem services losses due to 1 the proposed forest diversion Class I (Very Dense Forest), an hectare. Hence, the total NPV for the diverted project shall be T1,80,05,309 (approx.)
2	Loss of animal husbandry productivity, including loss of fodder	10% of NPV i.e. 1800531
3	Cost of human resettlement	NIL
4	Loss of public facilities and Administrative (road, buildings, Schools, dispensaries, electric lines, railways etc.) on forest land or which would require forest land if these facilities were diverted due to the project.	No utility shifting in the project Area
5	Possession value of forest land diverted	30% of the NPV i.e. INR 54,01,593
6	Cost of suffering to ousteed	There are no oustees involved in the forest area. However the final recommendation shall be made after the R&R suvey is completed.

S.No	Parameters	Remarks
7	Habitat Fragmentation cost	50% of the NPV i.e. 90,02,655
8	Compensatory afforestation and soil moisture conservation cost	The compensatory afforestation will be added later after receiving from DFO.

The total estimated cost of forest diversion Ecosystem services losses+ Loss of animal husbandryy productivity+ Cost of human resettlement+ Loss of public and Administrative facilities+ Possession value of forest land diverted+ Cost of suffering to outstees+ Habitat Fragmentation cost+ Compensatory afforestation and soil & moisture conservation cost. Hence, the Total Cost of Forest Diversion = 34,210,087.60

Table 9.3 Existing guidelines for Estimating benefits of forest diversion in CBA

[As per MoEF& CC guidelines for conducting Cost Benefit Analysis vide file no. 7-69/2011-FC(Pt.) dated 1st August, 2017]

Sl.No	Parameters	Remarks
1	Increase in productivity attributable to the specific project	The proposed project doesn't involve any manufacturing or production. Hence, this section is not applicable.
2	Number of population benefitted due to the project	Population of project districts, Kozhikode (3,086,293) and Wayanad (817,420) will get benefited due to proposed development of tunnel road (Source: Census of India, 2011). As per the traffic forecast on new proposed new alignment, 14,027 PCU @ 2030, 23,183 PCU @ 2040 and 35992 PCU & 2049. Economic benefit in terms of increase in trade in vehicular operation and maintenance and saving travel time. However, they have not been quantified as it will be a function of various government policy variables.
3	Economic benefits due to direct and indirect employment of the project	A total of about 915 persons shall be employed by the proposed project. The period of construction for the project is estimated to be 5 years. Considering 300 working days per year a total of 13,72,500 man days is expected to be Economic benefits due to directproposed project. The

Sl.No	Parameters	Remarks
		Total income for Rs 772,717,500.00/-
4	Economic benefits due to compensatory Afforestation	Compensatory Afforestation Rate @ 10,43,000 per Ha. Hence the total cost will be 10,43,000 x 17.263 Ha = Rs 3,64,36,162.00/- The compensatory afforestation will be added later after receiving from DFO.

The total estimated benefits of forest diversion = Number of population benefitted due to the project Economic benefits due to direct and indirect employment of the project + Economic benefits due to Compensatory afforestation. Hence, the total Environmental Benefit of Forest Diversion comes out to be Rs 772,717,500.00 + 36436162.00 = Rs 809,153,662.000

Based on value of products:

A. Total Benefit to the Society = Rs 809,153,662.00/-

B Total Cost to the Society = Rs 34,210,087.60/-

Therefore the Cost Benefit Ratio is:

$$Cost\ \text{Benefit Ratio} = \frac{\text{Total Environmental Benefits}}{\text{Total Cost of the Environment}}$$

$$= \frac{809{,}153{,}662.00}{34{,}210{,}087.60} = 23.7 > 1$$

Hence the project is viable.

9.4. Conclusion

Incorporating a thorough Cost-Benefit Analysis (CBA) into Environmental Impact Assessments (EIA) is essential for informed decision-making. By quantifying and comparing the economic costs and benefits of proposed projects, policymakers and stakeholders can make more informed choices that balance environmental protection with economic development.

According to the present CBA the project is a viable option.

Chapter 10. Environmental and Social Management Plan

10.1 Introduction

In order to address the impacts predicted in **0,** various mitigation measures, monitoring actions and a reporting schedule are suggested in this Chapter in the form of an Environmental and Social Management Action Plan (ESMP). The ESMP is a plan of action for avoidance, mitigation and management of the negative impacts of the project. Environmental enhancement is also an important component of ESMP.

An environmental and social management plan (ESMP) is a project or site specific plan developed to ensure that appropriate environmental management practises are followed during a project's construction and/ or operation.

An effective ESMP ensures:

- Application of best practise environmental management of the project;
- The implementation of a project's EIA including its conditions of approval or consent;
- Compliance with environmental legislation; and
- That environmental risks associated with a project are properly managed.

The EMAP includes a list of all project-related activities, impacts and their mitigation measures at different stages of project (construction Phase and operation Phase), Environmental monitoring plan and a clear reporting schedule. The EMAP sets a time frame to all proposed mitigation and monitoring actions with specific responsibility assigned to the proponents, the contractors and the regulatory agencies to implement the project and follow-up actions defined.

10.2. Objectives of the ESMP

The objectives of the ESMP are to:

- Define the management and mitigation measures to be applied by KRCL/KPWD and all contractors to identified environmental and social impacts both during construction and operation phases of the project.
- Provide specific guidelines as to the extent, timeframe and responsible parties in implementing the advised mitigation and management measures.
- Provide KRCL/KPWD management, its contractors and other stakeholders with legally permissible, workable, project-specific on-site environmental management controls over the project life.

- Enable KRCL/KPWD to ensure that project contractors fulfil stated environmental obligation on their behalf.
- Reduce the environmental and social impacts of construction activities through the proactive employment of sound and effective working practises.
- Provide for structured documentation of emerging environmental concerns and corrective actions taken to manage them.
- Demonstrate due diligence

10.3. ESMP Implementation

An Environmental and Social Management Plan has been prepared to identify and sequence environmental activities that are needed in order to complete a required construction process. Prior to commencement the Contractor will be required to prepare his own Construction Environmental and Social Management Plan that is in line with the project EIA.

10.3.1. Method Statement

Method statements would be completed on behalf of the Main Contractor or Sub Contractor by an Occupational Safety and Health Officer and qualified Environmentalist or other appropriate experienced personnel, in consultation with KPWD/KRCL environmental staff and, where necessary, environmental consultants. Their production would include a review of the environmental and safety and health risks and commitments, as identified in the ESMP and risk assessment, so that appropriate control measures are developed and included within the construction process.

Method statements would be reviewed by PIU, the Main or Sub Contractor’s appointed environmental manager and, where necessary, by an appropriate environmental specialist. Where necessary, all method statements would be submitted to the enforcement agencies as appropriate. Method statements would contain as a minimum:

- Location of the activity and access/egress arrangements;
- Works to be undertaken and methods of construction;
- Equipment including any machinery and materials to be used;
- Labour and supervision requirements;
- Safety ,Health and environmental considerations; and
- Any permit or consent requirements including registration of the work place and approval of deployed equipment where required e.g. of cranes.

10.3.2. Control of Construction Process

10.3.2.1. Supervision of Construction Activities

All construction activities including those carried out by subcontractors and suppliers would be supervised, or regularly checked through the completion of site inspections by the Contractors Environmental Manager, to ensure that requirements identified in risk assessments or method statements have been implemented. The frequency and extent of this supervision would vary according to the degree of competence displayed by the workforce and the level of risk to the environment.

Environmental deliverables required by the Construction Environmental Management Plan (CEMP) would be subject to regular independent supervision by either the Environmental Manager or the relevant environmental specialists. These inspections would be used to confirm that:

- Construction works are progressing in accordance with the agreed method statements';
- Agreed protection or mitigation measures are in place, prior to or during the implementation of construction activities;
- Construction works have been completed in accordance with the design and commitments made during the statutory approval process

10.3.2.2. Environmental Inspection and Reporting

The Contractors Environmental Manager would carry out an assessment of the project's environmental performance, based upon the reports from the environmental management representatives during the period, reports from the environmental specialists and from his own site inspections. This would be carried out at a frequency at no greater than monthly intervals but could be held more regularly depending on the nature of the construction activity. An assessment of the performance over the month would be made and quantified. A monthly report detailing performance for the period would be provided to the KPWD/KRCL and would include a summary of environmental inspections completed, audits undertaken, complaints and incidents.

The monthly environmental report would:

- Consider past performance from inspections, audit reports and monitoring data;
- Plan actions required to mitigate forthcoming risks; and
- Disseminate best practice.

10.3.3. Environmental and Social due Diligence during Construction

During the construction phase, environmental due diligence will be incorporated into the Project implementation mainly to:

- Control the residual risk of accidental environmental damage; and
- Prevent the negative environmental impacts during construction.

The contractor and supervising engineer will have the primary responsibility for the due diligence. The supervising Engineer MUST be required to include environmental considerations in the monthly progress reports and indicate progress in the implementation of mitigation measures as outlined in the ESMP.

The Construction risks to be monitored will include, but not be limited to the following issues:

- Handling of any hazardous materials including hydrocarbons as part of construction activities;

- Movement of machinery;
- Management of borrow and spoil areas including soil erosion;
- Sedimentation of watercourses;
- Collection and disposal of wastes;
- Management of pollution incidents;
- Safety and health management at construction sites; and
- Addressing local community concerns on the project implementation activities.

10.4. Environmental and Social Management Action Plan

All project-related activities, their impacts on environment, mitigation measures for the impacts at different stages of project (construction Phase and operation Phase), and the agency responsible for implementing the mitigation measures have been presented in the **Table 10.1**.

Table 10.1. Environmental and Social Management Action Plan

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
A.	**Project Preparation Phase**				
A.1.	Preparation of Detailed Project Report	Land	Loss of productive land	Proposed alignments are designed minimizing productive land requirement. Land acquisition is restricted only to the development of approach road to the existing connectivity	Design Consultant (Incorporated in DPR)
			Impacts due to siting of project related facilities	Guidelines for siting, management and redevelopment of these by the Concessionaire based on State PCB and other relevant guidelines are presented in Annexure 21 **to** Annexure 26**.**	Design Consultant (Incorporated in DPR)
			Soil erosion	Erosion control measures like compaction of earth, pitching, turfing and landscaping with adequate drainage are included in engineering design. All the above measures comply with IRC: 56-2011 - "Recommended Practice for Treatment of Embankment and Roadside Slopes for Erosion Control."	Design Consultant (Incorporated in DPR)
			Destabilization of slope	Slope stabilization measures like compaction of earth, pitching, construction of retaining wall and proper drainage system such as slope drains and storm water drains are included in the engineering design. All the above drainage facilities are proposed as per IRC: SP: 42 – 2014 – "Guidelines on Road Drainage". All the necessary measures as per IRC: SP: 48 – 1998 – "Hill Road Manual" are incorporated in hill road design process.	Design Consultant (Incorporated in DPR)
			Soil contamination due to spillage of oil and lubricants	Concrete flooring and oil interceptors are proposed for WMM plant area and work shop, vehicle washing and fuel handling area in construction camps as per the design presented in Annexure 19.	Design Consultant (Incorporated in DPR)
			Blocking of natural drainages and filling of water bodies leading to water logging /	Sufficient number of drainage structures like culverts, storm water drains etc. are included in the engineering design. Measures should to be adopted as per the IRC: SP: 42 – 2014 - "Guidelines on Road Drainage."	Design Consultant (Incorporated in DPR)

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
			flooding of adjacent low lying areas		
		Water	Contamination of water due to spillage of oil and lubricants and surface runoff with sediments from construction camps	Concrete flooring and oil interceptors are proposed for WMM plant area and work shop, vehicle washing and fuel handling area in construction camps as per the design presented in **Annexure 19** Sedimentation Trenches and Storm Water Drain are proposed for surface runoff from construction camps as per the design presented in **Annexure 20**	Design Consultant (Incorporated in DPR)
			Contamination of water due to sewage from construction camps, project sites and labour camps	Toilets, sewage collection system and septic tanks are proposed in construction camps and labour camps.	Design Consultant (Incorporated in DPR)
			Contamination of water due to foundation work for bridges.	A geo-technical study was conducted in the bridge locations and it has been found that the soil bearing capacity (SBC) varies from 150 to 250 kN/sqm. Hence open foundation is proposed for bridge construction, which generates comparatively less slurry than well or pile foundation. Enclosures / confinements to arrest the mix of slurry with water are proposed.	Design Consultant (Incorporated in DPR)
			Alterations to natural drainage patterns	Natural drainage patterns should not be altered	Design Consultant (Incorporated in DPR)
			Exploitation of ground water for construction.	Surface water bodies are identified as water sources for construction purposes.	Design Consultant (Incorporated in DPR)
		Air	Increase in air pollution	Propoer mitigation measures are addressed in EIA report	EIA Consultant (Incorporated

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
					in EIA)
		Noise	Increase in noise levels	No sensitive receptors are along the proposed alignment. Sensitive noise receptors within the 15 km radii of the project alignment identified and listed in **Table 0.1.** Mitigation measures are proposed and given in EIA Report**.**	EIA Consultant (Incorporated in EIA)
		Biological	Loss of trees	Tree cutting for the project is restricted only to the approach roads at start and end point connecting to the existing road, to minimise the no. of trees proposed to be cut. Compensatory avenue plantation should be proposed as part of the highway design as per IRC: SP: 21-2009 "Guidelines on Landscaping and Tree Plantation" with the consultation of Forest Dept..	EIA Consultant (Incorporated in EIA)
			Impact on forests	Diversion of forest land was minimized to the extent possible by proposing tunnel-road. New alignments through forest land was minimised to the extent possible.	Design Consultant (Incorporated in DPR)
		Socio-economic	Loss of land, structures and livelihoods	Proposed alignment is selected minimizing socio-economic impact along stretches. It is estimated that 9 structures and 1 open well are going to be affected due to the project. Information dissemination and community consultations were undertaken during the design stage.	EIA Consultant (Incorporated in EIA)
		Solid Waste management	Generation of debris	Demolition of sound structures was avoided as far as possible by reinforcing them instead of replacing with new structures. Recycling / reuse of debris in construction is considered wherever possible.	Design Consultant (Incorporated in DPR)
A.2.	Obtaining Forest Clearance	Application for Forest Clearance will be submitted to Forest Dept.			
A.3.	Obtaining Tree Cutting Permission	Application will be submitted to the concerned Forest Office and Tree marking and enumeration has to be done with the help of forest Officials.			
A.4.	Obtaining Consent to	The application for consent to establish the project will be submitted to Kerala Pollution Control Board (KPCB).			

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
	establish				
B.	**Pre-Construction Phase**				
B.1.	Land Acquisition	Land	No impact	-	-
		Water	No impact	-	-
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	No impact	-	-
		Socio-economic	Loss of land, buildings and livelihood,	The land acquisition will be undertaken in accordance with the RAP and entitlement framework. All R&R activities including payment of compensation to PAPs shall be completed before starting the construction. Land must be provided to the concessionaire free of any encumbrances.	State Govt. and Project Proponent
		Solid waste management	No impact	-	-
B.2.	Relocation of utilities	Land	No impact	-	-
		Water	No impact	-	-
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	No impact	-	-
		Socio-economic	Damages to utilities and inconvenience to public	Make sure that all the utilities being impacted due to the project are relocated by the concerned Departments / Agencies before starting the construction.	Concessionaire
		Solid waste management	No impact	-	-
B.3.	Identification of site for construction camp	Land	Loss of topsoil, soil contamination due to spillage of fuel, lubricants and hazardous chemicals	Locate the camp on non agricultural lands/ waste lands. Detailed site selection criteria given in **Annexure 30** should be followed and details of identified sites should be reported to the Construction Supervision Consultant (CSC) for approval in the format given in Annexure 37**.** Written permission from the land owner is to be obtained if the land is taken on lease. Construction Camp Management and Redevelopment Plan should be	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				prepared as per guidelines given in Annexure 22 and get it approved by the CSC.	
		Water	Surface water pollution due to run off from the site containing oil and silt, and waste water from vehicle washing area and sewage from toilets.	Locate the camp at a minimum distance of 200 m from any surface water body. Detailed site selection criteria given in **Annexure 22** should be followed. Consent to Establish the construction camp should be obtained from the SPCB under Water (Prevention and Control of Pollution) Act, 1974	Concessionaire
		Air	Air pollution due to fugitive dust and gaseous emissions from WMM plant and diesel generator.	Locate the camp at a min. distance of 500 m. in downwind direction of any major settlement or village. Detailed site selection criteria given in Annexure 22 should be followed. Consent to Establish the construction camp should be obtained from the SPCB under Air (Prevention and Control of Pollution) Act, 1981.	Concessionaire
		Noise	Noise pollution due to generator, machineries and movement of vehicles	Locate the camp at a min. distance of 500 m. away from any major settlement or village in downwind direction. Detailed site selection criteria given in Annexure 22 should be followed.	Concessionaire
		Biological	Loss of trees, Impact on forests and wildlife habitats	Record the number of trees to be cut and make provision in the Construction Camp Management and Redevelopment Plan to plant three times the number of trees to be cut. Locate the camp at a min. distance of 500 m. away from forests / wildlife habitats / mangroves / ecologically sensitive areas. Detailed site selection criteria given in **Annexure 22** should be followed.	Concessionaire
		Socio-economic	Inconvenience to local traffic in access roads to construction camp	Select camp site with sufficiently wide access roads for heavy vehicle movement without inconvenience to local traffic. Detailed site selection criteria given in **Annexure 22** should be followed.	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
		Solid waste management	No impact	-	-
B.4.	Identification of site for labour camps	Land	Loss of top soil and soil productivity due to soil compaction	As far as possible locate the camp on non agricultural or barren lands. Detailed site selection criteria given in Annexure 21 should be followed and details of identified sites should be reported to the CSC for approval in the format given as **Annexure 31** Written permission from the land owner is to be obtained if the land is taken on lease. Labour Camp Management and Redevelopment Plan should be prepared as per guidelines given in **Annexure 21** and submitted to CSC for approval.	Concessionaire
		Water	Unsafe disposal of domestic sewage to nearest water body.	Locate the camp at a minimum distance of 200 m from any surface water body. Detailed site selection criteria given in **Annexure 21** should be followed.	Concessionaire
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Cutting of trees / collection of fire wood and non-timber forest produce (NTFP) from forest, hunting of wild animals, occurrence of forest fire.	Record the number of trees to be cut and make provision in the Labour Camp Management and Redevelopment Plan to plant three times the number of trees to be cut. Locate the camp at a min. distance of 500 m. away from forests / wildlife habitats / mangroves / ecologically sensitive areas. Detailed site selection criteria given in Annexure 21 should be followed.	Concessionaire
		Socio-economic	Impact on Public health and law and order	Obtain permission from local governing body before setting up the camp as per the guidelines for management of labour camps given in Annexure 21**.**	Concessionaire
		Solid waste management	No Impact	-	-

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
B.5.	Identification of site for quarrying and stone crushing operations	Land	Loss of productive land, destabilization of slopes due to modification of natural conditions	Non agricultural or waste lands should be selected for siting quarries and crushers. Quarrying in unstable hill slopes should be avoided. Detailed site selection criteria given in Annexure 23**.** should be followed and details of identified sites should be reported to the CSC for approval in the format given in Annexure 32**.** Written permission from the land owner is to be obtained if the land is taken on lease. Quarry and Crusher Management and Redevelopment Plan should be prepared as per guidelines given in Annexure 23 and get it approved by CSC. Clearance should be obtained from Mining and Geology Department for Quarry and crusher	Concessionaire
		Water	Surface water pollution due to run off from the site	Stone quarry shall be located at a minimum distance of 50 m from any water body. Detailed site selection criteria given in **Annexure 23** should be followed.	Concessionaire
		Air	Increased air pollution due to fugitive dust	Quarry site shall be located at a minimum distance of: 500 m from any inhabited site, Railway line, National Highway, State Highway or Major District Road. The minimum distance between two stone crushers should be 1 km to avoid dust pollution influence of one over the other. Detailed site selection criteria given in **Annexure 23** should be followed. Consent to Establish the Crusher should be obtained from SPCB under Air (Prevention and Control of Pollution) Act, 1981	Concessionaire
		Noise	Increase in noise levels	Quarry site shall be located at a minimum distance of 500 m from any inhabited site. Detailed site selection criteria given in Annexure 23 should be followed.	Concessionaire
		Biological	Loss of trees, Impact on forests and wildlife habitats	Record the number of trees to be cut and make provision in the Quarry Management and Redevelopment Plan to plant three times the number of trees to be cut. Locate the quarry and crusher at a min. distance of 500 m. away from forests / wildlife habitats / mangroves / ecologically sensitive areas. Detailed site selection criteria given in **Annexure 23** should be followed.	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
		Socio-economic	Risk for local inhabitants and passengers through nearby roads, Inconvenience to local traffic in access roads to quarry and crusher	Quarry site shall be located at a minimum distance of: (i) 500 m from any inhabited site (ii) 500 m from National Highways, State Highways and Major District Roads, railways, ropeways and waterways **Select quarry and crusher site with sufficiently wide access roads for heavy vehicle movement without inconvenience to local traffic. Detailed site selection criteria given in Annexure 23 should be followed.** Following licenses should be obtained. (i) License from Petroleum and Explosive Safety Organization for storage of explosives for quarry (ii) License from Revenue Authorities for Quarry (iii) License from Gram Panchayath for Quarry and Crusher	Concessionaire
		Solid waste management	Impacts due to improper disposal of overburden from quarry site.	Site for overburden disposal should be planned within the quarry site or any other appropriate site. Quarry Management and Redevelopment Plan should address the disposal of overburden.	Concessionaire
B.6.	Identification of borrow sites	Land	Loss of productive land, loss of top soil, soil erosion, alterations in local topography, flooding of land due to collapse of river bund / irrigation tank bund.	Borrow site shall be selected preferably from barren, infertile lands and located at a minimum distance of: (i) 30 m away from the toe of the embankment along road side. (ii) located not less than 30 m from the toe of the bank along the river side or irrigation tank bund (iii) at least 500 m from villages and settlements Detailed site selection criteria given in **Annexure 24** should be followed and details of identified sites should be reported to the CSC for approval in the format given in **Annexure 33**. Written permission from the land owner is to be obtained if the land is taken on lease. Borrow Area Management and Redevelopment Plan should be prepared	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				as per the guidelines given in **Annexure 24** and get approved by CSC.	
		Water	Collapse of irrigation tank bund and loss of irrigation water.	Borrow area should be located at a minimum distance of 30m from the toe of the irrigation tank bund. Detailed site selection criteria given in **Annexure 24** should be followed.	Concessionaire
		Air	Increased air pollution due to fugitive dust	Borrow site shall be located at a minimum distance of 500 m in down-wind direction of villages and settlements. Detailed site selection criteria given in **Annexure 24**should be followed.	Concessionaire
		Noise	Increase in noise levels	Borrow site shall be located at a minimum distance of 500 m in down-wind direction of villages and settlements. Detailed site selection criteria given in Annexure 24 should be followed.	Concessionaire
		Biological	Loss of trees, Impact on forests and wildlife habitats	Record the number of trees to be cut in the borrow area and make provision in the Borrow Area Management and Redevelopment Plan to plant three times the number of trees to be cut. Locate the borrow area at a min. distance of 500 m. away from forests / wildlife habitats / mangroves / ecologically sensitive areas. Detailed site selection criteria given in Annexure 24 should be followed.	Concessionaire
		Socio-economic	Inconvenience to local traffic in access roads to borrow area, Occurrence of water borne diseases due to accumulation of water in borrowed lands.	Select borrow site with sufficiently wide access roads for heavy vehicle movement without inconvenience to local traffic. Detailed site selection criteria given in Annexure 24 should be followed. Borrow Area Management and Redevelopment Plan should address the water logging issue.	Concessionaire
		Solid waste management	No impact	-	-
B.7.	Identification of water sources	Land	No impact	-	-
		Water	Ground water depletion	Only surface water should be used for construction and dust suppression. Possibility of using treated industrial water for dust suppression should be	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				explored. Details of identified water sources should be submitted to CSC for approval in the format given in Annexure 36**.** Water for domestic use should be sourced from municipal water supply or from approved water suppliers. Permission from relevant state authority (PWD / Irrigation dept.) should be obtained for surface water extraction.	
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	No impact	-	-
		Socio-economic	Reduction in water available for agriculture and domestic purposes	Extraction of water from public water supply schemes, community spring water sources, community hand pumps, and community wells should be avoided. Local community should be consulted (with respect to the quantity of water, time and duration of withdrawal) before finalizing the surface water sources.	Concessionaire
		Solid Waste Management	No impact	-	-
B.8.	Identification of site for debris / excess soil/muck disposal	Land	Loss of soil productivity, soil contamination, soil erosion	Select barren / degraded land. Productive lands should be avoided as far as possible. Distance from source of debris generation to debris disposal site and detailed guidelines given in Annexure 25 should be considered in site selection process. Details of identified debris disposal site should be reported to CSC for approval in the format given in Annexure 34 Written permission should be obtained from the owner, in case of private land and from Gram Panchayth, in case of Panchayath land. Debris Disposal Management and Redevelopment Plan should be prepared as per the guidelines given in **Annexure 25** and get approved by CSC.	Concessionaire
		Water	Surface water pollution due to run off from the debris and soil	Debris disposal site should be at least 200 m away from surface water bodies. Detailed site selection criteria given in **Annexure 25** should be followed.	Concessionaire
		Air	Air pollution due to	No residential areas should be located within 100 m downwind side of the	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
			fugitive dust during dumping of debris and soil	debris disposal site. Detailed site selection criteria given Annexure 25 should be followed	
		Noise	Noise pollution due to movement of vehicles and dumping of debris.	No residential areas should be located within 100 m downwind side of the debris disposal site. Detailed site selection criteria given in Annexure 25 should be followed	Concessionaire
		Biological	Loss of vegetative cover, impact on wildlife habitats	Wherever possible, locate the site on waste lands. Site to be located at least 500 m away from wildlife habitats / Mangroves / Ecologically sensitive areas. Detailed site selection criteria given in **Annexure 25** should be followed.	Concessionaire
		Socio-economic	Obstruction to movement of local inhabitants, affect the safety and aesthetical beauty of the locality.	Public perception about the location of debris disposal site should be obtained before finalizing the location. Detailed site selection criteria given in Annexure 25 should be followed.	Concessionaire
		Solid waste management	No impact	-	-
C.	**Construction Phase**				
C.1.	**Site Preparation Activities**				
C.1.1.	Setting up of construction camp	Land	Soil contamination due to spillage of fuel and lubricants, soil erosion due to surface run off.	Topsoil conservation to be carried out as per guidelines given in Annexure 26. Concrete flooring and oil interceptors should be proposed for WMM plant area and work shop, vehicle washing and fuel handling area in construction camps as per the design presented in Annexure 19**.** Measures as per IRC: 109 – 1997 “Guidelines for Wet Mix Macadam Plant” should be adopted. Sedimentation trenches should be made along the storm water drain as presented in Annexure 20 to control soil erosion due to surface run off. Proper maintenance of vehicles and machineries should be carried out to	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				minimize the spillage of oil. Provision should be made for storage of used oil. Authorization should be obtained from the SPCB under Hazardous Waste (Management, Handling and Trans-boundary Movement) Rules, 2008 for collection, storage and disposal of hazardous wastes. Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed. Once the camp is setup, it should be entered in the register of sites given in **Annexure 35** Compliance Report on Setting up of Construction Camp should be submitted to CSC for approval in the format given **Annexure 37** prior to commencing operation.	
		Water	Contamination of water due to spillage of oil and lubricants and surface runoff with sediments from construction camps. Contamination of water due to sewage from construction camps	Concrete flooring and oil interceptors should be provided for WMM plant area and work shop, vehicle washing and fuel handling area in construction camps as per the design presented in Annexure 19. Sedimentation trenches should be made along the storm water drain as presented in Annexure 20 to catch the sediments in surface run off. Toilets, sewage collection system and septic tanks should be proposed in construction camps. Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed. Consent to operate the construction camp should be obtained from SPCB under Water (Prevention and Control of Pollution) Act, 1974 before starting the operation.	Concessionaire
		Air	Air pollution due to fugitive dust and gaseous emissions from WMM plant and diesel generator	Arrangements should be made for regular sprinkling of water for dust suppression. All the vehicles should have Pollution under Control certificate. Stack height and emission level of WMM plant and diesel generator should meet the relevant SPCB guidelines. WMM plants should have the latest, advanced pollution control measures available in the country. Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed. Consent to operate the construction camp should be obtained from SPCB	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				under Air (Prevention and Control of Pollution) Act, 1981 before starting the operation.	
		Noise	Increase in noise level due to diesel generator, other machineries and vehicles	Diesel generator should have noise control measures to meet the noise standards set by Central Pollution Control Board (75 dB(A) at 1 m from the enclosure surface for generators with integral acoustic enclosure. Acoustic enclosure for generators without integral acoustic enclosure shall be designed for minimum 25 dB(A) insertion loss or for meeting the ambient noise standards, whichever is on the higher side at 0.5 m from the enclosure). Noise level of vehicles used for construction activities should meet the noise standards set by Central Pollution Control Board (maximum 80 dB(A)). Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Biological	Loss of vegetation	Green belt development along the camp boundary should be undertaken. No. of trees planted should not be less than three times the number of trees cut. Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Socio-economic	Occupational health and safety impacts for workers	Safe drinking water and sanitation facilities should be made available to the construction workers. Personal protective equipments such as ear plugs, helmets, goggles, gloves etc. should be made available to the construction workers. Fire fighting equipments like fire extinguishers shall be provided in the camp as per fire safety standards. Fencing should be provided for the camp to prevent trespassing of humans and animals into the camp. Operation manuals and training should be provided to machine operators. Warning signs should be placed at accident prone areas. Other provisions to ensure worker's safety shall be followed as per guidelines given in **Annexure 27** Construction Camp Management and Redevelopment Plan approved by	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				the CSC should be strictly followed.	
		Solid Waste management	Unscientific disposal of debris / solid waste	Debris / solid waste should be disposed in debris disposal site approved by CSC. Guidelines for management of debris disposal given in should be followed.	Concessionaire
C.1.2.	Setting up of labour camp	Land	Loss of soil productivity	Topsoil conservation to be undertaken as per guidelines given in **Annexure 26**. Labour Camp Management and Redevelopment Plan approved by the CSC should be strictly followed. Once the camp is setup, it should be entered in the register of sites given in **Annexure 35** Compliance Report on Setting up of Labour Camp should be submitted to CSC for approval prior to commencing operation of the camp.	Concessionaire
		Water	Pollution of water bodies with sewage	Toilets, sewage collection system and septic tanks should be provided in labour camp. Labour Camp Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Loss of vegetation	Green belt development along the camp boundary should be undertaken. No. of trees planted should not be less than three times the number of trees cut.	Concessionaire
			Deforestation	LPG should be provided for cooking to avoid firewood collection from forest. Labour Camp Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Socio-economic	Health impact due to fire accidents, Increase in communicable diseases	Labour camps should not be constructed with inflammable materials. Fire safety standards should be followed in camp construction. Fire fighting equipments like fire extinguishers shall be provided in the camp as per fire safety standards. Worker's safety shall be ensured as per guidelines given in Annexure 27 Safe drinking water, toilets, sewage collection system and septic tanks should be provided in labour camp.	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				Labour Camp Management and Redevelopment Plan approved by the CSC should be strictly followed.	
		Solid Waste management	Unhygienic environment due to unsafe disposal of waste generated.	Provision of adequate space for segregated waste collection and waste handling. Provision of separate waste bins for bio-degradable, non-degradable and domestic hazardous waste.	Concessionaire
C.1.3.	Setting up of Quarry and Crusher	Land	Loss of top soil	Topsoil conservation should be undertaken as per guidelines given in Annexure 26. Quarry and Crusher Management and Redevelopment Plan approved by the CSC should be strictly followed. Once the quarry and crusher is setup, it should be entered in the register of sites given in Annexure 35. Compliance Report on Setting up of Quarry and Crusher should be submitted to CSC for approval prior to commencing operation of the quarry and crusher.	Concessionaire
		Water	Surface water pollution due to run off with sediments from the site	Contour trenches should be made around the quarry and crusher as presented in Annexure 20 to catch the sediments in surface run off. Quarry and Crusher Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Air	Air pollution due to fugitive dust and emissions from diesel generator	All dust producing units should be housed in a building with suitable roofing and flooring. Dust extraction unit with a collection system should be provided in the crusher unit and all transfer points. Stack height and emission level of diesel generator should meet the relevant SPCB guidelines. Water sprinkling arrangements for dust suppression at the crusher and access roads should be provided. Roads inside the crusher premises should be paved. Green belt development along the crusher site boundary should be undertaken. Consent to operate the crusher unit should be obtained from SPCB under Air (Prevention and Control of Pollution) Act, 1981 before starting the operation.	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				Quarry Area and Crusher Unit Management and Redevelopment Plan approved by the CSC should be strictly followed.	
		Noise	Noise pollution due to Crusher	All noise producing units should be housed in a building with wall of minimum 23 cm thickness and with suitable roofing and flooring.	Concessionaire
		Biological	Loss of vegetation	Green belt should be developed along the boundary of crusher site. Number of trees planted should not be less than three times the number of trees cut.	Concessionaire
		Socio-economic	Occupational health and safety impacts for workers, Risk for local inhabitants and passengers through nearby roads.	Safe drinking water and sanitation facilities should be provided for the construction workers. Personal protective equipments such as ear plugs, helmets, goggles, gloves etc. should be made available to the construction workers. Fencing should be provided for the quarry and crusher to prevent trespassing of humans and animals into the area. Blasting timings in quarry should be fixed avoiding the rush hours. Warning sign boards regarding blasting timings in quarry should be displayed at appropriate locations to inform public. Warning siren should be provided to inform the public and workers before blasting. Training should be provided to workers regarding safe operation procedures Quarry and Crusher Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Solid Waste Management	No impact	-	-
C.1.4.	Setting up of borrow area	Land	Loss of topsoil, soil erosion	Topsoil conservation to be undertaken as per guidelines given in **Annexure 26.** Contour trenches as presented in Annexure 20 should be made along the borrow area boundary considering the topography to prevent soil erosion. Borrow Area Management and Redevelopment Plan approved by CSC should be strictly followed. Once the borrow area is setup, it should be entered in the register of sites given in Annexure 35. Compliance Report on Setting up of borrow area should be submitted to	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				CSC for approval prior to commencing operation of the borrow area.	
		Water	Pollution of water bodies due to surface run off.	Contour trenches as presented in **Annexure 20** should be made along the borrow area boundary considering the topography to catch the sediments from surface runoff. Borrow Area Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Air	Air pollution due to fugitive dust.	Arrangements should be made for sprinkling of water for dust suppression. Borrow Area Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Noise	No impact	-	-
		Biological	Loss of trees	Three times the number of trees cut should be planted. Borrow Area Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Socio-economic	Risk for local inhabitants due to trespassing	Fencing should be provided for the borrow area to prevent trespassing of humans and animals into the area.	Concessionaire
		Solid Waste Management	No impact	-	-
C.1.5.	Preparation of debris / muck disposal site	Land	Loss of productive land, erosion of disposed soil	If the site is located in productive land, topsoil conservation should be undertaken as per guidelines given in Annexure 25**.** Contour trenches as presented in **Annexure 20** should be made along the debris disposal site boundary considering the topography to prevent soil erosion. Debris disposal site Management and Redevelopment Plan approved by CSC should be strictly followed. Once the camp is setup, it should be entered in the register of sites for opened and closed given in **Annexure 35**. Compliance Report on Setting up of debris disposal site should be submitted to CSC for approval prior to commencing operation of the site.	Concessionaire
		Water	Surface water pollution due to run	Contour trenches as presented in **Annexure 20** should be made along the debris disposal site boundary considering the topography to catch the	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
			off from the site	sediments in runoff.	
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Loss of trees	Three times the number of trees cut should be planted. Debris Disposal Site Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Socio-economic	Risk for local inhabitants due to trespassing	Fencing should be provided for the debris disposal site to prevent trespassing of humans and animals into the area.	Concessionaire
		Solid waste management	No impact	-	-
C.1.6.	Clearing, Grubbing and Stripping	Land	Destabilization of slopes, soil erosion.	Avenue plantation to be undertaken as per IRC: SP 21-2009 "Guidelines on Landscaping and Tree Plantation" to compensate for the lost trees. No. of trees planted should not be less than three times the no. of trees cut. Please refer **Annexure 15** for details of tree cutting along the corridor.	Concessionaire
		Water	No impact	-	-
		Air	Change in micro climate	Avenue plantation to be undertaken as per IRC: SP 21-2009 "Tree Plantation and Landscaping" to compensate for the lost trees. No. of trees planted should be more than three times the number of trees cut.	Concessionaire
		Noise	Increase in noise levels	Avenue plantation to be undertaken as per IRC: SP 21-2009 "Guidelines on Landscaping and Tree Plantation" to compensate for the lost trees. No. of trees planted should be more than three times the number of trees cut.	Concessionaire
		Biological	Loss of vegetative cover and impact on fauna	Trees shall be removed in phases. Small trees shall be transplanted wherever possible to minimise the impacts of loss of trees. Areas of tree plantation cleared will be replaced according to Compensatory Afforestation Policy under Forest Conservation Act - 1980. The compensatory avenue plantation shall be taken up at the onset of monsoon season as per IRC: SP 21-2009 "Guidelines on Landscaping and	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				Tree Plantation" and in consultation with the Kerala State Forest Department. No. of trees planted should be more than three times the no. of trees cut. The plants shall be provided with adequate protection from animals and proper monitoring shall be carried out to ensure their survival and growth. Landscaping shall be done with a lag of 3 to 4 months from the start of the work on any section. The section shall be deemed to be completed when the landscaping is over.	
		Socio-economic	Loss of tree shade. Safety of pedestrians and passers by.	The compensatory avenue plantation shall be carried out as per IRC: SP 21-2009 "Guidelines on Landscaping and Tree Plantation." Provide adequate signages and cordon off the area so as to ensure the safety of the pedestrians and passers by.	Concessionaire
		Solid waste management	Unscientific / unsafe disposal of tree waste	Tree wastes should not be burned.	Concessionaire
C.1.7.	Cutting of Earth	Land	Loss of topsoil, water logging due to alterations in natural drainage patterns.	Topsoil conservation to be undertaken as per guidelines given in Annexure 26. Avoid dumping of earth into canals, drainage channels and water bodies. As far as possible avoid construction activity during monsoon.	Concessionaire
		Water	Blocking of cross drainage and water logging, contaminating water bodies	Ensure compliance with design measures as per the drawings. Avoid dumping of earth into canals, drainage channels and water bodies.	Concessionaire
		Air	Increased air pollution due to fugitive dust/ emissions.	Sprinkling of water on site for dust suppression.	Concessionaire
		Noise	Increase in noise levels	Near sensitive receptors use temporary noise barriers and avoid work at night. For cutting of rocks, instead of mechanical blasting, rock cutting process	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				shall be carried out to reduce the noise pollution.	
		Biological	No impact	-	-
		Socio-economic	No impact	-	-
		Solid waste management	No impact	-	-
C.1.8.	Filling	Land	Loss of topsoil, alteration of natural drainage patterns.	Topsoil conservation to be undertaken as per guidelines given in **Annexure 26**. As far as possible, maintain the natural drainage pattern undisturbed.	Concessionaire
		Water	Diversion of natural surface water flows, alterations/blocking of cross drainage and water logging.	Ensure compliance with design measures as per the drawings. Earth, stone or any other construction material shall be properly disposed off safely so that the flow of water in cross drainage channels is not blocked.	Concessionaire
		Air	Increased air pollution due to fugitive dust / emissions.	Sprinkling of water on site for dust suppression.	Concessionaire
		Noise	Increase in noise levels	At construction sites within 150 m of human settlements, noisy construction shall be stopped between 10:00 pm and 6:00 am. Use temporary noise barriers near sensitive receptors.	Concessionaire
		Biological	No impact	-	-
		Socio-economic	Flooding of adjacent low lying land	Ensure compliance with design measures as per the drawings.	Concessionaire
		Solid waste management	No impact	-	-
C.1.9.	Clearing Grubbing and Stripping	Land	Destabilisation of slopes, soil erosion	Avenue plantation to be undertaken as per IRC: SP 21-2009 " Guidelines on Landscaping and Tree Plantation" to compensate for the lost trees. No. of trees planted should be less than three times the no. of trees cut.	Concessionaire
		Water	No impact	-	-

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
		Air	Increased air pollution	Sprinkling of water on site for dust suppression.	Concessionaire
		Noise	Increase in noise levels	Near sensitive receptors use temporary noise barriers.	Concessionaire
		Biological	No impact	-	-
		Socio-economic	No impact	-	-
		Solid waste management	No impact	-	Concessionaire
C.1.10.	Demolition	Land	No impact	-	-
		Water	No impact	-	-
		Air	Increased air pollution due to fugitive dust	Sprinkling of water on site for dust suppression.	Concessionaire
		Noise	Increase in noise levels due to demolition activity	Near sensitive receptors use temporary noise barriers and avoid work at night.	Concessionaire
		Biological	No impact	-	-
		Socio-economic	No impact	-	-
		Solid waste management	Unscientific / unsafe disposal of debris	Debris to be disposed off in the sites identified for the same as per guidelines.	Concessionaire
D.2.	**Construction Activities**				
D.2.1.	Tunnel construction activities including boring and blasting of rocks	Land	Increased risks of landslides and other Geological/ seismic hazards	Implement Geotechnical monitoring through Excavation Performance Review (EPR) system to continuously monitor the Geotechnical stability during the construction phase using appropriate instrumentation; Formulate an emergency communication plan for alerting the local community where the need arises	Concessionaire
			Contamination of soil due to spillage	Machinery and equipments are maintained and refilled in such a fashion that fuel spillage does not contaminate soil.	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
			of oil, lubricants and hazardous chemicals	Soil quality monitoring shall be conducted as per Environmental Monitoring Plan to ascertain level of contamination.	
		Water	Contamination water due to spillage and careless handling of oil and lubricants	Machinery and equipments are maintained and refilled in such a fashion that fuel spillage does not contaminate the water bodies. Fuel storage and refilling sites shall be kept away from cross drainage structures and important water bodies. All spills shall be disposed off as desired and the site shall be fully cleaned before handing over. Water quality monitoring shall be conducted as per Environmental Monitoring Plan to ascertain level of contamination.	Concessionaire
		Air	Increased air pollution	Sprinkling of water on site for dust suppression. The construction operations during nights, especially in the winter season shall be carried out under restricted conditions. All machinery and equipment used for construction shall be regularly maintained to ensure that the emission levels are as per norms of PCB. Air quality monitoring shall be conducted as per Environmental Monitoring Plan to detect any deterioration in air quality due to the construction activities.	Concessionaire
		Noise	Increase in noise levels	Construction contract shall clearly specify the use of equipment emitting noise of not greater than 90 dB (A) for the eight hour operation shift. The main noise producing sources such as the concrete mixers, generators, grader etc. shall be provided with noise shields around them. At construction sites within 150 m of human settlements, noisy construction shall be stopped between 10:00 pm and 6:00 am. Near sensitive receptors use temporary noise barriers and avoid work at night. Noise level monitoring shall be conducted as per Environmental Monitoring.	Concessionaire
		Biological	No impact	-	-
		Socio-economic	Disruption of Traffic	Traffic Management Plan shall be prepared based on guidelines presented in Annexure 28	Concessionaire
			Occurrence of	Other provisions to ensure worker's safety shall be followed as per	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
			accidents	guidelines given in Annexure 27. Follow guidelines in Annexure 29 to ensure safety in storage and handling of hazardous substances. The safety checklist given in Annexure 43 should be submitted to CSC at required intervals. On occurrence of any accident or injury, the safety officer should submit an accident report to the CSC in the format given in Annexure 44. The Concessionaire should establish an emergency response procedure and display on all work areas during construction activities Construction sites should be adequately barricaded from the general public and conspicuous warnings posted in national and local languages;	
		Solid waste management	Unscientific / unsafe disposal of debris	Debris to be disposed off in the sites identified for the same as per guidelines.	Concessionaire
D.2.2.	Use and servicing of fossil fuel powered plant; Oil storage; Concrete production and use	Land	Soil Pollution	No vehicle/plant maintenance shall take place on undesignated site. In case of emergency, a drip tray shall be used to avoid diesel and / or oil spills; Concrete mixing shall not be done on bare soil. Concrete must be mixed on mortarboards, a large metal sheet or concrete slab. The slabs for concrete mixing shall be removed on completion of construction works; Excavated material shall be stockpiled at a demarcated site, within the construction zone; Once the construction activities have terminated, rehabilitatio	Concessionaire
		Water	Oil Spill	Vehicle maintenance should be done on purpose-built impervious concrete platforms with oil and grease traps; Ensure that all equipment are in good condition, clean and free from leaks; Oil spill containment and cleanup equipment should be kept at the contractor's camp. Construct oil skimming tanks at the locations directed and in accordance with details approved by the Engineer. Oil recovered from the skimming tanks shall be stored in drums and removed from the site for safe disposal;	-

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				Monitor effluent discharge from the oil skimming tanks.	
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Riverine microhabitat alterations; Loss of otter dens; and Loss of breeding and nursery grounds for fishes and invertebrates	Ensure adequate waste management plan is in place and in use from the onset of construction; and Oil spill containment and clean-up equipment should always be available at the construction site with trained response team; Implement erosion and sediment management plan; Systematic search, capture and safe release of otters inhabiting the right of way (for the weir structures) and fish pass); and Selective clearing and restoration of vegetation after construction	Concessionaire
		Socio-economic	No impact	-	-
		Solid waste management	-	-	-
D.2.3.	Operation of construction camp	Land	Complete elimination of productive capacity of soil, spillage of fuel, lubricants and hazardous chemicals.	Proper maintenance of vehicles and machineries should be carried out to minimize the spillage of oil. Oil and grease waste generated from garages in construction camps should be drained out through catch drains and oil interceptors. Sanitation facilities, storm water drainage, catch drains and oil interceptors should be maintained properly. Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed. Details of WMM plant and machineries in operation should be reported to CSC in the format given in Annexure 41 **and** Annexure 42	Concessionaire
		Water	Surface water pollution due to run off and waste water / sewage disposal from the camps.	Sanitation facilities, storm water drainage, catch drains and oil interceptors should be maintained properly. Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed. Water quality monitoring should be conducted as per Environmental Monitoring Plan so that appropriate measures are taken up towards	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				abatement of pollution.	
		Air	Increase in air pollution due to operation of machineries.	PUC certificates of all machineries should be renewed at required intervals. Water sprinkling should be undertaken for dust suppression. Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed. Air quality monitoring should be conducted as per Environmental Monitoring Plan so that appropriate measures are taken up towards abatement of pollution.	Concessionaire
		Noise	Increase in noise level due to operation of machineries.	Diesel generators and vehicles used for construction activities should be maintained well to ensure that the noise levels continues to be within the noise standards set by Central Pollution Control Board (maximum 80 dB(A)). At construction camps within 150 m of human settlements, noisy construction should be stopped between 10:00 pm and 6:00 am. Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed. Noise level monitoring should be conducted as per Environmental Monitoring Plan.	-
		Biological	Loss of vegetation	Saplings planted for green belt development should be properly taken care of and protected to ensure their survival and growth.	-
		Socio-economic	Occupational health and safety impacts for workers	Provision of safe drinking water and access to sanitation services should be continued at satisfactory service levels.	Concessionaire
				Construction workers should use the personal protective equipments provided to them and it shall be replaced if necessary. Fire fighting equipments like fire extinguishers provided in the camp should be maintained well. Fencing of the camp to prevent trespassing of humans and animals into the camp should be maintained properly. Other provisions to ensure worker's safety should be followed as per **Annexure 27.** The safety checklist given in **Annexure 43** should be submitted to CSC at required intervals. On occurrence of any accident or	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				injury, the safety officer should submit an accident report to the CSC in the format given in **Annexure 44**. Follow guidelines in **Annexure 29** to ensure safety in storage and handling of hazardous substances. Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed. Construction sites should be adequately barricaded from the general public and conspicuous warnings posted in national and local languages;	
		Solid waste management	Unscientific / unsafe disposal of debris / waste	Collected oil and grease should be reused or sold out to approved oil recycling agencies. Debris / solid waste should be disposed in debris disposal site approved by CSC. Guidelines for management of debris disposal given in Annexure 25 should be followed.	Concessionaire
D.2.4.	Functioning of labour camp	Land	Contamination of soil due to waste water	Labour Camp Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Water	Surface water pollution due to run off from the site	Toilets, sewage collection system and septic tanks provided in labour camp should be properly maintained. Labour Camp Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Air	Air pollution due to burning of dry waste/ fire wood.	Waste bins should be provided for waste collection and safe disposal. LPG should be provided for cooking.	Concessionaire
		Noise	No impact.	-	-
		Biological	Loss of trees, Impact on forests, spread of forest fire	Saplings planted for green belt development should be properly taken care of and protected to ensure their survival and growth. If the camp is located near the forest, orient the labours to refrain from any activities involving spread of forest fire, poaching or NTFP collection.	Concessionaire
		Socio-economic	Increase in communicable diseases Increase in crime	Toilets, sewage collection system and septic tanks provided in labour camp should be properly maintained. To the extent possible local people should be included in the labour force. Information dissemination should be undertaken to generate awareness	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
			rate Indulgence in hunting and collection of forest produces.	among migrant labours about the sensitivities of the region.	
			Collection of firewood if camp is near the forest Chances of forest fires	Sensitisation of labours should be undertaken to refrain them from collecting fire wood or any other NTFPs from nearby forests, (if any). LPG should be provided for cooking and use of fire wood for cooking or any other purpose should be strictly banned.	Concessionaire
			Occurrence of accidents	Fire fighting equipments like fire extinguishers provided in the camp should be maintained well. Fencing of the camp to prevent trespassing of humans and animals into the camp should be maintained properly. Other provisions to ensure worker's safety should be followed as per guidelines given in **Annexure 27**. The safety checklist given in **Annexure 43** should be submitted to CSC at required intervals. On occurrence of any accident or injury, the safety officer should submit an accident report to the CSC in the format given in **Annexure 44**.	Concessionaire
		Solid waste management	Unhygienic environment due to unsafe disposal of solid waste generated.	Periodical maintenance of waste handling space should be undertaken. Provision of separate waste bins for bio-degradable, non-degradable and domestic hazardous waste should be continued. Disposal of collected waste in nearest approved landfill site or identified debris disposal site should be undertaken.	Concessionaire
D.2.5.	Quarrying and operation of crushers	Land	Loss of soil productivity, soil contamination	To avoid spillage of fuel and lubricants, the vehicles and equipment shall be properly maintained and repaired. Maintenance should be carried out on impervious platforms with spill collection provisions. Quarry Area and Crushing Unit Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Water	Surface water pollution due to run off from the site	To avoid spillage of fuel and lubricants, the vehicles and equipment should be properly maintained and repaired. Maintenance should be carried out on impervious platforms with spill collection provisions.	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				Quarry Area and Crushing Unit Management and Redevelopment Plan approved by the CSC should be strictly followed. Water quality monitoring shall be conducted as per Environmental Monitoring Plan to detect any contamination or spillage.	
		Air	Air pollution due to fugitive dust.	Sprinkling of water on site for dust suppression should be undertaken. Provide sufficient water storage facility for 2 days use. Roads inside the crusher premises should be tarred or concreted. Air quality monitoring should be conducted as per Environmental Monitoring Plan to detect air pollution.	Concessionaire
		Noise	Noise pollution due to stone blasting	Adopt controlled blasting techniques. Conduct quarrying in a skillful, scientific and systematic manner. Follow a routine and preventive maintenance procedure for the DG set in consultation with the DG set manufacturer. The stack height of the DG set has to be adequate. Workers shall not be exposed to sound of more than 85 – 90 DB for more than eight hours a day and shall be provided with ear plugs. Quarry Area and Crushing Unit Management and Redevelopment Plan approved by the CSC should be strictly followed. Noise quality monitoring shall be conducted as per Environmental Monitoring Plan to detect noise pollution.	Concessionaire
		Biological	No impact	-	-
		Socio-economic	Safety of labours	Adopt controlled blasting techniques. Conduct quarrying in a skillful, scientific and systematic manner. Provision of personal protective equipments to labours. Other provisions to ensure worker's safety shall be followed as per guidelines given in **Annexure 27**. Follow guidelines in Annexure 27 to ensure safety in storage and handling of hazardous substances. The safety checklist given in Annexure 43 should be submitted to CSC at required intervals. On occurrence of any accident or injury, the safety officer should submit an accident report to the CSC in the format given in **Annexure 44.** Sites should be adequately barricaded from the general public and	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				conspicuous warnings posted in national and local languages;	
		Solid waste management	No impact	-	-
D.2.6.	Borrowing of earth	Land	Loss of fertile lands, loss of topsoil, soil contamination, removal of vegetation, soil erosion, destabilization of slopes due to modification of natural conditions.	Borrow Area Management and Redevelopment Plan approved by the CSC should be strictly followed in undertaking borrowing of earth. Details of earthwork in borrow site to be reported to CSC in the format given in Annexure 40.	Concessionaire
		Water	Alterations in local drainage pattern, diversion of natural surface water flows, blocking of cross drainage and water logging.	Natural drainage patterns should not be altered or blocked. Borrow Area Management and Redevelopment Plan approved by the CSC should be strictly followed in undertaking borrowing of earth.	Concessionaire
		Air	Increased air pollution due to fugitive dust	Sprinkling of water on site for dust suppression should be undertaken.	Concessionaire
		Noise	Increase in noise levels	Workers should not be exposed to sound of more than 85 – 90 DB for more than eight hours a day and shall be provided with ear plugs. Noise level of vehicles used for construction activities should meet the noise standards set by Central Pollution Control Board (maximum 80 dB(A)) Construction Camp Management and Redevelopment Plan approved by the CSC should be strictly followed.	Concessionaire
		Biological	No impact	-	

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
		Socio-economic	Occupational health and safety impacts	Workers shall be provided with personal protective equipments such as ear plugs, helmets, goggles, gloves etc. Other provisions to ensure worker's safety shall be followed as per guidelines given in **Annexure 27.** The safety checklist given in Annexure 43 should be submitted to CSC at required intervals. On occurrence of any accident or injury, the safety officer should submit an accident report to the CSC in the format given in Annexure 44**.**	Concessionaire
		Solid waste management	No impact	-	-
D.2.7.	Extraction of Surface water	Land	No impact	-	-
		Water	Over exploitation of surface water	Water should be drawn from only those sources that have got prior approval of CSC.	Concessionaire
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Impact on fauna in lakes and rivers	Over extraction of surface water should be avoided.	Concessionaire
		Socio-economic	Reduction in water available for agriculture and domestic purposes	Over extraction of surface water should be avoided.	Concessionaire
		Solid waste	No impact	-	-
D.2.8.	Transportation of materials	Land	Spillage of fuel, lubricants and hazardous chemicals.	Vehicles and machinery are maintained and refilled in such a fashion that fuel spillage does not contaminate the soil. Fuel storage and refilling sites shall be kept away from cross drainage structures and important water bodies. Soil quality monitoring shall be conducted as per Environmental Monitoring Plan to ascertain level of contamination.	Concessionaire
			Soil erosion and sediment generation	Concessionaire must ensure clear delineation of construction work areas to avoid unnecessary vegetation clearance and soil loosening; The Concessionaire must implement planned erosion control measures to avoid erosion in areas that are prone to erosion, e.g. steep slopes and	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				drainage lines; Topsoil stockpiles will be vegetated to prevent erosion; No topsoil to be utilized during any construction activity; Implement soil conservation measures at stockpiled sites; Where feasible, topsoil must be reinstated and rehabilitated on top of sub soil; All excavation works must be properly backfilled and compacted; Ensure downstream water users are informed about any unprecedented release of heavily silted water into the river; Where possible, construction activities should be scheduled to occur outside of the rainy season, to reduce the anticipated volume of runoff during construction; and Sediment traps and barriers must be employed due to steep terrain.	
			Damage of haul road due to over usage.	Black topping of haul roads and their maintenance regularly for easy plying of construction vehicles as well as the regular local commuters.	Concessionaire
		Water	Contamination of water due to washing of vehicles, construction equipments and machineries	Avoid washing of vehicles, construction equipments and machineries near/inside the water bodies along the project stretch.	Concessionaire
		Air	Increased air pollution due to fugitive dust	Black topping of unpaved haul roads. Dust covers/ tarpaulins shall be provided to cover construction material loaded on trucks. Idling of delivery trucks or other equipment shall not be permitted during periods of unloading or when they are not in active. Sprinkling of water shall be carried out along the haul road at least twice a day on a regular basis during the entire construction period especially in the winter and summer seasons. All vehicles should have PUC certificates.	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
		Noise	Increase in noise levels	Where ever the haul road is passing within 150 m of human settlements, the transportation of material shall be stopped during night time (between 10:00 pm and 6:00 am.).	Concessionaire
		Biological	No impact	-	-
		Socio-economic	Inconvenience to local travelers. Increase in accidents	Black top the road and maintain it regularly Provide adequate traffic safety measures. Establish and enforce a strict code of conduct for all project drivers including outside suppliers delivering materials. The code should focus on safety, especially speed, and loading, especially banning all carriage of staff, workers and passengers except in seats;	Concessionaire
		Solid waste management	No impact	-	-
D.2.9.	Compacting earth and laying of sub-base course	Land	No impact	Soil quality monitoring shall be conducted as per Environmental Monitoring Plan so that appropriate measures are taken up towards abatement of pollution	-
		Water	No impact	Water quality monitoring shall be conducted as per Environmental Monitoring Plan so that appropriate measures are taken up towards abatement of pollution.	-
		Air	Increased air pollution	Sprinkling of water on site for dust suppression. All vehicles, equipment and machinery used for construction shall be regularly maintained to ensure that the emission levels are as per norms of PCB. The construction operations during nights, especially in the winter season shall be carried out under restricted conditions. Air quality monitoring shall be conducted as per Environmental Monitoring Plan to detect any deterioration in air quality due to the construction activities.	Concessionaire
		Noise	Increase in noise levels	Construction contract shall clearly specify the use of equipment emitting noise of not greater than 90 dB (A) for the eight hour operation shift. For protection of construction workers, earplugs shall be provided to those working very close to the noise generating machinery. At construction sites within 150 m of human settlements, noisy	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				construction shall be stopped between 10:00 pm and 6:00 am Near sensitive receptors use temporary noise barriers and avoid work at night. Noise level monitoring shall be conducted as per Environmental Monitoring.	
		Biological	No impact	-	-
		Socio-economic	Disruption of Traffic	Traffic Management Plan shall be prepared based on guidelines presented in **Annexure 28.** Diversion roads to be paved, adequate traffic safety measures to be adopted and reported to CSC in the format given in **Annexure 45**	Concessionaire
			Occurrence of accidents	Other provisions to ensure worker's safety shall be followed as per guidelines given Annexure 27**.** The safety checklist given in **Annexure 43** should be submitted to CSC at required intervals. On occurrence of any accident or injury, the safety officer should submit an accident report to the CSC in the format given in **Annexure 44**	Concessionaire
		Solid waste management	Utilisation of fly ash	If the site is within 100 km from thermal power plant permission under Fly Ash Notification, 2007, to be obtained from regional office of MoEF for using fly ash in the construction process.	Concessionaire
			Unscientific/ unsafe disposal of excess soil	Debris to be disposed off in the sites identified for the same as per guidelines given in **Annexure 25**	Concessionaire
D.2.10.	Laying base course and surface course	Land	No Impact	Soil quality monitoring shall be conducted as per Environmental Monitoring Plan so that appropriate measures are taken up towards abatement of pollution.	Concessionaire
		Water	No Impact	Water quality monitoring shall be conducted as per Environmental Monitoring Plan so that appropriate measures are taken up towards abatement of pollution.	Concessionaire
		Air	Increased air pollution due to fugitive dust generation	Sprinkling of water on site for dust suppression. All equipment and machinery used for construction shall be regularly maintained to ensure that the emission levels are as per norms of PCB. Air quality monitoring shall be conducted as per Environmental Monitoring Plan to detect any deterioration in air quality due to the	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				construction activities.	
		Noise	Increase in noise levels	Construction contract shall clearly specify the use of equipment emitting noise of not greater than 90 dB (A) for the eight hour operation shift. For protection of construction workers, earplugs shall be provided to those working very close to the noise generating machinery. At construction sites within 150 m of human settlements, noisy construction shall be stopped between 10:00 pm and 6:00 am. Near sensitive receptors use temporary noise barriers and avoid work at night. Noise level monitoring shall be conducted as per Environmental Monitoring.	Concessionaire
		Biological	No impact	-	-
		Socio-economic	Disruption of Traffic	Traffic Management Plan shall be prepared based on guidelines presented in **Annexure 28**. Diversion roads to be paved, adequate traffic safety measures to be adopted and reported to CSC in the format given in Annexure 45	Concessionaire
			Occurrence of accidents	Other provisions to ensure worker's safety shall be followed as per guidelines given in Annexure 27**.** Follow guidelines in Annexure 29 to ensure safety in storage and handling of hazardous substances. The safety checklist given in Annexure 43 should be submitted to CSC at required intervals. On occurrence of any accident or injury, the safety officer should submit an accident report to the CSC in the format given in Annexure 44	Concessionaire
		Solid waste management	No impact	-	-
D.2.11.	Construction of bridges,	Land	Spillage of fuel, lubricants and hazardous chemicals	Machinery and equipments used in bridge and culvert construction are maintained and refilled in such a fashion that fuel spillage does not contaminate the soil. Fuel storage and refilling sites shall be kept away from cross drainage structures and important water bodies. All spills shall be disposed off as desired and the site shall be fully cleaned before handing over.	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				Soil quality monitoring shall be conducted as per Environmental Monitoring Plan to ascertain level of contamination.	
		Water	Water pollution due to infusion of slurry into the water body during foundation construction. Impact on water quality due to remnants of construction materials.	Avoid foundation construction of bridges/ culverts during monsoon season. The foundation area should be separated from the other areas with an impervious barrier. This barrier will act as a settling tank for the solids and will prevent substantial increase in the turbidity of surrounding water. The sludge should be removed periodically and disposed off in the selected construction debris disposal sites. Remnants of construction material shall be cleared/ disposed off before vacating the construction site. All construction operators, drivers and workshop personal to be trained well so that can take immediate measures for spill of contaminate. Water quality monitoring shall be conducted as per Environmental Monitoring Plan to ascertain level of contamination.	Concessionaire
		Air	Increased air pollution	Sprinkling of water on site for dust suppression. The construction operations during nights, especially in the winter season shall be carried out under restricted conditions. All the equipment and machinery used for construction shall be regularly maintained to ensure that the emission levels are as per norms of PCB. Air quality monitoring shall be conducted as per Environmental Monitoring Plan to detect any deterioration in air quality due to the construction activities.	Concessionaire
		Noise	Increase in noise levels	Construction contract shall clearly specify the use of equipment emitting noise of not greater than 90 dB (A) for the eight hour operation shift. For protection of construction workers, earplugs shall be provided to those working very close to the noise generating machinery. At construction sites within 150 m of human settlements, noisy construction shall be stopped between 10:00 pm and 6:00 am. Near sensitive receptors use temporary noise barriers and avoid work at night. Noise level monitoring shall be conducted as per Environmental	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
				Monitoring.	
		Biological	Impact on aquatic biota due to disposal of construction material	Demolished old bridge shall be collected in scientific manner and disposed off safely into predetermined debris disposal site. Construction activity to be restricted during breeding period.	Concessionaire
		Socio-economic	Disruption of Traffic	Traffic Management Plan shall be prepared based on guidelines presented in Annexure 28**.**	Concessionaire
			Occurrence of accidents	Other provisions to ensure worker's safety shall be followed as per guidelines given in Annexure 27**.** Follow guidelines in Annexure 29 to ensure safety in storage and handling of hazardous substances. The safety checklist given in Annexure 43 should be submitted to CSC at required intervals. On occurrence of any accident or injury, the safety officer should submit an accident report to the CSC in the format given in Annexure 44**.**	Concessionaire
		Solid waste management	Unscientific / unsafe disposal of debris	All spills and construction shall be disposed off in the sites identified for the same as per guidelines and the site shall be fully cleaned before handing over.	Concessionaire
D.2.12.	Debris / Muck disposal	Land	No impact	It can also be used for filling of low lying play grounds etc.	Concessionaire
		Water		Provide proper drainage facility so that the site do not contaminate any water sources, rivers etc.	
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	No impact	-	-
		Socio-economic	No impact	-	-
		Solid waste management	No impact	-	-
E.	**Post Construction Phase**				

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
E.1	Water diversion into the tunnel		Reduced downstream flow (affecting both domestic and ecological needs)	Allow for downstream compensation flow Ensure strict adherence to the proposed abstraction weirs operation principles Deliberate, compensation release of adequate amount of water downstream to mitigate alteration of the river ecosystem Undertake wet season survey and subsequent annual aquatic fauna surveys for both wet and dry seasons to monitor trends and inform any further management interventions	KPWD
			Deterioration of downstream water quality	Conduct regular water sampling and laboratory analysis to monitor the water quality variations	KPWD
			Changes in riverine and riparian floral compositions	Support local communities to plant indigenous trees along the waterbodies in the project area. Awareness on the same should be enhanced; Undertake continuous ecological monitoring of hydrophytes and high water specific species to track and mitigate any emerging impacts of the project on the plants.	
E.2.	Tunnel leaks		Loss of Water	Monitor volumes at intakes and outfall to allow loss detection; and Ensure regular inspection and maintenance of the tunnel.	KPWD
E.3.	Redevelopment of construction camp sites	Land	Rejuvenation of land	All spills shall be disposed off as desired and the site shall be fully cleaned before handing over. All measures envisaged in construction camp redevelopment plan approved by the SC shall be undertaken.	Concessionaire
		Water	Increased water recharge	Plantation along the boundary, erosion control measures, or slope stabilization measures shall be undertaken based on the activities envisaged in the redevelopment plan approved by the SC.	Concessionaire
		Air	Improvement in air quality	-	-
		Noise	No impact	-	-
		Biological	Increased vegetation	Plantations along the boundary shall be undertaken.	Concessionaire
		Socio-	No impact	-	-

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
		economic			
		Solid waste management	No impact	-	-
E.4.	Redevelopment of quarry sites	Land	Rejuvenation of land	Plantation along the boundary, erosion control measures, or slope stabilization measures shall be undertaken based on the activities envisaged in quarry redevelopment plan approved by the SC.	Concessionaire
		Water	Increased water recharge	Based on the quarry redevelopment plan approved by the SC necessary development activity like water recharging or developing it into a fishing pond shall be undertaken.	Concessionaire
		Air	Improvement in air quality	-	-
		Noise	No impact	-	
		Biological	Increased vegetation	Based on the quarry redevelopment plan approved by the SC necessary re-vegetation activities shall be undertaken.	Concessionaire
		Socio-economic	Involvement of local community and enhancement of their livelihood	Involve local community in the implementation of redevelopment plan.	Concessionaire
		Solid waste management	No impact	-	-
E.5.	Redevelopment of borrow sites	Land	Rejuvenation of land	Undertake leveling or slope stabilization based on borrow redevelopment plan approved by the SC. Top soil reuse to be undertaken depending on the type of redevelopment envisaged in the plan. Status of borrow area redevelopment to be reported to CSC in the format given in **Annexure 46**.	Concessionaire
		Water	Increased water recharge	Depending upon the type and form of rehabilitation to be adopted slope stabilization measures and small bund creations may be undertaken.	Concessionaire
		Air	Improvement in air quality	-	-
		Noise	No impact	-	-
		Biological	Increased	Surplus trees after avenue plantation will be utilized for green belt	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
			vegetation	development of exhausted borrow areas.	
		Socio-economic	Involvement of local community and enhancement of their livelihood	Involve local community in the implementation of redevelopment plan.	Concessionaire
		Solid waste management	No impact	-	-
E.6.	Redevelopment of labour camp sites	Land	Rejuvenation of land	All spills shall be disposed off as desired and the site shall be fully cleaned before handing over. All measures envisaged in construction camp redevelopment plan approved by the SC shall be undertaken.	Concessionaire
		Water	Increased water recharge	Plantation along the boundary, erosion control measures, or slope stabilization measures shall be undertaken based on the activities envisaged in the redevelopment plan approved by the SC.	Concessionaire
		Air	Improvement in air quality	-	-
		Noise	No impact	-	-
		Biological	Increased vegetation	Plantations along the boundary shall be undertaken.	Concessionaire
		Socio-economic	No impact	-	-
		Solid waste management	No impact	-	-
E.7.	Operationalisation of the project stretch	Land	Improvement of road geometry and pavement condition	Proper implementation of traffic rules will be by the traffic Police. Proper maintenance of traffic signs and implementation of accident care facilities along the road will be by the project implementation agency.	Concessionaire
		Water	Water logging during monsoon will not take place.	The cross drainage system and the flood water drains shall be periodically cleared. Contingency plans for clean up of spills of oil, fuel and toxic chemicals. Drainage systems shall be maintained well to accommodate proper storm water flow.	Concessionaire
		Air	Reduced dust	Proper implementation of vehicular emission control rules by the State	Concessionaire

Sl. No.	Activity	Environmental Attribute	Potential Impact	Management Measures	Responsibility
			generation from road. Increased vehicular emissions due to increased traffic	Motor Vehicles Department. Roadside tree plantation shall be restored and maintained as per the compensatory plantation plan. SPM, RSPM, CO, SO_2, and NO_x to be monitored as per Environmental Monitoring Plan.	
		Noise	Increase in the ambient noise levels, especially during night time along the project road.	Development of greenbelt shall comprise of selected species of trees with high canopy along the project road for attenuation of noise. Use of horns shall be restricted at sensitive locations like schools and hospitals through the use of appropriate signboards along the road. Use of air horns shall be minimized during night. Noise barriers shall be provided along the road at sensitive locations such as hospitals, schools, residential areas, courts etc. Noise monitoring shall be conducted as per Environmental Monitoring Plan.	Concessionaire
		Biological	Improved biodiversity and aesthetics	The cross drainage system and the flood water drains shall be periodically cleared. Regular maintenance of plantations especially during summer season till defect liability period gets over.	Concessionaire
		Socio-economic	Less chances of accidents.	Proper implementation of traffic rules by the traffic Police. Proper maintenance of traffic signs and implementation of accident care facilities along the road will be by the project implementation agency.	Concessionaire
			Safety		Concessionaire
		Solid waste management	No impact	-	-

10.5. Block Cost Estimation for EMP

The cost of implementing above mitigation measures as estimated in **Table 10.2** and conducting the environmental monitoring as per the Environmental Monitoring Plan works out to Rs 1.02 Crores.

Table 10.2. Cost Estimates for Environmental Management Plan

S. No.	Item	Unit	Rate (in INR)	Quantity	Cost (in INR)	Remarks
1	**Mitigation Measures other than Good Engineering practices**					
1.1	Readymade Oil and Grease interceptors at vehicle maintenance and hot mix plant areas in construction camp	Number	50000	2	100000	Refer **Annexure 19**
	Sub Total				**100000**	
2	**Compensatory Plantation (1:3 Ratio)**					
2.1	Plantation, fencing & maintenance of saplings for 5 years	Number	1779	6220	11065380	Trees shall be planted with the consultation of Forest Dept. Covered in the Engineering cost as Item No. 11.9
2.2	Tree Cutting Cost	Covered under Site Clearing cost (Engineering cost)				
	Sub Total				**0**	
3	**Monitoring of Environmental Attributes during Construction Phase**					
3.1	Monitoring of Air Quality at Project facilities	Per Samples	6490	60	389400	Two locations for three season in a year for 5 years
3.2	Monitoring of Noise Level at Project Facilities	Per Samples	3850	30	115500	Two locations for three season in a year for 5 years
3.3	Monitoring of Water Quality at Critical Locations	Per Samples	6000	15	90000	One location for three season in a year for 5 years
3.4	Monitoring of Soil Quality at Critical Locations	Per Samples	7000	15	105000	One location for three season in a year for 5 years
3.5	Additional Soil Monitoring during Spills at Project Facilities	Per Samples	7000	15	105000	One location for three season in a year for 5 years
	Sub Total				**804900**	
4	**Cost for Muck Management Plan**					
4.1	**Engineering Measures**					
4.1.1	Gabion wall around area (350m x 300m)	Cum	37800			Included in the Engineering Cost
	Sub Total					-
4.2	**Biological Measures**					

S. No.	Item	Unit	Rate (in INR)	Quantity	Cost (in INR)	Remarks
4.2.1	Plantation of muck disposal sites	ha	482,726.75	10	4827267.5	
4.2.2	Barbed wire fencing on 2m high RCC posts	ha	50,000.00	10	500000	
4.2.3	Watch&ward 1 no. @ Rs. 10000 p.m. for 5 years	month	10,000.00	60	600000	
	Sub Total				**5927267.5**	
Total Cost During Construction Stage (A)					**6,832,167.5**	
5	**Monitoring of Environmental Attributes during Operation Phase**					
5.1	Monitoring of Air Quality at Critical Locations	Per Sample	2800	12	33600	Two locations for three season in a year for 2 years
5.2	Monitoring of Noise Levels at Critical Locations	Per Sample	1200	12	14400	Two locations for three season in a year for 2 years
5.3	Monitoring of Water Quality at Critical Locations	Per Sample	5500	6	33000	One location for three season in a year for 2 years
5.4	Monitoring of Soil Quality at Critical Locations	Per Sample	4675	6	28050	One locations for three season in a year for 2 years
Total Cost During Operation Stage (B)					**109,050**	
Grand Total (A+B)					**6,941,218**	
6	**Miscellaneous Cost**					
6.1	Training	Lumpsum			500000	
6.2	Holding meetings for policy planning and subsequent review meetings with Revenue Department, Forest Department, local representatives, NGOs, etc. regarding development controls.	Year	5	15000	75000	
6.3	Maintenance of vehicle with the Environment Cell, Data processing, administrative support, stationery etc.	Months	60	35000	2100000	
6.4	Digital Camera for the Environment Cell	No.	1	10000	10000	
Total Miscellaneous Cost (C)					**2,685,000**	
Total Cost					**9,726,218**	
Contingency @ 5% on Total Environmental Cost					**486310.875**	
GRAND TOTAL					**10,212,528**	

10.6. Compliance Report

The project management shall submit half-yearly compliance reports. All such reports shall be public documents. The latest such compliance report shall be displayed on the web site of the concerned regulatory authority.

10.7. Institutional Strengthening and Arrangement

Though rich in legal and regulatory instruments, the implementing agencies are unable to regulate and monitor a sound environmental management plan due to lack of enforcement capacity. Therefore, violations or missed mitigation commitments often go unreported. The gaps and deficiencies pointed out can be removed by proper arrangements. Institutional strengthening component has accordingly been identified. As such, the overall arrangement is as follows.

10.7.1. Organizational Arrangements

An Environmental Unit shall be established for the proposed project, with a manager to address the environmental issues. The Environmental Unit will have proper staff to ensure the implementation of Environmental Management Action Plan (EMAP) and related measures. The Manager (Environment) shall be familiar with the Indian environmental legislations, shall have proper training in the relevant fields, be familiar with the environment and related issues of the region, and will be able to coordinate with NGOs, community groups and government departments.

10.7.2. Environmental Training

Training of staff shall be done at a number of levels. Some short-term training is required for the Environment Manager, other staff members of the Environment Unit and the contractor staff to raise their levels of environmental awareness. Help of State Pollution Control Board shall be sought in this regard. In the long-term training, special environmental issues shall be examined and likely solutions shall be provided to the Environmental Unit.

10.7.3. Environmental Monitoring

In order to ensure that the prescribed environmental norms are maintained during the constructional and the operational phases, regular monitoring is one of the most important components of the institutional arrangement. The regular monitoring of Air pollution, Water quality, Noise pollution and maintenance of trees, etc. shall be done as per Environmental Monitoring Plan. The field reports of various environmental components shall be received quarterly, and lapses, if any, have to be taken care of.

10.8. Reporting Mechanism

Monitoring and Evaluation are critical activities in implementation of all projects. Monitoring involves periodic checking to ascertain whether activities are going according to the plans. It provides the necessary feedback for project management to keep the programme on schedule. The reporting system shall operate linearly with the contractor who is at the lowest rung of the implementation system reporting to the Supervision Consultant, who in turn shall report to the KRCL and KPWD, Govt. of Kerala. All reporting by the contractor and Supervision Consultant shall be on a quarterly basis. The ESDU in association with PIU shall be responsible for preparing targets for each of the identified EMP activities. All subsequent reporting by the contractor shall be monitored as per these targets set by them before the contractors move on to the site.

The compliance monitoring and the progress reports on environmental components may be clubbed together and submitted to the KRCL/KPWD, quarterly during the implementation period. The operation stage monitoring reports may be annual or biennial provided the Project Environmental Completion Report shows that the implementation was satisfactory. Otherwise, the operation stage monitoring reports shall have to be prepared as specified in the said Project Environmental Completion Report.

During the implementation period, a compliance report may include description of the items of EMP, which were not complied with by any of the responsible agencies. It would also report the management and field actions taken to enforce compliance. It may however, be noted that certain items of the EMP might not be possibly complied with in the field due to a various reasons. The intention of the compliance report is not to suppress these issues but to bring out the circumstances and reasons for which compliance was not possible (such as jurisdictional issues). This would help in rationalizing the implementation of the EMAP during the remaining duration of implementation. Solutions for further effective implementation shall also come out as a result of the compliance monitoring reports. Responsibilities for overseeing will rest with the Supervision Consultant's staff reporting to the PIU and ESDU at corporate office.

Documents / Reports to be prepared by the Concessionaire

Concessionaire should submit the following documents/ reports on management and redevelopment of various construction related activities to CSC for approval

- Construction camp management and redevelopment plan
- Labour camp management and redevelopment plan
- Quarry and crusher management and redevelopment plan
- Borrow[M A21] area management and redevelopment plan
- Debris disposal site management and redevelopment plan

Guidelines for preparation of above management and redevelopment plan are presented in Annexure 21 to Annexure 29**.** Other reports to be prepared by the concessionaire are given in Annexure 30 to Annexure 46 and are mentioned in EMAP.

Chapter 11. Summary & Conclusions

11.1 Introduction

The Environmental Impact Assessment (EIA) Report for the proposed twin tunnel with 4-lane Tunnel Road from Anakkampoyil of Kozhikode district to Meppadi of Wayanad district (from Des. Ch. 0+000 to km 8+735) has been prepared according to the the structure of the EIA Report presented in the EIA Notification, 2006 by Ministry of Environment, Forests and Climate Change (MoEF&CC), Government of India. The subject study is based on detailed field reconnaissance surveys, inventories and available secondary information.

Kerala Public Works Department (KPWD) is the Project Proponent of the subject project. GoK through KPWD has nominated M/s. Konkan Railway Corporation Limited (KRCL) as a Special Purpose Vehicle (SPV) for the implementation and execution of the proposed road project availing funds from Kerala Infrastructure Investment Fund Board (KIIFB). The work of EIA Study has been entrusted by KRCL with M/s. KITCO Limited, through LOA CO/PD/I/NP-AKMTR – EIA 2022 dated 21.01.2023 being a Category ‘A’ accredited agency by QCI-NABET for Highways sector.

The proposed tunnel is a 8.735 kms long four-lane Tunnel Road including approaches (from existing roads) for providing connectivity between Anakkampoyil-Kalladi-Meppadi in Kozhikode and Wayanad Districts of Kerala. Geographically the project road/tunnel runs from south-west to north-east between lattitudes of 11°27'2.04"N and 11°31'20.67"N and Longitude of 76° 6'5.61"E and 76° 8'1.38"E. It traverses through 2 districts (Kozhikode and Wayanad), 2 Taluks and 4 revenue villages. Generally the land use along the project stretch is mixed with agricultural-plantation, forest and barren/open land.

Summary of Environmental clearances/ permits/ approvals required for the sub-project is presented in **Table 11.1.**

Table 11.1. Environmental Permits / Approvals Required for the Sub-project

Sl. No	Type of Clearance	Statutory Authority
Pre construction stage		
1.	Forest Clearance Under Forest Conservation Act, 1980	Ministry of Environment, Forests & Climate Change (MoEF&CC) / Kerala State Forest Department (KSFD)
2.	Tree felling permission from Kerala Forest Department	Kerala State Forest Department. (KSFD)
Construction stage (Prior to work initiation)		
4.	CFE (Consent for Establishment) under The Air (Prevention & Control of Pollution) Act, 1981	Kerala State Pollution Control Board (KSPCB)
5.	CFE (Consent for Establishment) under The Water (Prevention & Control of Pollution) Act, 1974	Kerala State Pollution Control Board (KSPCB)

Sl. No	Type of Clearance	Statutory Authority
6.	Permission to store Hazardous Materials under Hazardous Waste (Management and Handling) Act 1989	Kerala State Pollution Control Board (KSPCB)
7.	NOCs under the Explosives Act 1888 and Explosives Rules 2008 for procuring, possessing and use of explosives for blasting the rock/hill.	Chief Controller of Explosives, petroleum & Explosive Safety Organization
8.	PUC certificate for vehicles for construction under Central Motor and Vehicle Act 1988	Transport Department, GoK.
9.	Quarry lease deeds and license under The Mines Act, 1958	Department of Mines and Geology, GoK.
10.	Permission for taking surface water/ groundwater as per the Kerala Groundwater (Control and Regulation) Act, 2002)	Irrigation Dept/Groundwater Board
11	Traffic management plan (Police Department)	Superintendent of Police
12	Labour license, Labour compensation insurance and Contractor's all risk policy, Registration of Workers as per Contract Labour (Regulation and Abolition) Act, 1970 & Building and Other Construction Workers Act	Labour Commissionerate
13	Permission for construction and demolition waste management as per the Construction and Demolition Waste Management Rule – 2016.	Concerned Local Body
14	Permission for extraction of minerals under Kerala Minor Mineral Construction Rule 2016	Mining and Geology Department

11.2. Project Description

This project is formed by connecting two existing roads i.e. Anakkampoyil-Muthappanpuzha-Marippuzha road (MDR) and Meppadi-Kalladi-Chooramala road (SH-59) with a tunnel road. Summary of the improvement is as follows.

Table 11.2. Summary of Improvement Proposals*

Sl No	Chainage (km)		Length (m)	Remarks
	From	To		
1	0+000	0+100	100	Merging of 2 lane to 4 Lane + PS – Main Road
2	0+100	0+215	115	4 Lane + PS (Main Road) with Service on both side
3	0+215	0+310	95	4 Lane + PS (Main Road) with Service on RHS side
4	0+310	0+430	120	120m long, two separate Bow String Bridges (in each traffic direction) across Iravnjipuzha
5	0+430	0+510	80	4 Lane + PS - Main Road
6	0+510	8+540	8030	4 Lane 'D' Shape unidirectional Twin Tube Tunnel
7	8+540	8+620	80	Cut & Cover – unidirectional Twin Tube Tunnel
8	8+620	8+735	115	Merging of 4 lane to 2 Lane + PS – Main Road

*Source: Vol III: Drawing

11.2.1. Tunnel

Twin Tube Tunnel of 2 Lane in each traffic direction has been proposed from Chainage km 0+510 to km 8+620.

Salient features of the tunnel is as follows.

- Twin tube Tunnel of 2 lane in each traffic direction
- **Length:** 8.110 km for Four-lane traffic (Two tubes of 2 lane each-unidirectional)
- **Shape (cross-section) of Tunnel:** D-shaped, fully lined.
- **Finished width:** 10.00 m at road level. (8.0m pavement and 1.0m footpath on both sides) in each direction
- **General altitude of ground at tunnel:** 701m (South) to 865m (North) wherein highest altitude in-between is 1831m above mean sea level
- **General altitude of the tunnel profile:** 679m (South) to 852m (North) above mean sea level
- **Designated vehicular speed:** 80 km/h (50 mph)
- **Geology of tunneling media:** The tunnel passes through Charnockite and its variants in major portion of the alignment and through Hornblende Gneiss formations in northern part of the tunnel alignment.
- **Overburden:** Maximum, approximately 1,080 metres (3542 ft), average more than 600 m (1,970 ft).
- **Lay-bys with width** 14.0m width (12.0m pavement and 1.0m footpath on both sides) in each direction have been proposed at every 750m interval to cater for a refuge to park vehicles in case of any emergencies.
- **Cross-passages** between the tunnel at every 300m shall be provided to divert the traffic through emergency times.
- **Construction technique:** Drill & Blast with NATM

Safety Measures: Two separate tunnel tubes of 2-lane each (uni-directional) for road traffic is provided with cross-passages at every 300m to inter-connect the two tubes. The Cross passages are mandatory in long tunnels for evacuation during emergencies.

In case of fires inside the tunnel, smoke is extracted by remotely controlled exhaust dampers in the ceiling. Two dampers in the vicinity of the fire location are completely opened, all other dampers are closed. A concentrated extraction of approx. 200 m^3/s at the fire location is proposed. Fire Protection systems proposed consists of fire water pump and wet riser system with hydrant connection fire plug connection and fire extinguishers. Fire fighting measures like Fire Hydrant, Fixed fire fighting system (water mist system), Manual Fire Extinguishers, Fire Pumps and Fire water tank have been proposed.

The following elements have been proposed for the ventilation system.

- Exhaust air axial fans of the main tunnel transverse ventilation system

- Fresh air axial fans of the main tunnel transverse ventilation system
- Jet fans of the main tunnel longitudinal ventilation system

In spite of all the above safety measures, it is proposed to prohibit Tankers laden with fuel and other highly inflammable material.

Since the tunnel is likely to witness heavy traffic, CCTV cameras shall be placed at regular intervals in the tunnel which are connected to two monitoring rooms on both ends of the tunnel for vehicular management and pollution monitoring.

The Extra Low Voltage Services (ELV) for the tunnel shall include the following:

- Tunnel emergency lighting.
- Emergency call system (ECS).
- CCTV monitoring.
- Variable message signs (VMS).
- Traffic lights.
- Over height vehicle detection.
- Traffic logging equipment.
- Guidance system.
- Tunnel radio system.
- Internal telephone system.
- Sound system/ Public addressing (PA) system.
- Tunnel physical variables measurement system.
- Escape route lighting

11.2.2. Typical Cross Section

As per the traffic studies and analysis a four lane wide carriage-way with paved shoulder has been proposed. 1.50m wide earthen shoulders are proposed on either side of Paved shoulders. Therefore, the total roadway width proposed is 12.0m for approach road and 8.0m for Tunnel section in each direction. The width of Major bridge at deck level is 13.50m whereas for culverts it is 12.50m in each direction. Embankment slope proposed is 2(H):1(V) and in cutting 1(H):1(V).

Cross sectional elements are presented in **Table 11.3**.

Table 11.3. Details of Cross Section Elements

Description	Approach	Tunnel
Proposed carriageway	14.00m (7.00m + 7.00m)	14.00 m (7.00m +7.00m)
Proposed paved shoulder	5.00m (2.50m + 2.50m)	1.00m (0.50m + 0.50m)as shy marking in each tube
Median	Varying (1.50m minimum)	Nil
Proposed earthen shoulder	3.00m (1.50m + 1.50m)	Nil
Cross camber on Proposed carriageway (Rigid pavement)	2 %	2 %
Cross camber on proposed Earthen shoulder	3 %	NA
Footpath / Drain	Unlined and Lined (Varies)	2.00m (1.0m + 1.0m) in each tube

Chainage-wise details of TCSs adopted are presented in the **Table 11.4.**

Table 11.4. Chainage-wise Summary of TSC Adopted

Sl No	Design Chainage (m)		Length (m)	Type of TCS	Description
	From	To			
1	0.00	100.00	100.00	TCS-1	Typical cross section for 4-Lane highway with

Sl No	Design Chainage (m)		Length (m)	Type of TCS	Description
	From	To			
					paved shoulder in embankment (Merging of 2 Lane to 4 lane road)
2	100.00	215.00	115.00	TCS-2	Typical cross section for 4-Lane highway with Paved Shoulder and Service Road on both side
3	215.00	310.00	95.00	TCS-3	Typical cross section for 4-Lane highway with paved shoulder in cutting
4	310.00	430.00	120.00	TCS-4	Typical cross section for Major Bridge
5	430.00	460.00	30.00	TCS-1	Typical cross section for 4-Lane highway with paved shoulder in embankment
6	460.00	510.00	50.00	TCS-3	Typical cross section for 4-Lane highway with paved shoulder in cutting
7	510.00	700.00	190.00	TCS-6	Typical Cross Section of Tunnel Section – Type - II
8	700.00	8300.00	7600.00	TCS-5	Typical Cross Section of Tunnel Section- Type - I
9	8300.00	8400.00	100.00	TCS-6	Typical Cross Section of Tunnel Section - Type - II
10	8400.00	8480.00	80.00	TCS-7	Typical Cross Section of Tunnel Section- Type - III
11	8480.00	8540.00	60.00	TCS-8	Typical Cross Section of Tunnel Section- Type - IV
12	8540.00	8620.00	80.00	TCS-9	Typical Cross Section of Tunnel Section- Cut & Cover
13	8620.00	8700.00	80.00	TCS-3	Typical cross section for 4-Lane highway with paved shoulder in cutting including junction improvement
14	8700.00	8735.00	35.00	TCS-1	Typical cross section for 4-Lane highway with paved shoulder in embankment (Merging of 2 Lane to 4 lane road)
Total Length (m)			**8735.00**		

Note – Separate cross sections are proposed for the cross drainage structures (Culverts) and Vehicular Underpass (VUP) falling in this section

11.2.3. Pavement

Rigid pavement is proposed for entire stretch. The proposed pavement composition is as follows.

Table 11.5. Details of Pavement Composition

Homogeneous Section	Design CBR (%)	PQC (mm)	DLC (mm)	Granular Sub base (mm)	Total Thickness (mm)
Complete Stretch	**8**	**300**	**150**	**200**	**650**

11.2.4. Culverts

New box culverts are proposed in the following locations in order to avoid the stagnation of water at the valley point as presented in **Table 11.6.**

Table 11.6. List of Proposals for Culverts

Sl No	Detials of Existing Structures			Improvement Proposals			
	Design Chainage (km)	Type of Structure	Span Configuration (No. x m)	Recommendation	Type of Structure	Span Configuration (No. x m)	Remarks
1	0+154	Pipe culvert	1x1	Reconstruction	Box culvert	1 x 3.0 x 4.0	Main Road
2	8+645	Nil	Nil	New Construction	Box culvert	1 x 2.0 x 2.0	Meppadi-Kalladi-Chooralmala Road
3	8+690	Nil	Nil	New Construction	Box Culvert	1 x 2.0 x 2.0	Cross Road

11.2.5. Bridges

Based on the Bridge Inventory & Condition survey, geometry improvement of the highway alignment and submergence locatsions a construction proposal for bridges has been proposed and is presented in **Table 11.7.**

Table 11.7. List of New Construction of Major Bridges

Sl No	Detials of Existing Structures				Improvement Proposals				
	Design Chainage(km)	Type of Structure		Span Configuration (No. x m)	Recommendation	Type of Structure	Span Configuration (No. x m)	Proposed Lane ConfigurationT	Total Width of Structure (m)
		Super Structure	Sub-Structure						
1	0+370	Nil	Nil	Nil	New Construction	Bow-String Girder	1x120	2 lane	13.5
2	0+373	Nil	Nil	Nil	New Construction	Bow-String Girder	1x120	2 lane	13.5

11.2.6. Vehicular Underpass (VUP)

For better connectivity of eastern area of the proposed project road, a full height Vehicular Underpass (VUP) has been planned near Marripuzha village at km 0+200. Lane configuration of this VUP is 2 lane carriageway with 5.50m clear vertical clearance.

11.2.7. Major and Minor Intersections

There are no major junctions on project alignment.

In total there are 2 minor junctions proposed for development on project road.

Table 11.8. Proposals for Minor Intersections

Sl No	Chainage (m)	Location	Type of Junction	Type Road (SH/MDR/VR)
1	30.00	Maripuzha Junction	+	VR
2	8645.00	Meenakshi Temple	+	MDR & VR

11.2.8. Drainage

For earthen drain, 500 mm bed width is proposed, for lined drain, 1.0 m width is proposed and for RCC box Drain in tunnel.

11.2.9. Traffic Control and Safety Devices

A. Road Signs

Traffic control devices, whether used singly or in combination, must contribute to the safe and effective control of traffic. The traffic sign face details and the specifications are designed as per the codal provisions of IRC: 67:2012. General principles for using signs described in IRC: SP: 44 Code to Highway safety are followed.

B. Road Markings

Road Markings are an important means of traffic control on roads. Road markings and the specifications on the project facility are carried as per the codal provisions of IRC:35-2015 and Specifications for Road and Bridge Works. Road markings design are not only limited to lane markings, edge markings, centre line of the project facility but also to mark bus stops, bus lay bye, cross roads at major junctions, direction arrows and pedestrian crossings.

C. Traffic Safety Devices

Traffic Safety devices are required to improve safety on proposed facilities. Following Safety devices are considered on project facility:

- Crash Barriers – provided where canal is running parallel to the project facility
- Pedestrian guard rails – provided front face of footpath
- Pedestrian railing – Provided at back of footpath where pond is located
- Speed Breakers – Provided on cross roads where it meets to main road
- Road Studs – provided on approaches of project facility in junction areas

Illumination

Road lighting has been designed in accordance with the recommendations of IS codes. An average illumination level of 30 lux has been considered

11.2.10. Summary of the Proposals

Summary of the details of proposed design in terms of its physical features, existing and projected traffic, structures, facilities, amenities, and cost are provided in **Table 11.9**.

Table 11.9. Summary of Project Activity Details

Sl. No.	Attributes	Details
1	Start Point (South end location)	Maripuzha (Kozhikode District) on MDR (Elevation=678m above MSL)
2	End Point (North end location)	Meenakshi River Bridge (Wayanad District) on SH-59 (Elevation=851m above MSL)
3	State	Kerala, India
4	Length falls in Each district	

<table>
<tr><th>Sl. No.</th><th>Attributes</th><th colspan="2">Details</th></tr>
<tr><td>a)</td><td>Route Length in Kozhikode District (m)</td><td colspan="2">3150</td></tr>
<tr><td>b)</td><td>Route Length in Wayanad District (m)</td><td colspan="2">5585</td></tr>
<tr><td>5</td><td>Total Route length (m)</td><td colspan="2">8735</td></tr>
<tr><td>6</td><td>Existing Traffic - AADT (PCU)</td><td colspan="2">1. At Adivaram, (Thamnarassery Ghat)- 18,955 PCU
2. At Meeppadi Junction – 12,129 PCU</td></tr>
<tr><td>7</td><td>Projected Traffic (PCU)</td><td colspan="2">14,027 (2030), 23,183 (2040), 35,992 (2050)</td></tr>
<tr><td>8</td><td>Number of curves</td><td colspan="2">06</td></tr>
<tr><td>9</td><td>Minimum Radius of curve (m)</td><td colspan="2">800</td></tr>
<tr><td>10</td><td>Length of road on curves (m)</td><td colspan="2">2705</td></tr>
<tr><td>11</td><td>Lane configuration</td><td colspan="2">4 Lane with Paved Shoulder</td></tr>
<tr><td>12</td><td>Carriageway width (m) (Tunnel)
Carriageway Width (m) (Approach Road)</td><td colspan="2">7.0m with 0.5m kerb shyness on either side
7.0m with 2.50m paved shoulder one side & 0.5m kerb shyness on other side</td></tr>
<tr><td>13</td><td>Pavement type</td><td colspan="2">Rigid Pavement</td></tr>
<tr><td>14</td><td>Tunnel length (m)</td><td colspan="2">8110 unidirectional Twin Tube Tunnel</td></tr>
<tr><td>15</td><td>Cross Passages</td><td colspan="2">At every 300m</td></tr>
<tr><td>16</td><td>South approach Road length (m)</td><td colspan="2">510</td></tr>
<tr><td>17</td><td>North approach Road length (m)</td><td colspan="2">115</td></tr>
<tr><td>18</td><td>Major Bridges</td><td colspan="2">2 Nos. on Iravajipuzha</td></tr>
<tr><td>19</td><td>Minor Bridges/Culverts</td><td colspan="2">3 Nos.</td></tr>
<tr><td>20</td><td>Vehicular Underpass (VUP)</td><td colspan="2">1 No.</td></tr>
<tr><td>21</td><td>Service Road / Slip Road</td><td colspan="2">200m</td></tr>
<tr><td>22</td><td>Junction improvement</td><td colspan="2">2 Nos.</td></tr>
<tr><td>23</td><td>Design Speed (KMPH)</td><td colspan="2">80</td></tr>
<tr><td>24</td><td>Maximum Tunnel gradient (%)</td><td colspan="2">2.50</td></tr>
<tr><td>25</td><td>Total Route length in Private land (m)</td><td colspan="2">2964</td></tr>
<tr><td>26</td><td>Total Route length in Forest land (m)</td><td colspan="2">5771</td></tr>
<tr><td>27</td><td>Highest elevation along route</td><td colspan="2">1831m above MSL.
(Maximum overburden 1090m.)</td></tr>
<tr><td>28</td><td>Additonal land requirement including dumping site (Ha)</td><td colspan="2">Approx.19.484 (7.482 Ha for Tunnel Road + 10ha for Muck disposal site + 2 Ha for Site Camp)</td></tr>
<tr><td>29</td><td>Forest area to be diverted (Ha)</td><td colspan="2">17.263</td></tr>
<tr><td>30</td><td>No. of trees to be cut</td><td colspan="2">177</td></tr>
<tr><td>31</td><td>Geology</td><td colspan="2">Good</td></tr>
<tr><td>32</td><td>Period of construction</td><td colspan="2">60 Months</td></tr>
<tr><td rowspan="11">33</td><td rowspan="11">Raw Material Requirement</td><td>Item</td><td>Quantity</td></tr>
<tr><td>Blue metal</td><td>657415</td></tr>
<tr><td>Bricks</td><td>180</td></tr>
<tr><td>Sand</td><td>288922.60</td></tr>
<tr><td>Cement</td><td>124247.61</td></tr>
<tr><td>Steel - HYSD/Mild</td><td>7998.93</td></tr>
<tr><td>Steel - Structural</td><td>3955.67</td></tr>
<tr><td>Fly Ash</td><td>0</td></tr>
<tr><td>Bitumen</td><td>161.42</td></tr>
<tr><td>Diesel</td><td>19.87 ML</td></tr>
<tr><td>Water</td><td>238.84 ML</td></tr>
<tr><td>34</td><td>Manpower requirement</td><td colspan="2">915</td></tr>
<tr><td>35</td><td>Estimated cost</td><td colspan="2"></td></tr>
</table>

Sl. No.	Attributes	Details
a)	Cost of Civil Works	₹ 1471.57 Cr.
b)	Project Cost including Centages	₹ 2008.20 Cr.
c)	Total Project Cost	₹ 2043.74 Cr.

11.3. Analysis of Alternatives

It is customary to include a 'Without project alternative' in order to confirm that the proposed tunnel road is a requirement of the people of Malabar region and hence need to be implemented. The project tunnel road is an important highway for the overall development of the region and the State. The 'without project' will not allow any of these improvements therefore cannot be acceptable to the local people.

The 'without project' will not resolve this issue; on the other hand, due to the proposed improvements it is most likely that the project road will serve as a much safer highway for the commuters.

Detailed analyses of the alternatives have been conducted taking into account both with and without project. The proposed strengthening of the road is likely to have a positive impact on the economic value of the region. However, there are certain environment and social issue, these needs to be mitigated for sustainable development.

Detailed analysis for the alternative for alignment were considered for the project. Socio- Env-techno – economic parameters like route length, tunnel length, forest ares to be diverted, geological features, connectivity, land requirement, cost etc. were considerd for finalizing the alignment.

Summary of list of recommended alternative routes are presented **Table 11.10**.

Table 11.10. Summary of Alternative Routes Considered

Sl. No.	Details	Alt-1	Alt-2	Alt-3	Alt-4
1	South end Location	Maripuzha	Maripuzha	Muthappa-npuzha	Maripuzha
2	North end Location	Vellarimala	Meenakshi Bridge	Meenakshi Bridge	Kalladi Bridge
3	Route Length (m)	7642	8735	10405	8612
4	Tunnel Length (m)	6870	8110	10050	7570
5	South approach Road (m)	580	510	210	580
6	North approach Road (m)	192.5	115	145	462
7	Effective length of project road (Maripuzha to Meenakshi Bridge) (km)	11.642	8.735	-	10.612
8	Major Bridges	1	1	1	2
9	Length of Major Bridge (m)	240	240	240	340 (260+80)
10	Minor Bridges/Culverts	3	3	3	3
11	Design Speed in Approach (KMPH)	80	80	80	65
12	Tunnel Gradient (%)	2.89	2.50	2.97	2.98
13	Land Requirement including dumping site	Approx. 26	Approx.15	Approx. 16	Approx. 17

Sl. No.	Details	Alt-1	Alt-2	Alt-3	Alt-4
	(Ha)				
14	Improvement required for Chooralamala road to the south ofMeenakshi Bridge	Yes (4.0 km)	Nil	Nil	Yes (1.6 km)
15	Geology	North end & further 2.0 km is in highly landslide prone areas	Good	Good	North end & further 1.0km is in landslide prone areas
16	Degradation of forest	High	Least	Moderate	Moderate
17	Feasibility for improvement of existing North Road	Complex task due to Forest land	Feasible	Feasible	Feasible with additional cost
18	Travel Time	Maximum	Least	Minimum	Moderate
19	Vehicle Operating Cost	Maximum	Minimum	Minimum	Moderate

After examining the various aspects of the four alternatives, based on the anticipated impacts, purpose and objectives, it is recommended to adopt Alt- 2 in view of constructability, geometry, shortest connectivity and economic advantages. After examining the various aspects of the four alternatives, based on the anticipated impacts, purpose and objectives, Government of Kerala (GoK) has approved the recommended Alt-2 vide its letter no- G1/71/2020-PWD dated 06/05/2021.

Design of the pavement with different options has been carried out with a view to determine the suitability and economics of providing non-conventional layers in the pavement. Based on the pavement study conducted, rigid pavement for entire stretch is proposed.

Various alternative were considerd for finalizing tunneling method. Drill and Blasting – NATM is proposed for the proposed tunnel construction.

11.4. Description of Environment

Collection of the baseline environmental status of the project influence area helps to predict the magnitude of impacts that are likely to be caused due to the proposed improvements of the project road. It also helps to identify critical environmental attributes required to be monitored during and after the proposed developments. In addition to the baseline environmental monitoring, field inspection at all the sensitive locations, collection of secondary information for all the environmental components and discussions with the officials, NGO’s and local public were conducted by the Consultants to prepare the baseline environmental profile of the project area.

11.4.1. Land Environment

Geography and Topography: Physiographically, the project area falls in hilly terrain. Topographically, the region is having undulating plain with a number of scattered hillocks. This project road is located at an average altitude ranging from 700 to 2061 metres above the sea level.

Geology and Mineralogy: The project region is characterized by Archaean charnockite, belonging to the Charnockite Group. Clay, limeshell, magnetic iron ore, ilmenite and building stones are the economic minerals seen in Kozhikode district. In respect of economic mineral, Quarts reef, containing minute qualities of gold occur in Wayanad district.

Seismicity and Volcanic Activity: As per the seismic zone classification of India, the project area falls in zone III, i.e. moderate active category. The whole project area falls in the vast volcanic basalt beds of Deccan plateau, which formed towards the end of Cretaceous period, between 67 and 65 million years ago. There is no recent seismic and volcanic activity reported along the project area.

Soil Characteristics: As per the soil map by KSLUB, the project area falls in Soil Mapping Units of KL 21 (Moderately deep, somewhat excessively drained gravelly clay soils with coherent material at 75 to 100 cm on moderately sloping medium hills with thick vegetation, with moderate erosion)of Kozhikode district and KL 19 (Very deep, well drained, clayey soils on moderately sloping high hills with thin vegetarians, with moderate erosion; associated with rock outcrops) and KL 20 (Deep, somewhat excessively drained, gravelly clay soils with, moderate surface gravelliness on steeply sloping high hills with thick vegetarian, with moderate erosion ; associated with very deep, well drained, clayey soils on gently slopes) of Wayanad district Soil quality of the project area was analysed as the part of baseline environmental monitoring during August 2022 to August 2023. As per the monitoring result, the sandy clay textured soil was found to be predominant in the project area. pH of the soil varied from 6.21 and 6.85 there by indicating that soil is slightly acidic in nature. Electrical conductivity in the samples were observed to be ranging from 52 to 65 µmhos/cm.

Land use: The land use along the project stretch is predominantly forest, followed by agriculture-plantation, rural settlement, water bodies and open/barren land. There are no major settlement along the project route.

Landslide / Landslip Problem: Soil erosion, landslide or landslip problems are reported from the project area (within 10 km radii of the project area. As per the District Disaster Management Plan for Wayanad and Kozhikode districts, areas near to the proposed tunnel road is marked as high or moderately. Puthumala is approximately 0.85 km away from the proposed tunnel road, where a massive destructive landslide occurred during monsoon season of 2019.

Agriculture : The main crops in the project area are Paddy, Pulses, Ginger, Pepper etc. Coconut, Tapioca, Areca nut, Cashew nut, Banana, Rubber and Betel vine are important source of income in the rural areas. Also, fruits like Jack, Mango, Banana, Plantain, Pineapple, Papaya and vegetables like; Drumstick, Turmeric, Ginger, Tapioca, Bitterguard are grown. Plantations of coconuts are common in the project area whereas rubber and cashew are also planted.

11.4.2. Water Environment

Hydrology: Iruvanjipuzha / Iruvazhanjippuzha crosses the project tunnel road near to the starting location (km 0+320). Kalladi river and a stream flows over the project tunnel alignment (approx. CH. km 6+660 and km 0+950). The project road ends near Meenakshi River.

Surface and Ground Water Quality: As part of the baseline environmental monitoring programme surface and ground water sampling was done during August 2022 to August 2023. Ground water samples were collected from two locaitons. It has been inferred from the monitoring results that all important potability parameters of water are falling within the limit for all ground water samples, but presence of coliform bacteria is confirmed during the analysis. The pH value of the samples ranges from 6.23-6.45 which is within the accecptable limit. Surface water samples were collected from three locations;. From the analysis, it is observed that the monitoring parameters of water samples were well within the the statndards except for pH.

11.4.3. Air Environment

Meteorology: This climate of project districts is considered to be “Am” according to the Köppen-Geiger climate classification. Kozhikode district receives the annual average rainfall of 5190 mm. Wayanad experiences salubrious climate with mean rainfall of 2786 mm. Average minimum temperature (monthly) of Kozhikode district is 26.7ºC (August) and average maximum temperature (monthly) is 29.05ºC (April). For Wayanad district, they are 21.7ºC (December) and 25.6ºC (April) The relative humidity of the project districts ranges from 74 to 92 % during morning hours and from 64 to 89% in evening hours..

Ambient Air Quality: Ambient air quality along the project area is generally good due to the absence of air polluting industries or allied urban activities. Vehicles are the only source of emission of gases like NOx, SOx, etc. Air sampling and analysis were conducted during August 2022 to August 2023 along the project road at two pre-defined locations. The locations are Anakkampoyi and Meppadi. The analysis results shows that the parameters assessed are well within the stipulated CPCB limits for ambient air quality except for PM_{10}, and it was mainly due to the interference of road construction activities near the monitoring location.

11.4.4. Noise Environment

The major source of noise is passing vehicles along the existing roads in the project area. There are no large industrial establishments along the alignment that could be significant source of noise. Noise monitoring conducted along the project road as part of baseline environmental monitoring from August 2022 to August 2023 at same locations where the air sampling was conducted. The result. shows that all noise levels are within the permissible limits.

11.4.5. Biological Environment

Protected Natural Habitat: The project area is located in Western Ghats, a UNESCO World Heritage Site and is one of the 36 hotspots of biological diversity. It is also recognized as one of the world’s eight ‘hottest hotspots’ of biological diversity. Part of Nilgiri Biosphere Reserve, the first biosphere reserve in India established in the year 1986, falls within the 10 km radii of the project alignment.

No other protected natural habitats (National Parks / Wildlife Sanctuary / other protected areas under Wildlife (Protection) Act, 1972) is situated within 15 km radius of the project tunnel road. The project alignment does not passes through any notified CRZ area. Nearest protected area (under Wildlife (Protection) Act, 1972)) to the project, alignment is Malabar Wildlife Sanctuary, which is located 15.80 km away (aerial distance) from the proposed alignment.

Wildlife Habitat outside Protected Areas: The project area is part of Western Ghat, a hotspot for biodiversity and is home to 5,000 species of flora and fauna. The project area lies in the Ecologically Sensitive Area (ESA) of Western Ghat as recommended by High Level Working Group Report on Western Ghats.

Presence of forests: The project tunnel road is passes through forest area. The Forests along the project road are classified as Evergreen / Semi evergreen forests. Approximately 17.263 Ha of forest land is to be diverted for the proposed project, out of which 16.269 Ha forest land is for underground usage and 0.994 Ha forest land is for overground usage.

Terrestrail Vegetation:. Vegetation cover of the project area (lying along the proposed tunnel-road alignment in 15 km on either side) is constituted by a combination of wet tropical evergreen, semi-evergreen and moist deciduous forests; montane grasslands; evergreen riparian belts of Iruvazhanjipuzha and sparse vegetation of the rocky slopes, apart from tea, coffee, cardamom, teak and eucalyptus plantations and agri-horticultural farms.

Floristic composition of the project area and surroundings (study area) was analyzed through random survey covering the stretch involved in the proposed tunnel-road alignment (500 m on either side of the tunnel-road alignment) and its peripheral areas (covering 15 km on either side) and available authentic secondary information.

Fauna / Wildlife:. Assessment of faunal composition including vertebrate classes such as Mammalia, Aves, Reptile and Amphibians and non-vertebrate class Insect (Butterflies and Donates) was carried out through random sampling in the project environment. 4 odonates’ species, 28 species of butterflies, 3 species of amphibians, 7 species of reptiles, 63 species of birds and 12 species were recorded during the survey.

Human Wildlife Conflicts: Human wildlife conflict is recorded across the project area; it is high in the Meppadi side. HWC is observed high during summer season, as the animals entering human habitation in search for food and water in this season. Higher conflict was reflected both in the number of cases that were registered against elephants in these districts as well as the amount of compensation paid for elephant damages. Elephants were also among the top three wildlife species causing damage.

11.4.6. Socio-Economic and Health Environment

The project road is passing through 4 revenue villages, spread over two taluks in two districts. There are 53 human settlements observed with the 15 km radii of the alignment.

Demography: The project alignment passes through Thiruvambadi and Kodenchery gram panchayaths of Kozhikode district and Meppadi gram panchayath of Wayanad district. Out of these, Meppadi panchayath is the most populated panchayath (37,785), followed by Kodenchery (34,854) and Thiruvambadi (28,820) panchayths. 3,577 tribes (1,792 males & 1785 females) are residing at Meppadi panchayath. Tribal population of Kodenchery and Thiruvambadi panchayaths are 1003 and 365. Kodenchery panchayath (29,761) show the highest literacy among the project panchayaths, followed by Meppadi and Thiruvambadi panchayaths.

Workforce Population: Thiruvambadi panchayath has the maximum per cent of work force. Out of the total population, 12,526 persons (about 39.82%) are workers and 17,343 (about 60.18%) persons are non-workers. This can be inferred that almost half of the population is depending on others for their livelihood. Kodenchery panchayath has least working population (35.94% of total population). Meppadi panchayath has working population of 39.39% of total population.

11.4.6.1. Socio-Economic Profile of the Direct Impact Zonne

As part of the study, census, socio-economic survey has been conducted in the Direct Impact Zone (500 m either side of the project alignment) to list out the favorable and adverse impacts due to the project. General characteristics of the population of the project area is as follows.

The female population of southern side is more compared to the northern region of the project area. About 48.83 % of total population belongs to Christians followed by 26.18 % of Hindus and 25% of Muslims. The working-age population is the total population in an area that is considered able and likely to work based on the number of people in a predetermined age range. Working age group distribution of the PAPs in the DIZ is 61.18 %. Percent of Dependent population of DIZ is 38.81%. It observered that no families belonging to Schedule Tribes and other traditional forest dwellers are residing in the land proposed for acquisition.

Income and Proverty Level: Ration card issued by Civil Supplies Department was considered to assess the poverty level of the project region. As per the survey, 50% of population in the southern region belong to non-priority category. i.e., they are economically sound. But in northern region, 50% of total population belongs to BPL category, where in the southern region it is only 10 % of the total population. 23 % of total population in northern region is belongs to "Most economically backward class", whereas in the southern region, it is only 3%. Overall, the southern region is observed with more economically sound population compared to northern region.

Literacy and Education: The survey reveals that level of education for southern region is quite good compared to the northern region. 35 % of PAPs in the southern region is either SSLC or graduates, but in the northern region, it is only 27 %. 15% of the PAPs in southern region is illiterate and 20 % for the northern region. 16 % of PAPs in southern region and 12 % of PAPs in northern region are not willing to respond to the question.

Source of Income: Employment/occupation either in agriculture sector was the major source of income. 2.3 % in south side and 15.8% in north side of the surveyed population worked in govt. sector. 15.8 % of surveyed population in the northern region is doing business. 3.9 % of the surveyed population in the southern region worked in private sector. 3.8 % in south side and 10.56 8% in north side of the surveyed population worked as driver. Around 3.8 % in southern side and 5.26 % in southern population are expatriate. 52.6% of surveyed population in the northern side is working as coolie. 7.7 % of households in the southern region grazed cattle and goats in the pastures in the DIZ and earned an income. Income from casual/temporary jobs or other jobs was also one of the major source of income for almost all the households from northern region, which is contributed about 37% of the population.

Health Status: The survey results reveals that health status of the PAPs in both regions is comparatively good. Covid-19 pandemic threaten situation is observed in many of the surveyed places. 3 % of the PAPs in the southern region and 4 % of the PAPs in the northern region is suffered with cardiac problems.

Health Status: Details of residence were assessed with various parameters like, duration of occupancy, type of occupancy, type of house, type of floor etc.

Access to Services: Water supply through gravity and own wells were the primary sources of water for the PAFs in the DIZ. A few households holds public tap and Jalanidhi connection for their primary source of water. Safe toilet and closed bathing space is being used by cent percent of the households in the DIZ. All the respondent in the southern region have gas connection and electricity. All the respondents in the northern region have electricity connection in their house, but only 19 of them have gas connection.

Credit Faciltiy: 42% (13 Nos.) (in southern portion) and 27% (6 Nos) (in northern portion) of the surveyed households had availed credit facilities. Co-operative banks, public sector banks and private sector banks were the major sources utilized for availing the credit facility.

11.5. Anticipated Environmental Impacts and Mitigation Measures

11.5.1. Potential Negative Impacts of the Project during Construction Phase

The activities during the construction phase of the project road includes leveling of site, clearing of trees along the alignment, widening of existing road with paved shoulders, construction of culverts and bridges, and quarry operations for the road work. Some of the potential direct and indirect negative impacts of the project during construction phase will be the following.

- Diversion of forest areas and cutting of trees.
- There are chances of loss of topsoil due to clearing and grubbing of vegetation for new alignment, borrow area and quarry operation, construction camps and material stacking yard
- No considerable impacts on flora and fauna can be observed due to the construction activities
- Temporary impact on the drainage pattern due to embankment, culvert and bridge constructions
- No considerable impact on traffic management system will happen
- Increased air pollution (including dust) only during project road construction
- Increased noise and vibration levels due to the movement of vehicles, tunneling activities and construction activities can be observed only during construction period.
- Bare minimum soil erosion leading to loss of top soil and pollution of surface water bodies
- Spillage of oils and other hazardous materials may lead to pollution of surface and sub-surface waters depending upon the quantity of spillage
- No considerable Pollution of rivers and canals due to construction of bridges

11.5.1.1. Impact on Land use / Land Cover

The proposed tunnel road development requires acquisition agricultural land and forestland. Loss of productive agricultural land may result from the establishment of construction camps, batch mix plant and WMM plant, quarry and borrow area[M A22].

11.5.1.2. Impact on Geology / Topology

Removal of soil and earth strata will cause changes in topography. As per site-specific investigations, the geological formations in the selected project sites are judged stable and will be able to withstand the impacts of drilling and blasting. However, at any unstable formation encountered during tunneling and underground excavation, blasting may lead to high vibrations. Construction of embankments results in alteration of geography of the area.

11.5.1.3. Impact on Soil

The impact on soil due to the project will be in terms of topsoil contamination and soil erosion. Establishment of construction camp and movement of construction vehicle and machineries on agriculture land will results in compaction of top soil. Disposal of construction waste and domestic waste in unscientific way may result in loss of productive land.

11.5.1.4. Impact on Slope Stability

Proposed strengthening may cause destabilization of hill slope at ghat locations. Hence, minimum tunneling has been proposed at hill slope to avoid further disturbance to the hill slopes.

11.5.1.5. Impact on Surface Water

Disposal of construction debris near the vicinity of water bodies may cause stagnation / diversion of natural drainage. Drawing of water for construction camps for domestic use from local water sources may disturb water supply use for the local inhabitants. Construction activity at bridge and culvert locations may cause water pollution.

11.5.1.6. Impact on Ground Water

Extraction of ground water for construction activities and domestic use of labour camps will result in depletion of local ground water table. Since the water usage will be mainly from the river water for construction purposes, no adverse impact on groundwater availability is expected.

11.5.1.7. Impact on Surface Water Quality

The proposed tunnel may permeable during their construction and impermeable or semi-permeable during their operation. Discharge of untreated wastewater generated from construction camps, labour camps to nearby water bodies will leads to deterioration water quality. Runoff from hill slopes, embankments and earthen shoulder may increase the chances of soil erosion, which result in turbidity and siltation of water bodies. Cleaning of construction machineries, equipments and vehicles shall deteriorate the water quality.

11.5.1.8. Impact on Ground Water Quality

Selection of construction camps adjacent to open well will lead to contamination of ground water due to unscientific usage of water near open wells.

11.5.1.9. Impact on Meteorology / Climate

Slight change in the micro-climate of the area is expected. However, impact on the climate conditions from the proposed road project widening will not be significant in long run as deforestation and / or removal of vegetation will be compensated by compensatory plantation to the tune of double the area denuded.

11.5.1.10. Impact on Air Quality

There will be rise in PM levels during the construction activities, which shall again be within prescribed limit after the construction activities are over. The level of CO is likely to be increase, however level shall remain within prescribed standards.

11.5.1.11. Impact on Noise Level

The area is likely to experience an increment in noise level due to increase in vehicle density during the operation phase. Locations of sensitive receptors were identified and noise barriers in the form of compound wall are proposed at these locations to mitigate the noise level up to acceptable levels.

11.5.1.12. Impacts due to Vibration by Blasting

The ground vibrations, noise and fly rock constitutes the chief environmental impact of blasting. where monitoring of ground particle velocity by means of suitable instruments is adopted as a means of vibration control, the peak ground particle velocity may not exceed the following:

a) Soils, weatherd or soft roack	70 mm/s
b) Hard rock	100 mm/s

11.5.1.13. Impacts on Landcover and Flora

Total extent of forestland involved in the project execution is 17.263 ha of which 34.10 ha implicates only underground use (in tunnel development). Involvement of forestland is to the tune of 16.269 ha, which involves mainly underground use except for 0.994 ha riverine area of Iruvazhanjipuzha. Therefore, the project execution will not result in significant land cover modification or fragmentation of habitats

Loss of Trees: The project development involves removal of a total number of 177 trees out of which 103 from forest land and 74 from private lands.

Construction Phase: Earthworks, rock excavation, transport of muck and operation of heavy machinery will result in the alteration of air, land and surface water quality by emanation of dust and gaseous pollutants and through inflow of mud and suspended particles in to the river system. The mud and sediments entering the river/stream will change the water quality to affect aquatic and riparian habitats and life forms including benthic flora. Checking illegal entry in to the forest system will provide an additional effective solution.

Operation Phase: Extensive vehicular traffic and influx of people in the area during operation phase might cause invasion of alien weeds to cause habitat degradation.

11.5.1.14. Impacts on Terrestrail Fauna and Wildlfie

Since the tunnel-road, construction primarily involves underground use of forestland, significant alteration and fragmentation of habitats is not anticipated. Human-animal conflicts often arise in both Meppadi and Anakkampoil areas. Extended human interference, vehicular movement and operation of machines during construction would further affect the movement of elephants in the area. However, no far-reaching impacts are anticipated to affect the forage, migration or distribution of elephants in the form of habitat loss, habitat fragmentation or alteration as the construction proposed is largely underground. Further, there will be no loss of waterhole, permanent tracks and corridors due to the project execution.

11.5.1.15. Impacts on Socio-Economic Environment

There no settlements along the project corridor. 9 structures and one open well are affected due to the project. The total private land to be acquired for the the project tunnel road is 7.482 Ha. Additionally 10 Ha land is proposed to be acquired for dumping.

11.5.2. Potential Positive Impacts of the Project

The positive impacts of the project are

- Reduction in air pollution along existing road due to reduction in traffic congestion and smooth vehicular movement
- Reduction in air and noise pollution and accidents in built-up areas due to construction of bypasses.
- Reduction in fuel consumption and travel time due to better service level of roads
- Improved safe and efficient connectivity between the project districts.
- Generation of local employment during road construction
- Improvement of local economy and industry due to better infrastructure facilities

11.5.3. Potential Negative Impacts of the Project during Operation Phase

During the operational phase of the project, traffic in the project road and the average speed of vehicles will increase. Some of the potential direct and indirect negative impacts of the project during operation phase are the following.

- No considerable increased noise pollution if the traffic volume increases and if the vehicles moves at a speed more than the prescribed speed due to the vehicular movement at high speed
- Not much air pollution due to newly introduced vehicular traffic
- Minimum impact on natural drainage pattern of the project area

11.5.4.Mitigation Avoidance and Enhancement Measures

Mitigation and enhancement measures have been planned for identified adverse environmental impacts. The construction workers camp will be located at least 500 m away from nearby habitations. Construction yard, hot mix plants, etc. will also be located more than 500 m away from habitations and in downwind directions. A blasting plan is recommended prior to the construction. In order to compensate negative impacts on flora due to cutting of trees the project plans compensatory plantation in the ratio of 1:3 i.e. for every tree to be cut, three trees will be planted. As the space for compensatory afforestation might not be adequate along the project road, this plantation shall be taken up by the forest department, after payment of the cost for raising and maintaining the saplings for five years. The project will take an opportunity to provide environmental enhancement measures to improve aesthetics in the project area. The planned environmental enhancement measures include plantation in available clear space in ROW, enhancement of water bodies etc. In order to avoid contamination of water bodies during construction Silt fencing, oil interceptors at storage areas and at construction yard have been proposed.

11.6. Environmental Monitoring Programme

The responsibility of implementing the mitigation measures lies with Environment Team duly appointed by the Contractor/Concessionaire. The overall supervision of Environmental monitoring works during construction and operation stage shall be carried out by KPWD with the help of the Monitoring Consultant.

To mitigate the potential negative impacts of proposed development and measurement the performance of mitigation measures, an Environmental Monitoring and Management Plan is developed. The formulation of an appropriate environmental monitoring plan and its diligent implementation are keys to overall success for the project.

An Environmental Monitoring Plan as presented in **Table 11.11** is proposed as part of the EMP to evaluate the efficiency of implementation of mitigation measures recommended in the EMP and to facilitate management decisions for the project.

Table 11.11. Environmental Monitoring Plan

Air Quality Monitoring	
Project stage	Construction and operation stages
Parameter	PM_{10}, $PM_{2.5}$, SO_2, NO_x, CO and Pb
Sampling Method	High volume air sampler to be located 50 m from the source of pollution in the downwind direction. Method specified by CPCB for analysis shall be followed
Standards	Revised National Ambient Air Quality (NAAQ) Standards set by CPCB
Frequency	Once in every season for three seasons (except monsoon) per year for every year of construction
Duration	Continuous 24 hours / or for 1 full working day
Locations	One monitoring station near each construction related facility namely, WMM plant, labour camp, staff quarters, borrow location and quarry location, and at sensitive locations along the project road at an average distance of 10 km during construction stage. Monitoring shall be done at each additional construction related facility, if present. At sensitive locations along the project road at an average distance of 10 km during operation stage.
Measures	Wherever air pollution parameters increase above specified standards, additional measures as decided by the engineer shall be adopted
Implementation	Contractor through approved monitoring agencies
Supervision	MoRTH (or) Sub consultants appointed by MoRTH
Water quality Monitoring	
Project stage	Construction stage
Parameter	pH, BOD, COD, TDS, Pb, Oil & Grease, Detergents and Faecal Coliforms for Surface water. pH, TDS, Total hardness, Sulphate, Chloride, Fe, and Pb for groundwater.
Sampling Method	Grab sample collected from source and analysis as per Standard Methods for Examination of water and Waste water
Standards	Water quality criteria by CPCB and for Drinking water (IS; 10500,1991)
Frequency	Twice a year (pre monsoon and post monsoon seasons) during the entire construction period
Duration	One-time grab sampling
Location	At major water bodies along the road at an average distance of 20 km
Measures	At locations of increased water pollution towards down stream, all inflow channels shall be checked for pollution loads and channel delivering higher pollution loads

	shall be terminated from disposal into the water source.
Implementation	Contractor through approved monitoring agencies
Supervision	MoRTH (or) Sub consultants appointed by MoRTH
Noise Level Monitoring	
Project stage	Construction and operation stages
Parameter	Noise level on dB (A) scale
Sampling Method	Measure equivalent noise levels using an integrated noise level meter kept at a distance of 15m from edge of the pavement
Standards	Noise Pollution (Regulation and Control) Rulers, 2000
Frequency	Once in every seasons (except monsoon) for each year of construction
Duration	Reading to be taken at 15 seconds interval for 15 minutes every hour for 24 hours and then average will be taken
Location	Near the WMM plant and near sensitive locations such as school hospital etc. along the road at an average distance of 10 km during construction stage. Monitoring shall be done at each additional WMM plant, if present. Near sensitive locations such as school hospital etc. along the road at an average distance of 10 km during operation stage
Measures	Incase of noise levels causing disturbance to the sensitive receptors, management measures as suggested in the EMP shall be carried out.
Implementation	Contractor through approved monitoring agencies
Supervision	MoRTH (or) Sub consultants appointed by MoRTH
Soil Quality Monitoring	
Project stage	Construction
Parameter	Monitoring of Pb, SAR and Oil & Grease
Sampling Method	Sample of soil collected to be acidified and analyzed using absorption spectrophotometer
Standards	Threshold for each contaminant set by IRIS database of USEPA until national standards are promulgated
Frequency	During the pre monsoon and post monsoon seasons in each year for the entire construction period
Duration	One-time grab sampling
Location	At productive agriculture lands abutting traffic detours and traffic diversions and major intersections at an average distance of 20 km along the road.
Measures	At location of increased pollution levels, source shall be identified and shall be diverted from future disposal
Implementation	Contractor through approved monitoring agencies
Supervision	MoRTH (or) Sub consultants appointed by MoRTH

11.7. Additional Studies

11.7.1. Public Consultation

Considering the fact that involving local communities in the project planning is basis of the participatory planning, stakeholder consultations at various levels were conducted during different stages of the project. Suggestions and options given by the people improves technical and economic efficiency of the project and suggested improvement proposals of the people (if adopted by the project) also generates sense of ownership within communities thus eases implementation process. Stakeholder consultations were conducted for the project comprised one-to-one interviews and focus group discussions. The stakeholder consultations were conducted before project design and after project design. The suggestions obtained during pre-design consultation were considered in the project design.

11.7.2. Social Impact Assessment and R&R Action Plan

The additional land required for the approach road was estimated based on the land acquisition plan prepared by design consultant. Accordingly, an additional private land of 7.482 Ha. Also an area of 10 Ha land is to be acquired for muck disposal.

The proposed project falls in forest area and private land. Hence private land acquisition is required for project activity. Since the tunnel and roads are proposed as an alternative to churam road, the existing road may not cater to the anticipated traffic. It may necessitate to widen the existing roads and dedicated pathway for pedestrians. Width of the existing road is six meters and it is envisaged that acquisition of few commercial properties (Depending on road width) at Meppady junction may be anticipated.

Based on survey in the proposed project would affect 27 property holders directly considering both north and south end of tunnel and approach roads as well. It includes four residential buildings, three vacant buildings, one prayer hall, Six commercial institutions and private lands (details of households directly have been added as Annexure 47).

When the land is being acquired, the proponent shall adopt principles and procedures in accordance with the provisions of National Land Acquisition, Rehabilitation and Resettlement Act, (RFCTLARR-ACT) 2013 and other relevant policy of the state.

11.7.3. Geological & Geomorphological Features of the Project Impact Area

The proposed tunnel passes under the Highlands and Mountainous Peaks physiographic units of the area. The impact area comprises the rugged terrain of the Western Ghats and parts of the Wayanad plateau. Geological features indicate presence of the oldest rocks reported from the State (rocks of the Wayanad Group), presence of mafic granulites metamorphosed under deep burial conditions and their later gradual uplift and charnockitisation. Subsequent granitisation events and associated migmatisation led to the formation of gneisses (gneissic charnockite/charnockitic gneisses), quartzo-feldspathic gneisses, retrogression products of hornblende±biotite gneisses, emplacement of granites, pegmatites, dolerite dykes and quartz veins. All these indicate a very complex and protracted geological history involving tectonic upheavals (at least 6 times or more). This has manifestation in the tectonic/structural features such as multiple folding events and fracture/fault formation. Petrographic investigations substantiate the deformation milieu. Crushing of minerals has been observed. Logging of rock samples from the drilled 8 bore holes indicate that Rock Quality Designation (RQD) values, a major consideration in tunnel design are broadly poor, warranting more detailed investigations of the tunnel overburden through Shallow Seismic Survey for fracture zones identification. Thick weathering profile development is characteristic of the terrain that may hold perched water table on the ground and some water pools feeding the wild life. Extent of that, and the seepage possibility during tunnelling needs elucidation. Electrical Resistivity Tomography survey with appropriate spacing/configuration of electrodes may be thought of.

Geomorphic features, a resultant of the geological processes, bring out the rugged nature of the terrain with steep, very steep and extremely steep slope categories and landform units. requiring precautions during the construction stage to avert vibration induced landslips.

11.7.4. Natural Resource Conservation and Optimisation

In order to reduce the impact on forest flora and land use of the area, it was decided to restrict the 4-lane (also considered the traffic forecast). Approximately, 17.263 Ha of forest land is to be utilised for the project, out of which 16.269 Ha forest land is for underground usage and 0.994 Ha forest land is for overground usage..

11.7.5. Risk Assessment & Disaster Management Plan

The objective of the Risk Analysis Study is to identify potential credible hazards arising out of the facilities that handle, process, store and transport of hazardous substances, to mitigate severity and to aid in preparing effective emergency response plans by delineating a disaster management plan to handle onsite and offsite emergencies.

Response Emergency Team will assess the magnitude of incident by connecting with the incident site and initiate the initial response operation. In case the connectivity couldn’t be established, the Response Team shall be proceeding to the site seeking backup support from the neighbouring health care facilities and assess the situation accordingly. On reporting the preliminary assessment by SIC to CIC, the CIC shall be declaring emergency and direct for safe transition from normal operation to emergency operation and systematic shut down as per the requirements.

11.8. Project Benefits

All road users will be benefited from the proposed improvement on account of comfort, safety and reduced vehicle operating costs. The project road will give better connectivity for Kozhikode and Wayand districts and this will lead to increase in export of agricultural products like fruits, vegetables. It is expected that overall, the proposed Kochi-Bengalure Industrial Corridor will reduce the travel time between the two economic hubs. The seamless connectivity will provide better access to vehicles as a link to the existing NH 766 (which connects Kozhikode in Kerala with Kollegal in Karnataka via Mysore) and SH-59 (Meppadi - Kalladi - Chooramala on north side of tunnel road). The Project will reduce travel time and provide boost to trade and commerce linked to the regions connected through this highway. The proposed corridor will take away traffic pressures from existing NH-766 passing through various cities. Also, long-distance traffic will shift to the proposed highway, thereby reducing traffic and congestion on the existing NH and SH for regional and local usage. While National Highway 766 serves as the major connectivity between Kozhikode and Wayanad and to neighbouring States, the project will be an important initiative to provide an alternative route connecting with the existing road network. Long-distance traffic will shift from existing NH to the proposed tunnel road, resulting in lesser congestion leading to higher fuel savings and reduced travel time.

A significant economic benefit of the improvement project is generation of employment opportunitiesduring the construction activities, which will be available to the people, including affected community. Besides, they will also draw benefits from the economic activities as a result of increased traffic flow and movement of vehicles. In the long term, project road will help in the economic development of the entire region.

11.9. Environmental Management Plan

In order to address the impacts predicted for various project activities, mitigation measures, environmental enhancement measures, monitoring actions and a reporting schedule are suggested in the form of an Environmental Management Plan (EMP). The EMP includes a list of all project related activities and impacts and their mitigation measures at different stages of project, namely, pre-construction phase, construction phase and operation Phase, Environmental monitoring plan and a clear reporting schedule. The EMP sets a time frame to all proposed mitigation and monitoring actions with specific responsibility assigned to the proponents, the contractors and the regulatory agencies.

11.9.1. Block Cost Estimate for EMP

The cost of implementing above mitigation measures and conducting the environmental monitoring as per the Environmental Monitoring Plan works out to **Rs. 1.02 Cr**.

Chapter 12. Disclosure of Consultants Engaged

KITCO Ltd., Kochi, a consultancy organization accredited by the QCI / NABET for the sector on Port & Harbours, dredging , breakwaters, marine terminal etc. KITCO Limited, the Project Consultants have been engaged to carryout the Comprehnsive Environemental Impact Assessment (CEIA) Study / Field Work and detailed Social Impact Assessment (SIA) Study, Preparation and Submission Environment Impact Assessment Report for the proposed construction of Twin Tube Tunnel Road (2+2 Lane) Including Four Lane Approaches between Anakkampoyil- Kalladi-Meppadi in Kozhikode and Wayanad Districts of Kerala State. Vide letter no: with M/s. KITCO Limited, through W.O No CP/PD-I/NP/AKMTR/01-2019 dated 25.09.2020 with confirming expansion of scope through W.O No CO/PD-I/NP-AKMPTR-EIA-2022 dated 12th January, 2023 being an accredited agency by QCI-NABET for Schedule 7f – Highways Category B is identified as the Project Proponent. KPWD is the statutory authority for designing, planning, monitoring, constructing and undertaking maintenance of public works of the State Government such as Government Buildings, Roads, Bridges etc.

The following experts have been aligned for the EIA Study as per the QCI-NABET guidelines.

NABET Accrediated Certificate

NABL Accrediated Certificate

EIA Coordinator	:	Mrs. Meena Nambiar
Signature & Date:	:	I, hereby, certify that I was a part of the EIA team in the capacity Coordinator

Functional Area Experts:

S. No.	Functional Areas	Name of the expert/s	Tasks Performed	Signature & Date
1	WP	Mr.Vinod Kumar L	1. Understanding the project and predicting the areas which need to be addressed. 2. Identifying areas which require environmental monitoring. 3. Reviewing the results of monitoring. 4. Analyzing the water demand and adequacy of the source. 5. Development of Water Balance chart 6. Development of water reutilization	

S. No.	Functional Areas	Name of the expert/s	Tasks Performed	Signature & Date
			options. 7. Development of rain water harvesting and utilization options. 8. Prediction of impacts of the project and suggesting mitigation measures. 9. Preparation of Environmental Management Plan.	
1.	SHW	Mr.Vinod Kumar L	1. Understanding the project and predicting the areas which need to be addressed. 2. Identification of the waster generation sources 3. Development of detailed waste management mechanism for the proposed development. 4. Identification of Impacts due to the improper waste management and addressing eth proper mitigation measures. 5. Preparation of	

S. No.	Functional Areas	Name of the expert/s	Tasks Performed	Signature & Date
			Environmental Management Plan.	
6.	LU	Dr. P V Benjamin	1. Understanding the project and predicting the areas which need to be addressed. 2. Identification of surrounding land uses 3. Analyzing the impacts/alteration of the proposal on surrounding land use Development	

S. No.	Functional Areas	Name of the expert/s	Tasks Performed	Signature & Date
			of proper mitigation measures Preparation of Environmental Management Plan.	
4.	AP	Dr.V.N. Sivasankara Pillai	1. Understanding the project and predicting the areas which need to be addressed. 2. Identifying areas which require environmental monitoring. 3. Reviewing the results of monitoring. 4. Prediction of impacts and suggesting mitigation measures. 5. Preparation of Environmental Management Plan.	
6.	NV	Mrs. Sindhu N T	1. Understanding the project and predicting the areas which need to be addressed. 2. Identifying areas which require environmental monitoring. 3. Reviewing the results of	

S. No.	Functional Areas	Name of the expert/s	Tasks Performed	Signature & Date
			monitoring. 4. Prediction of impacts and suggesting mitigation measures. 5. Preparation of Environmental Management Plan.	
6.	EB	Dr. Shaji P K	1. Understanding the project and predicting the areas which need to be addressed 2. Identification of existing ecology of the site 3. Identification of threat of the project to the existing biodiversity 4. Identification of measures proposed to be taken to minimize the likely impacts on important site features 5. Development of proposal for green belt development 6. Preparation of Environmental Management Plan.	
7.	SE	Mr. Pavithran Kuttichi	1. Understanding the project and predicting the areas which need to be	

S. No.	Functional Areas	Name of the expert/s	Tasks Performed	Signature & Date
			addressed 2. Identification of existing Scio economic structure of the study area 3. Identification of changes to the existing demographic structure of local population due the development 4. Prediction of expected adverse effects on local communities, disturbance to sacred sites or other cultural value due to the project implementation and suggestion of safeguard measures to be taken. 5. Preparation of Environmental Management Plan.	
6.	HG	Dr. Kunjupillai Soman	1. Understanding the project and predicting the areas which need to be addressed. 2. Identification impact on ground water quality of the	

S. No.	Functional Areas	Name of the expert/s	Tasks Performed	Signature & Date
			of surrounding 3. Prediction of alteration to the natural drainage of the area due to the project. 4. Prediction of impacts and suggesting mitigation measures. 5. Preparation of Environmental Management Plan.	
6.	SC	Dr. V.N. Sivasankara Pillai	1. Understanding the project and predicting the areas which need to be addressed. 2. Identifying areas which require environmental monitoring. 3. Reviewing the results of monitoring 4. Identification of soil type, slope analysis, vulnerability to subsidence, seismicity etc of the site for development. 5. Prediction of significant land disturbance resulting in erosion, subsidence & instability due	

S. No.	Functional Areas	Name of the expert/s	Tasks Performed	Signature & Date
			to project implementation. 6. Suggestion of the mitigation measures against the impact predicted. 7. Preparation of Environmental Management Plan.	
8.	RH	Dr.K.P Sankaranarayanan Pillai	1.Understanding the project in totality and analyzing the areas where study need to be focused. 2.Guidance in preparation of risk assessment and report 3.Preparation of Environmental Management Plan including the risk assessment outcomes	

Declaration by the Head of the Accredited Consultant Organization/authorized person

I, Mr. Harinarayanaraj, Managing Director, KITCO hereby, confirm that the above mentioned experts prepared the CEIA Report for Construction of Twin Tube Unidirectional Tunnel Road (2+2 Lane) with Four Lane Approach (from existing roads) for providing direct connectivity between Anakkampoyil- Kalladi - Meppadi in Kozhikode and Wayanad Districts of Kerala State

Signature:

Name: Mr. Harinarayanaraj

Designation: Managing Director

Name of the EIA Consultant Organization: KITCO Ltd.

NABET Certificate No. & Issue Date: NABET/EIA/2023/RA 0164

<u>Abbreviations Used</u>

S. No.	Functional Area Code	Complete name of the Functional Areas
1.	WP	Water Pollution Prevention, Control & Prediction of Impacts
2.	SHW	Solid Waste and Hazardous Waste Management
3.	MSW	Municipal Solid Waste
4.	HW	Hazardous Waste
5.	LU	Land Use
6.	AP	Air Pollution prevention, Monitoring & Control
7.	NV	Noise/Vibration
8.	EB	Ecology and Biodiversity
9.	SE	Socio- Economic
10.	HG	Hydrology, ground Water& Water Conservation
11.	SC	Soil Conservation

-

Chapter 12. References

- Topo Sheets & District Planning Maps, Survey of India
- Ground water details, Central Ground Water Department, Bhopal
- Data on different meteorological parameters for ten years, India Meteorological Department, Bangalore
- Forest Working Plans & Forest Maps, Kerala Forest Department
- Pollution level details Kerala State Pollution Control Board
- District Statistical Handbooks, District Collector's Office
- Area / village wise details, Gram Panchayats offices
- District Administrative websites
- Kerala Forest Department website

Annexures

Annexure 1: National Ambient Air Quality Standards by CPCB

"[SCHEDULE VII]

[See rule 3(3B)]

NATIONAL AMBIENT AIR QUALITY STANDARDS

S.No	Pollutants	Time-weighted average	Concentration in ambient air		Method of measurement
			Industrial Residential, Rural & other Areas	Ecologically Sensitive Area (Notified by Central Government)	
1	Sulphur Dioxide (SO_2) $\mu g/m^3$	Annual* 24 hours**	50 80	20 80	-Improved West and Geake -Ultraviolet fluorescence
2	Nitrogen Dioxide (NO_2) $\mu g/m^3$	Annual* 24 hours**	40 80	30 80	-Modified Jacob & Hochheiser (Na-Arsenite) -Chemiluminescence
3	Particulate Matter (Size less than 10 µm) or PM_{10} $\mu g/m^3$	Annual* 24 hours**	60 100	60 100	-Gravimetric -TOEM -Beta attenuation
4	Particulate Matter (Size less than 2.5 µm) or $PM_{2.5}$ $\mu g/m^3$	Annual* 24 hours**	40 60	40 60	-Gravimetric -TOEM -Beta attenuation
5	Carbon Monoxide (CO) mg/m^3	8 hours** 1 hour**	02 04	02 04	- Non Dispersive Infra Red (NDIR) Spectroscopy

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

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

Note: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

Annexure 2: National Ambient Air Quality Standards for Noise by CPCB

Sl. No.	Area	Leq dB (A)	
		Day Time*	Night Time**
1	Industrial Area	75	70
2	Commercial Area	65	55
3	Residential Area	55	45
4	Silent Zone***	50	40

Notes :

* Day Time -- 0600 hour to 2100 hour (15 hours)

** Night time --2100 hour to 0600 hour (09 hours)

*** Areas upto 100 metres around certain premises like hospitals, educational institutions and courts may be declared as silence zones by the competent authority ;

Annexure 3: National Standards for Drinking Water (IS:10500), 2012

Sl. No	Substance or Characteristic	Requirement (Desirable Limit)	Permissible Limit in the absence of Alternate source
Essential characteristics			
1	Colour, (Hazen units, Max)	5	25
2	Odour	Unobjectonable	Unobjectionable
3	Taste	Agreeable	Agreeable
4	Turbidity (NTU, Max)	5	10
5	pH Value	6.5 to 8.5	No Relaxation
6	Total Hardness (as $CaCO_3$) mg/lit., Max	300	600
7	Iron (as Fe) mg/lit, Max	0.3	1
8	Chlorides (as Cl) mg/lit, Max.	250	1000
9	Residual free chlorine, mg/lit, Min	0.2	--
Desirable Characteristics			
10	Dissolved solids mg/lit, Max	500	2000
11	Calcium (as Ca) mg/lit, Max	75	200
12	Copper (as Cu) mg/lit, Max	0.05	1.5
13	Manganese (as Mn)mg/lit, Max	0.1	0.3
14	Sulfate (as SO_4) mg/lit, Max	200	400
15	Nitrate (as NO_3) mg/lit, Max	45	100
16	Fluoride (as F) mg/lit, Max	1.9	1.5
17	Phenolic Compounds (as C_6H_5OH) mg/lit, Max.	0.001	0.002
18	Mercury (as Hg)mg/lit, Max	0.001	No relaxation
19	Cadmium (as Cd)mg/lit, Max	0.01	No relaxation
20	Selenium (as Se)mg/lit, Max	0.01	No relaxation
21	Arsenic (as As) mg/lit, Max	0.05	No relaxation
22	Cyanide (as CN) mg/lit, Max	0.05	No relaxation
23	Lead (as Pb) mg/lit, Max	0.05	No relaxation
24	Zinc (as Zn) mg/lit, Max	5	15
25	Anionic detergents (as MBAS) mg/lit, Max	0.2	1
26	Chromium (as Cr^{6+}) mg/lit, Max	0.05	No relaxation
27	Polynuclear aromatic hydro carbons (as PAH) g/lit, Max	--	--
28	Mineral Oil mg/lit, Max	0.01	0.03
29	Pesticides mg/l, Max	Absent	0.001
30	Radioactive Materials		
	i. Alpha emitters Bq/l, Max	--	0.1
	ii. Beta emitters pci/l, Max	--	1
31	Alkalinity mg/lit, Max	200	600
32	Aluminium (as Al) mg/l, Max	0.03	0.2
33	Boron mg/lit, Max	1	5
Bacteriological Parameters			
a) For water entering a distribution system Coliform count in any sample of 100 ml should be zero(0). b) For water in a distribution system (i) E Coli count in 100 ml of any sample must be zero (0). (ii) Coliform organisms should not be more than 10 per 100 ml in any sample. (iii) Coliform organisms should not be present in 100 ml of any two consecutive samples or more than 5% of the samples collected for the year.			

Annexure 4: Water Qualilty Criteria CPCB. National Standards for Inland Surface Waters Subject to Pollution (IS:2296)

Class C – Drinking water with conventional treatment followed by disinfection.

Sl No.	Parameter and Unit	Class of Water	Criteria
1	Drinking WaterSource without conventional treatment but after disinfection	A	Total Coliforms Organism MPN/100ml shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 20C 2mg/l or less
2	Outdoor bathing (Organised)	B	Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more Biochemical Oxygen Demand 5 days 20C 3mg/l or less
3	Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 20C 3mg/l or less
4	Propagation of Wild life and Fisheries	D	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/l or less
5	Irrigation, Industrial Cooling, Controlled Waste disposal	E	pH betwwn 6.0 to 8.5 Electrical Conductivity at 25C micro mhos/cm Max.2250 Sodium absorption Ratio Max. 26 Boron Max. 2mg/l
		Below E	Not Meeting A, B, C, D & E Criteria

Annexure 5: National Standards for Discharge of Effluents

S. No.	Parameter	Inland surface water	Public sewers	Land for irrigation	Marine/coastalare as
.	2		3	.	.
.	.	(a)	(b)	(c)	(d)
1	Colour and odour	All efforts should be made to remove colour and unpleasant odour as far as practicable		All efforts should be made to remove colour and unpleasant odour as far as practicable	All efforts should be made to remove colour and unpleasant odour as far as practicable
2	Suspended solids mg/l, max.	100	600	200	(a) For process waste water (b) For cooling water effluent 10 per cent above total suspended matter of influent.
3	Particle size of suspended solids	shall pass 850 micron IS Sieve	-	-	(a) Floatable solids, solidsmax. 3 mm (b) Settleable solids, max 856 microns
4	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
5	Temperature	shall not exceed 5oC above the receiving water temperature			shall not exceed 5oCabove the receiving water temperature
6	Oil and grease, mg/l max,	10	20	10	20
7	Total residual chlorine, mg/l max	1.0	-	-	1.0
8	Ammonical nitrogen (as N),mg/l, max.	50	50	-	50
9	Total kjeldahl nitrogen (as N);mg/l, max. mg/l, max.	100	-	-	100
10	Free ammonia (as NH3), mg/l,max.	5.0	-	-	5.0
11	Biochemical oxygen demand (3 days at 27oC), mg/l, max.	30	350	100	100
12	Chemical oxygen demand, mg/l, max.	250	-	-	250
13	Arsenic(as As).	0.2	0.2	0.2	0.2
14	Mercury (As Hg),	0.01	0.01	-	0.01

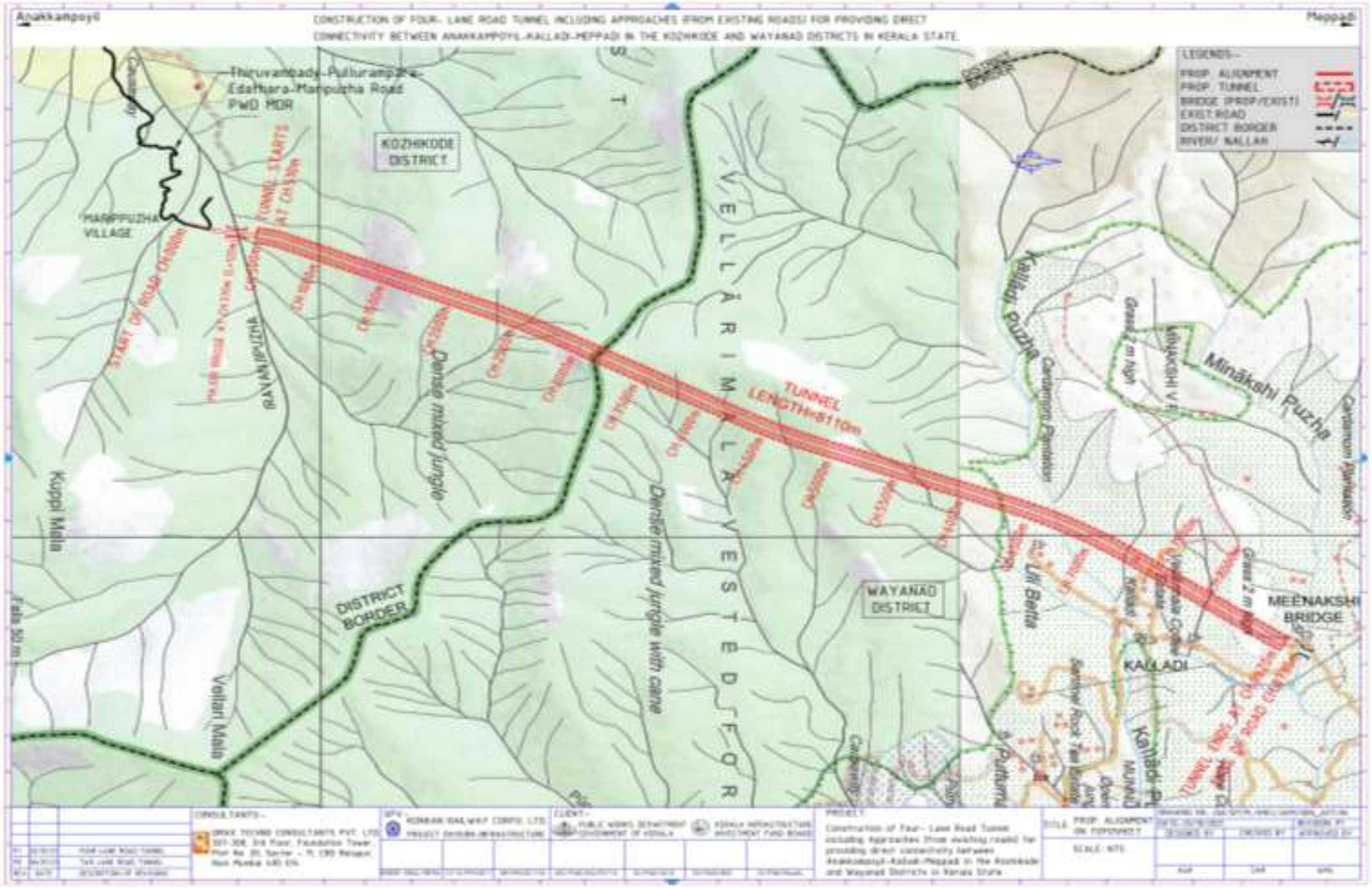
S. No.	Parameter	Inland surface water	Public sewers	Land for irrigation	Marine/coastalare as
.	2		3	.	.
.	.	(a)	(b)	(c)	(d)
	mg/l, max.				
15	Lead (as Pb) mg/l, max	0.1	1.0	-	2.0
16	Cadmium (as Cd) mg/l, max	2.0	1.0	-	2.0
17	Hexavalent chro-mium (as Cr + 6),mg/l, max.	0.1	2.0	-	1.0
18	Total chromium (as Cr) mg/l, max.	2.0	2.0	-	2.0
19	Copper (as Cu)mg/l, max.	3.0	3.0	-	3.0
20	Zinc (as Zn) mg/l, max.	5.0	15	-	15
21	Selenium (as Se)	0.05	0.05	-	0.05
22	Nickel (as Ni) mg/l, max.	3.0	3.0	-	5.0
23	Cyanide (as CN) mg/l, max.	0.2	2.0	0.2	0.2
24	Fluoride (as F) mg/l, max.	2.0	15	-	15
25	Dissolved phos-phates (as P),mg/l, max.	5.0	-	-	-
26	Sulphide (as S) mg/l, max.	2.0	-	-	5.0
27	Phenolic compounds (as C6H50H)mg/l, max.	1.0	5.0	-	5.0
28	Radioactive materials: (a) Alpha emitters micro curie mg/l, max. (b)Beta emittersmicro curie mg/l	10-7 10-6	10-7 10-6	10-8 10-7	10-7 10-6
29	Bio-assay test	90% suivival of fish after 96 hours in 100% effluent	90% suivival of fish after 96 hours in 100% effluent	90% suivival of fish after 96 hours in 100% effluent	90% suivival of fish after 96 hours in 100% effluent
30	Manganese	2 mg/l	2 mg/l	-	2 mg/l
31	Iron (as Fe)	3mg/l	3mg/l	-	3mg/l
32	Vanadium (as V)	0.2mg/l	0.2mg/l	-	0.2mg/l
33	Nitrate Nitrogen	10 mg/l	-	-	20 mg/l

** These standards shall be applicable for industries, operations or processes other than those industries, operations or process for which standards have been specified in Schedule of the Environment Protection Rules, 1989.*

Annexure 6: Codes of Practice of Indian Road Congress (IRC) in terms of Environment

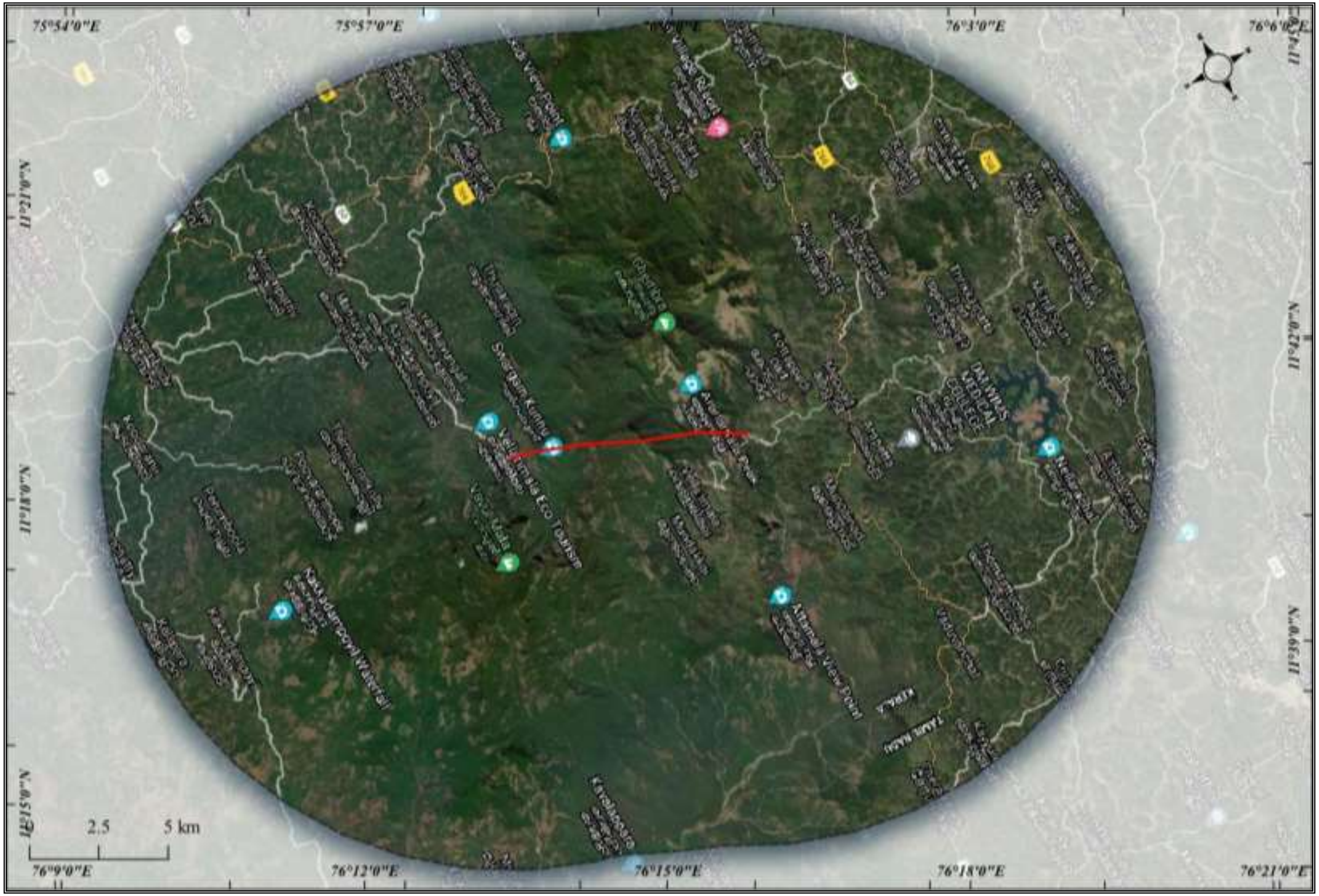
Sl. No.	IRC Code	Description
1	**IRC:SP: 91-2010**	**Guideline for Rod Tunnel**
2	IRC:34-2011	Recommendations for Road Construction in Areas Affected by Water Logging, Flooding and/or Salts Infestation (First Revision)
3	IRC:56-2011	Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control (First Revision)
4	IRC-109-2015	Guidelines for Wet Mix Macadam
5	IRC:103-2022	Guidelines for Pedestrian Facilities
6	IRC:104-1988	Guidelines for Environmental Impact Assessment of Highway Projects
7	IRC:SP:21-2009	Guidelines on Landscaping and Tree Plantation
8	IRC: SP: 42 – 2014	Guidelines on Road Drainage
9	IRC: SP: 44 – 1996	Highway Safety Code
10	IRC: SP: 48 – 1998	Hill Road Manual
11	IRC: SP: 88 - 2019	Road Safety Audit Manual

Annexure 7:Key Plan of the Project Road Shows the Nature of Terrain, Drainage and other

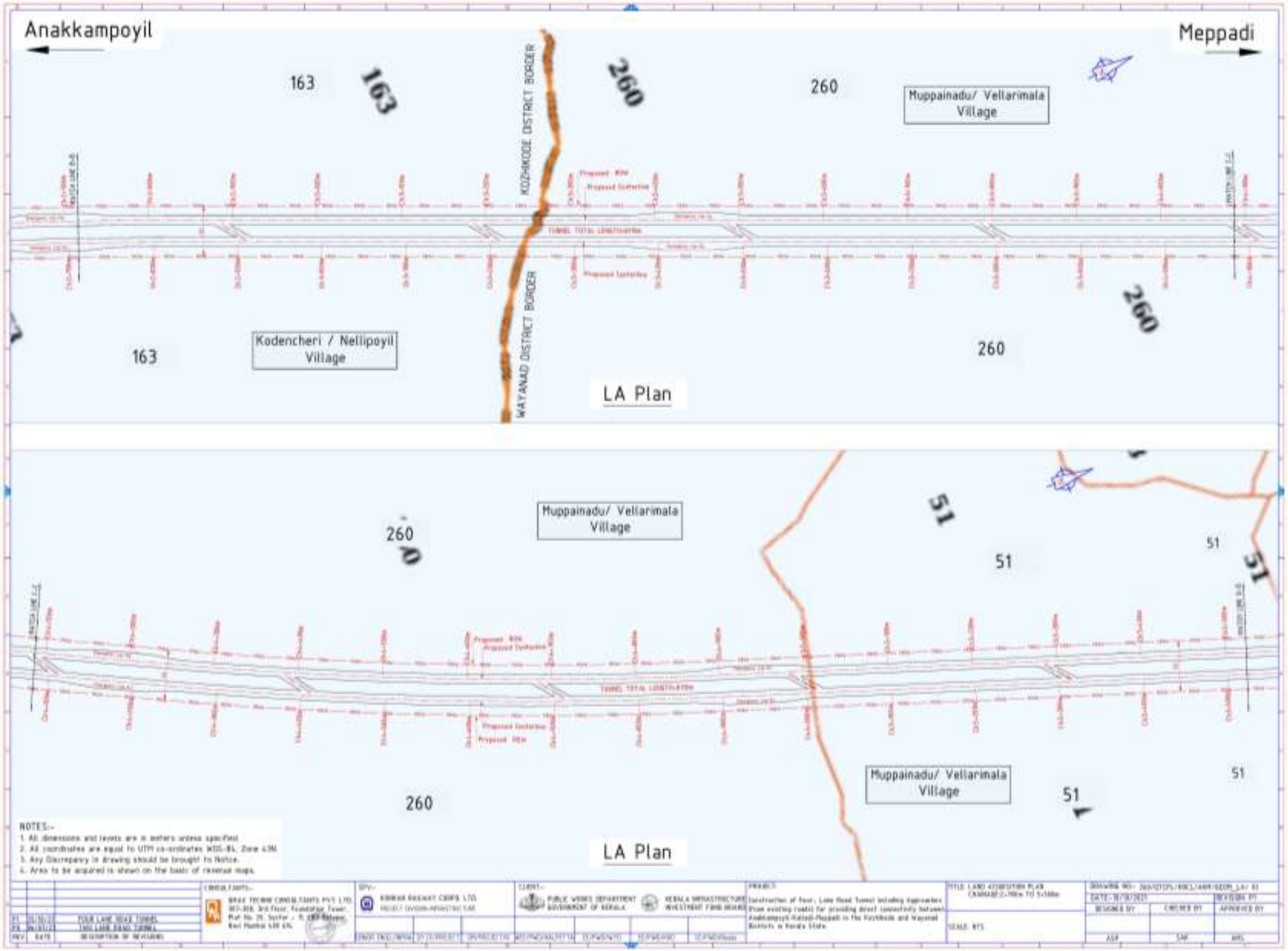


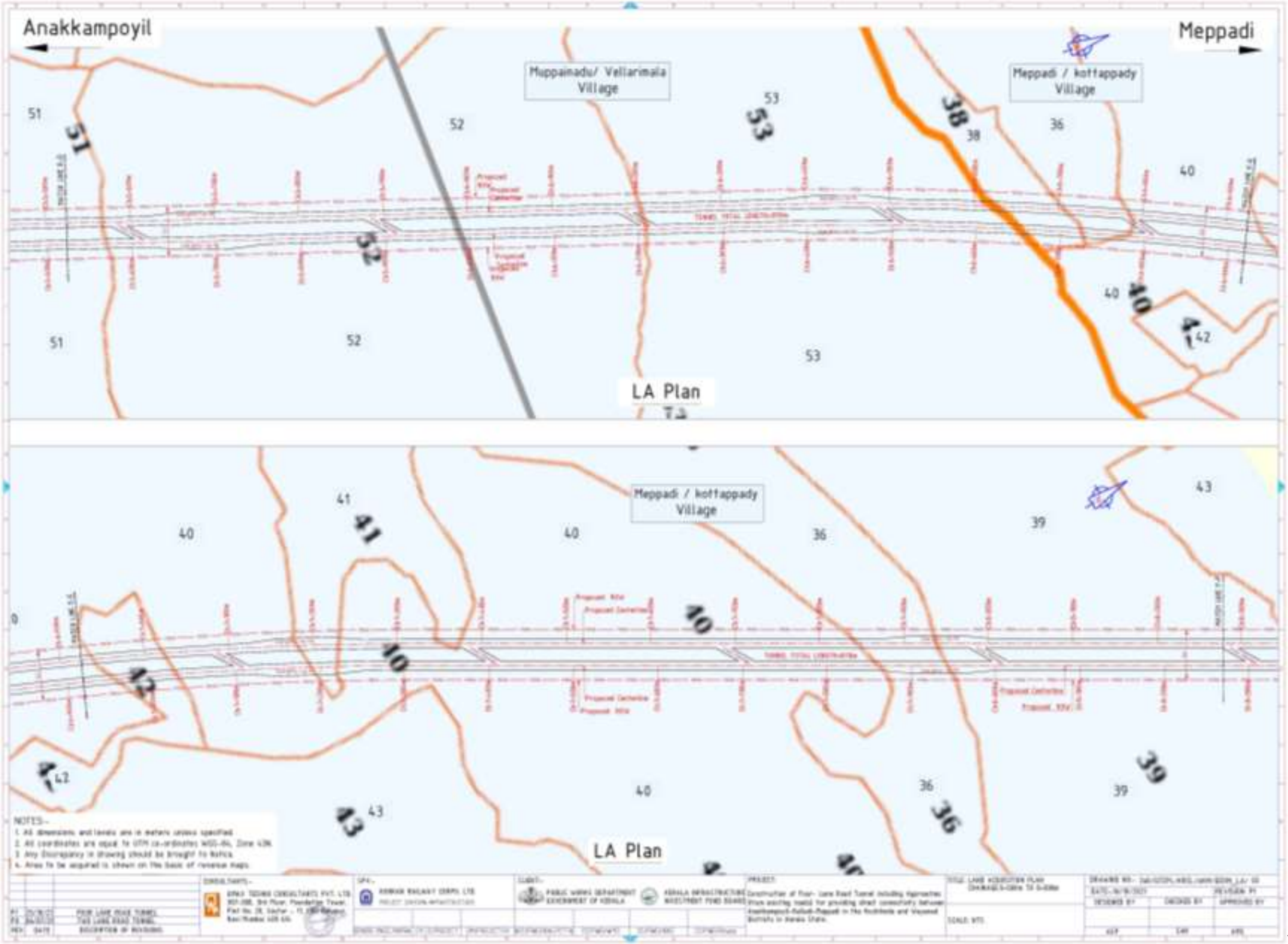
geOGRAPH

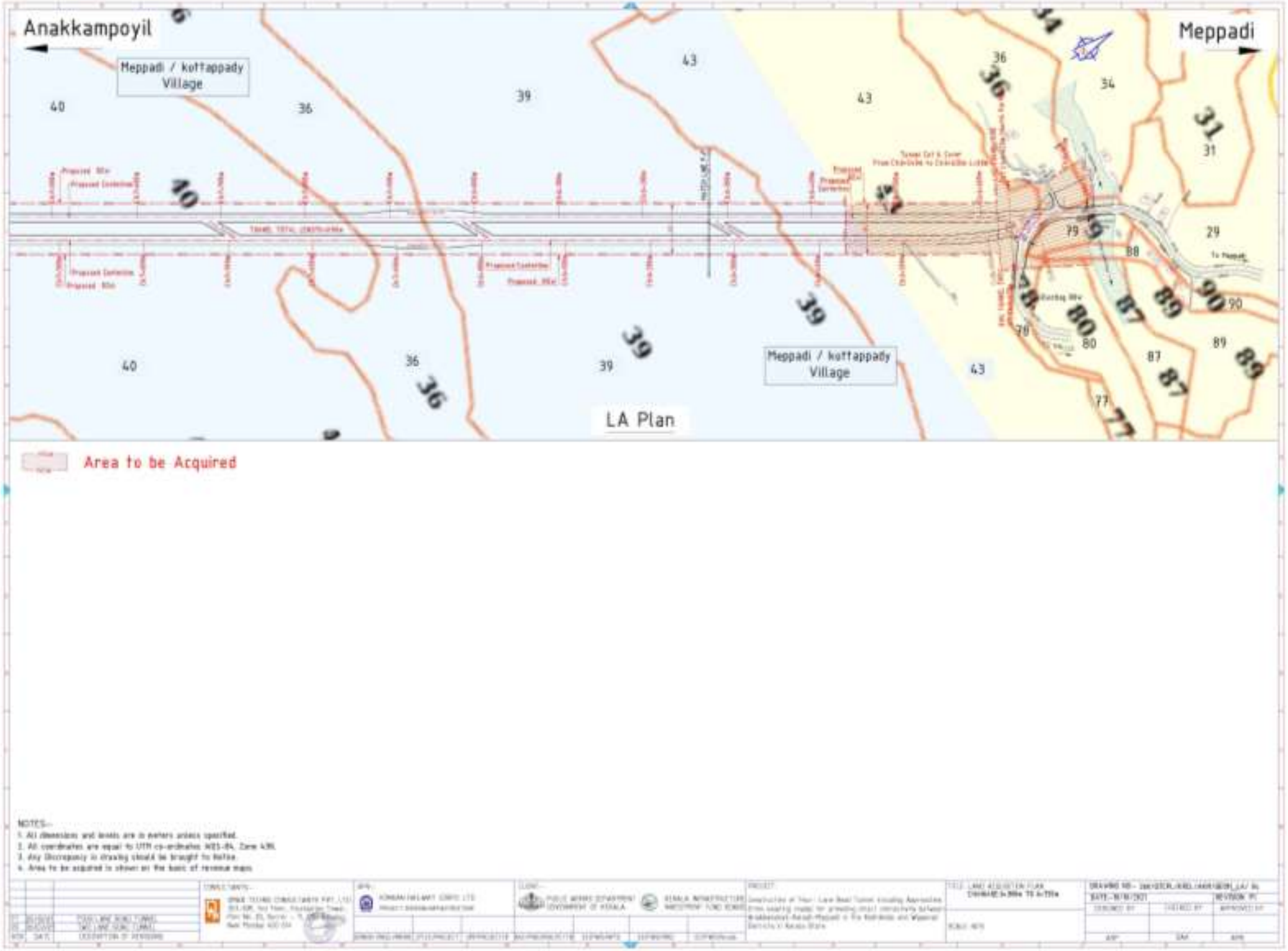
Annexure 8: Satellite Imagery of Project Tunnel Road Showing Environmental Sensitive Features



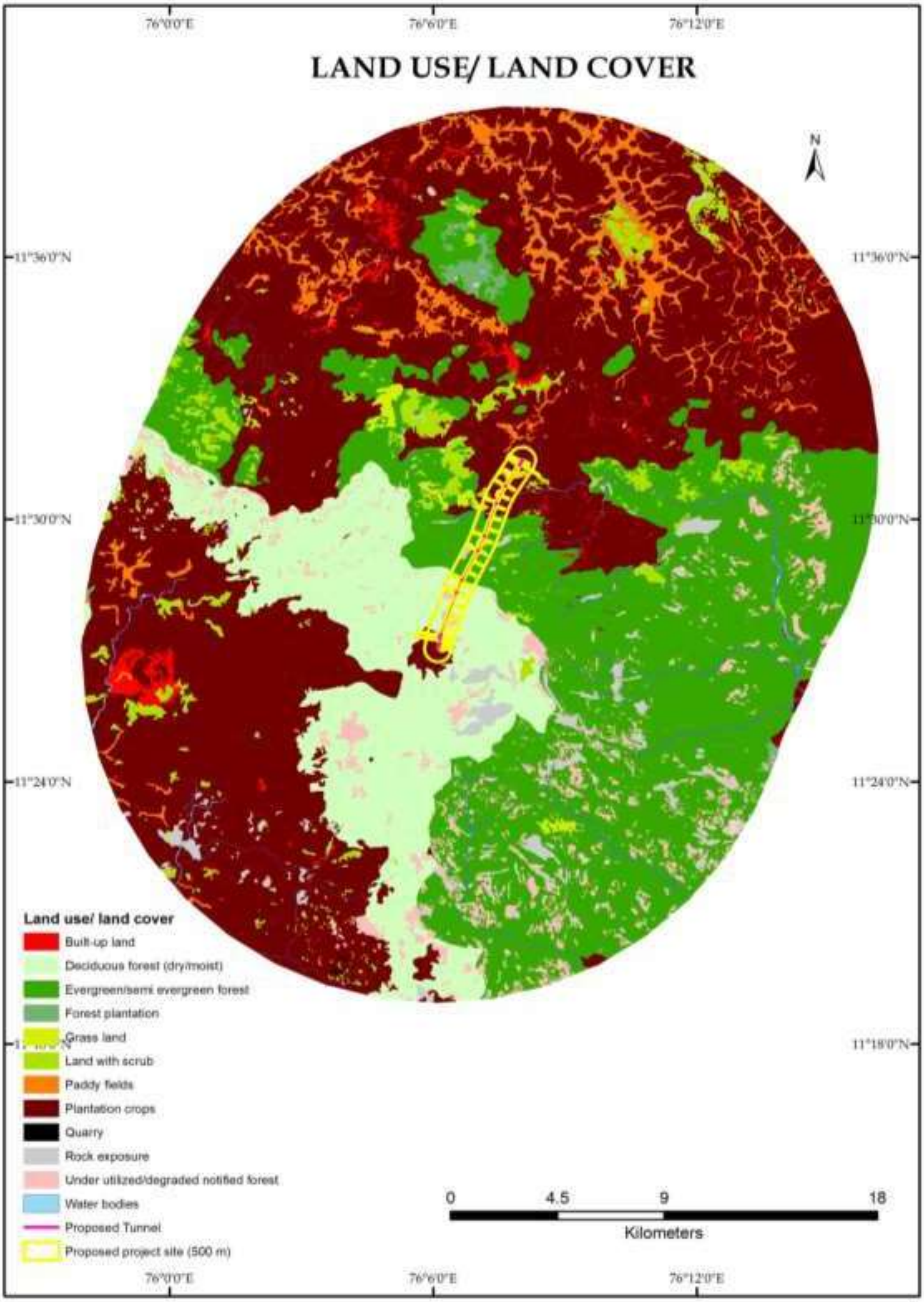
Annexure 9: Project Tunnel Road with Administrative Boundaries


Anakkampoyil
Meppadi
163
260
Muppainadu/ Vellarimala Village
KOZHIKODE DISTRICT BORDER
WAYANAD DISTRICT BORDER
Kodencheri / Nellipoyil Village
LA Plan
51
NOTES:-

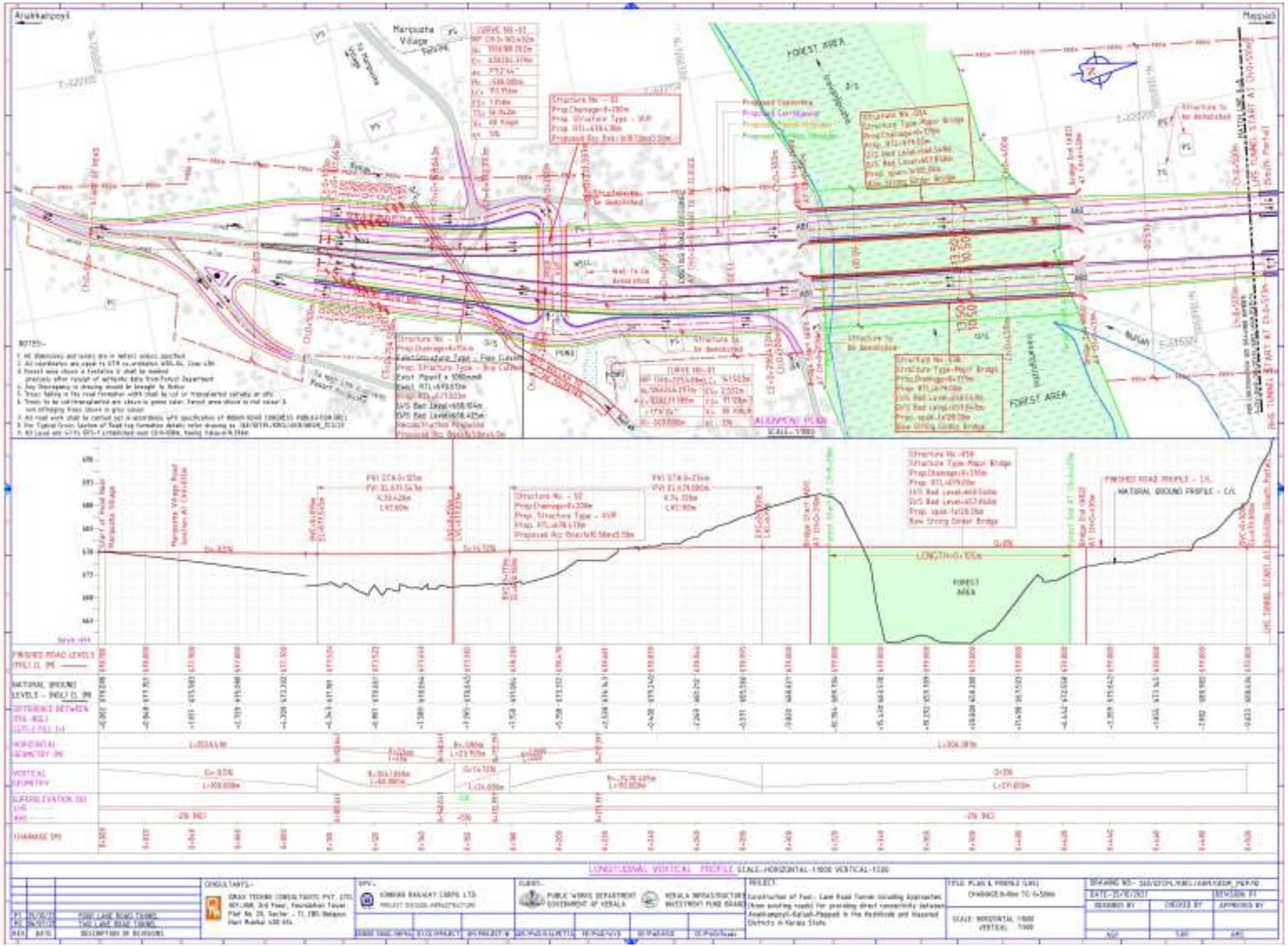

Anakkampoyil
Meppadi
Muppainadu/ Vellarimala Village
Meppadi / kottappady Village
LA Plan
Meppadi / kottappady Village
LA Plan
NOTES:-

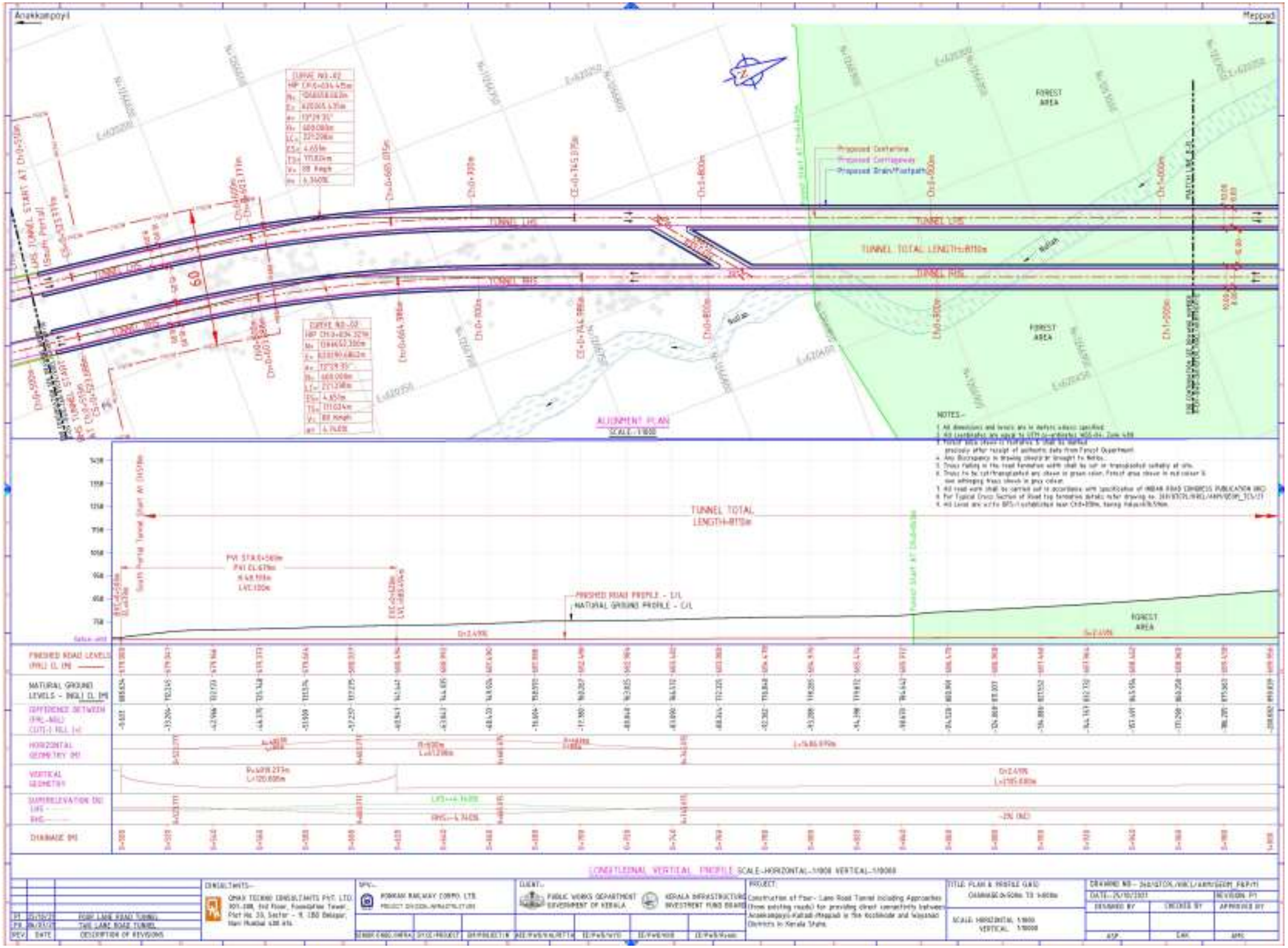

Anakkampoyil
Meppadi
Meppadi / kottappady Village
Meppadi / kottappady Village
LA Plan
Area to be Acquired

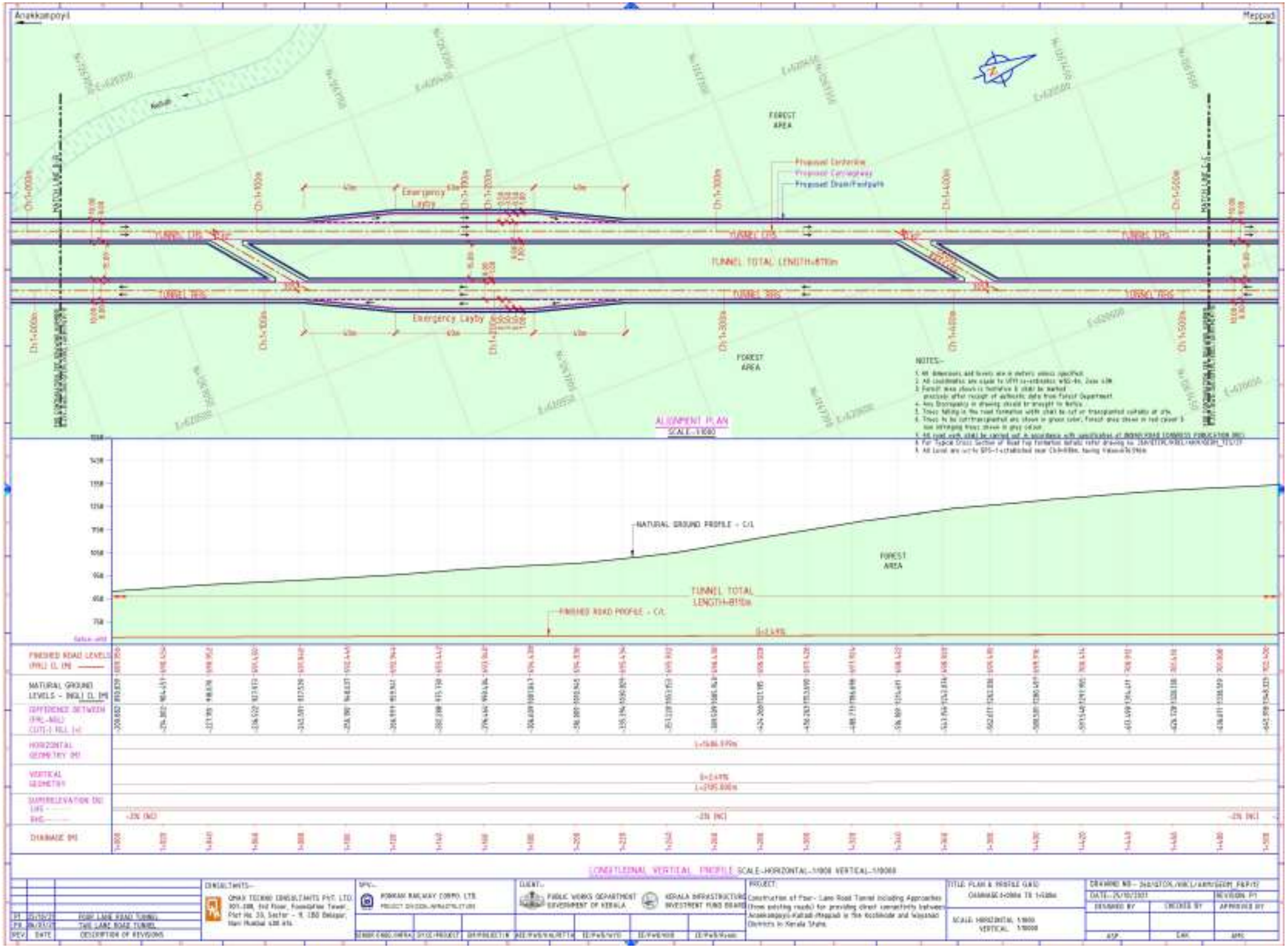
Annexure 10: Land Use Map of the Project Area (15 km)

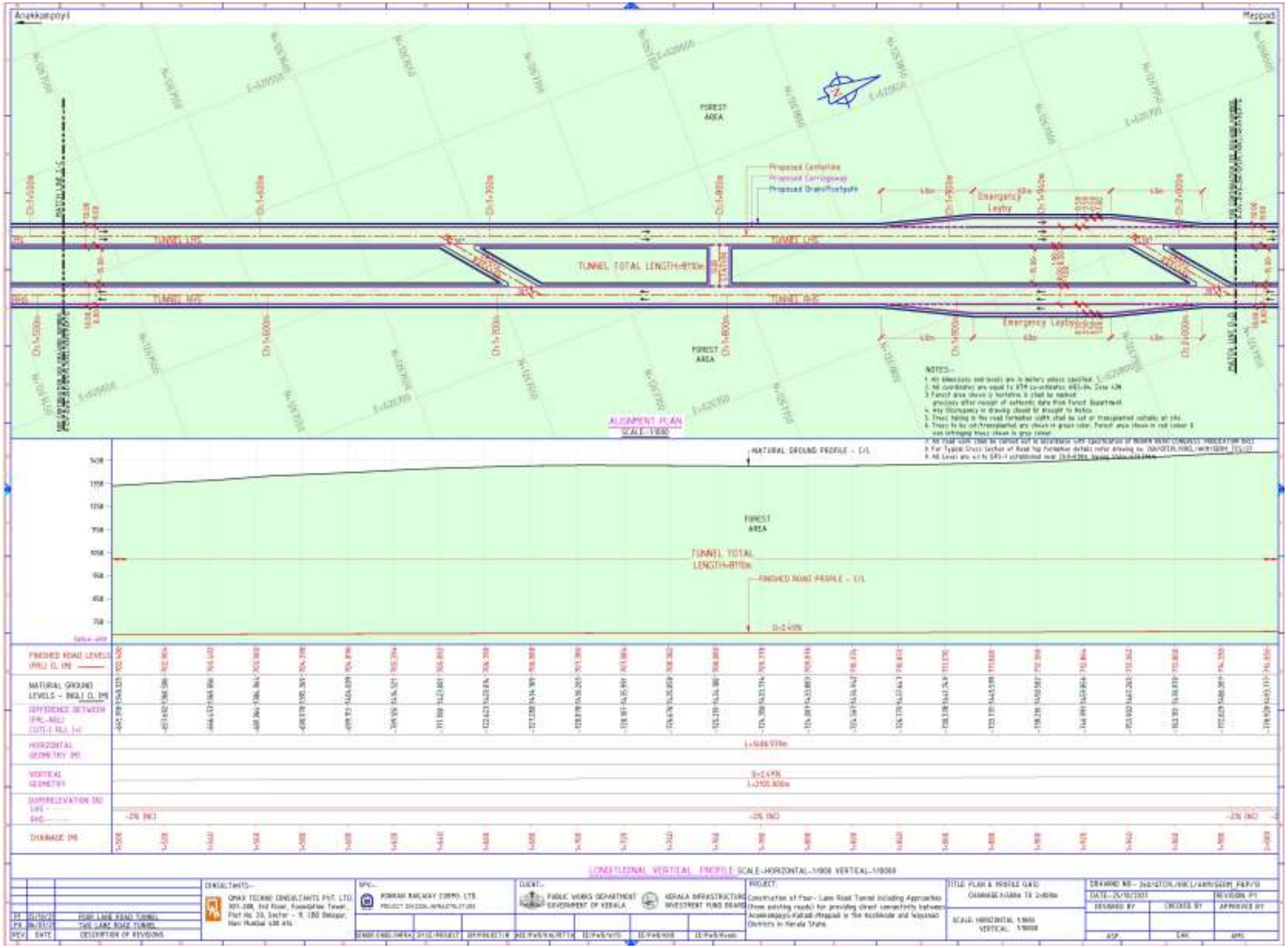


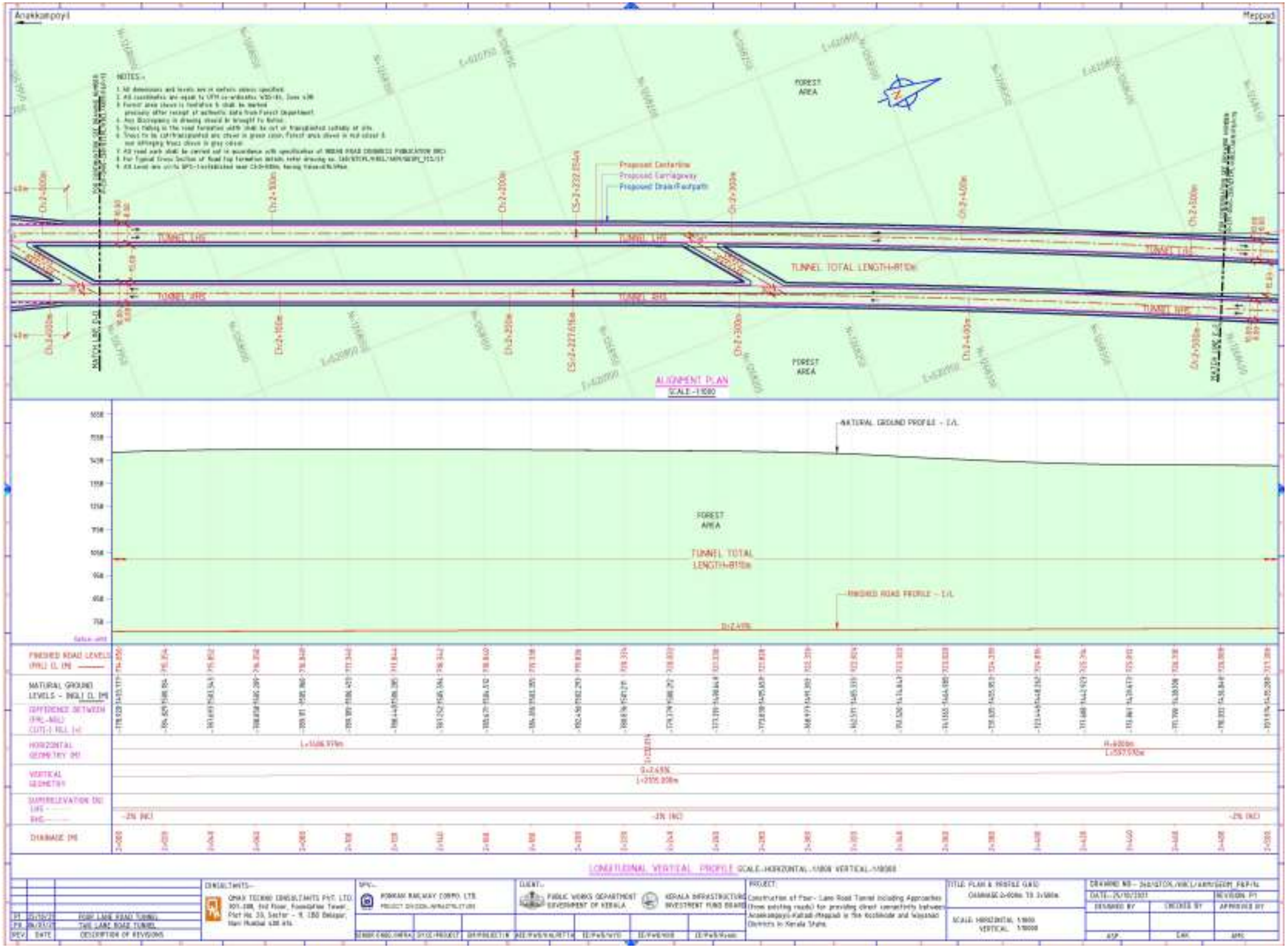
Annexure 11: Detailed Ground Surveyed Map Showing the Existing Features along the Project Road

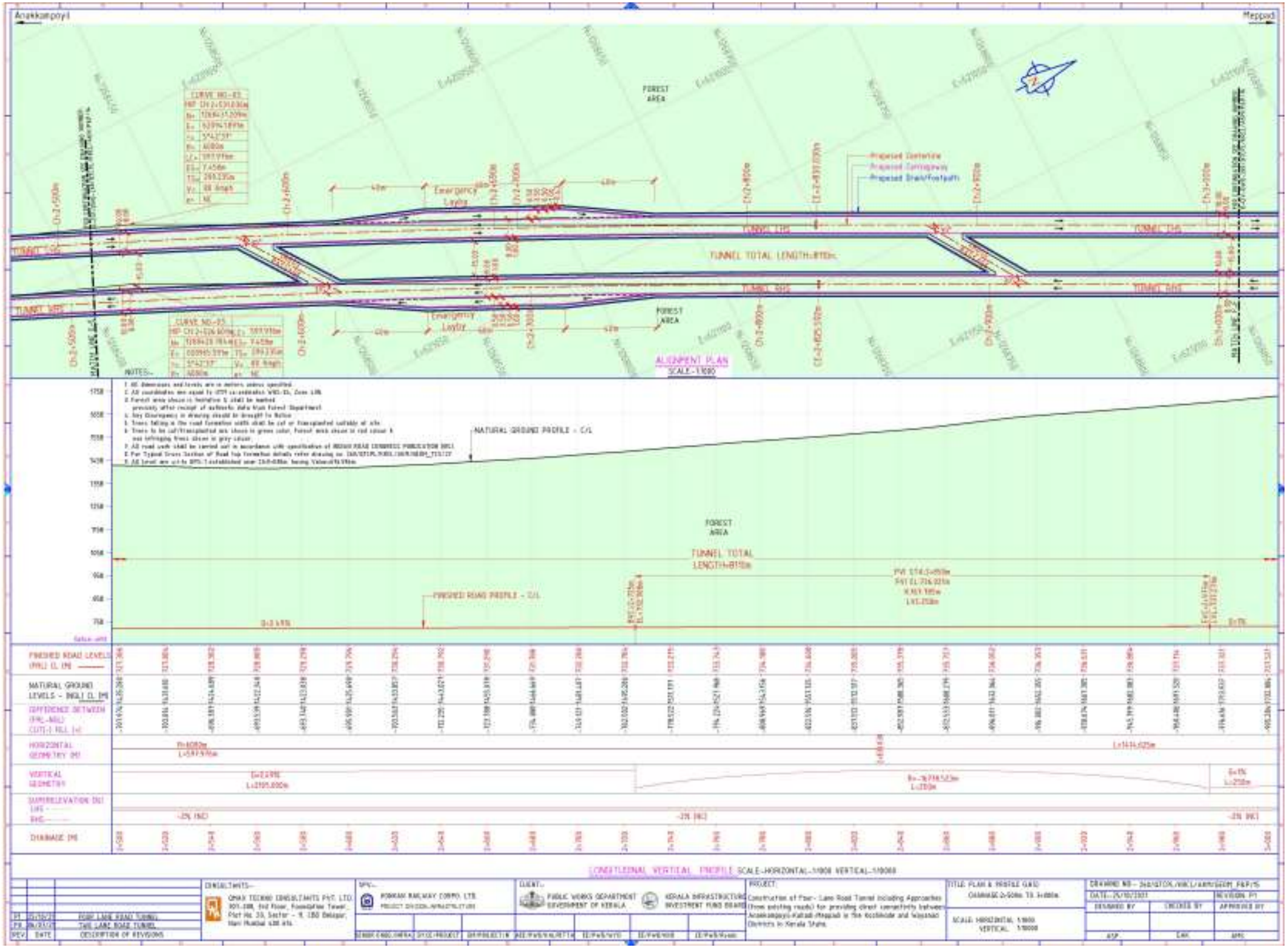


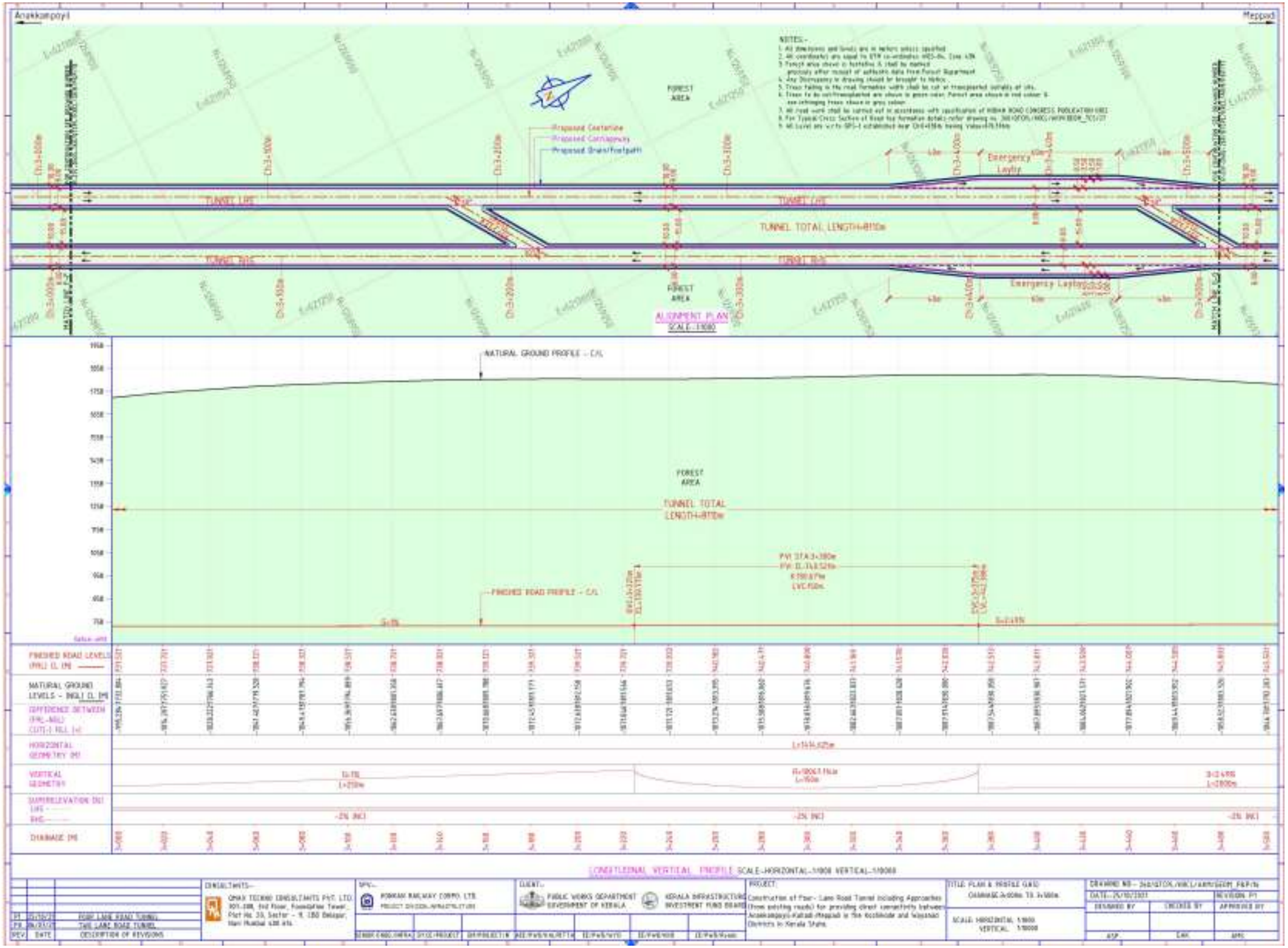

Anakkampoyil
Meppadi
FOREST AREA
TUNNEL TOTAL LENGTH=8110m
ALIGNMENT PLAN
NOTES-
TUNNEL TOTAL LENGTH=8110m
FOREST AREA
LONGITUDINAL VERTICAL PROFILE

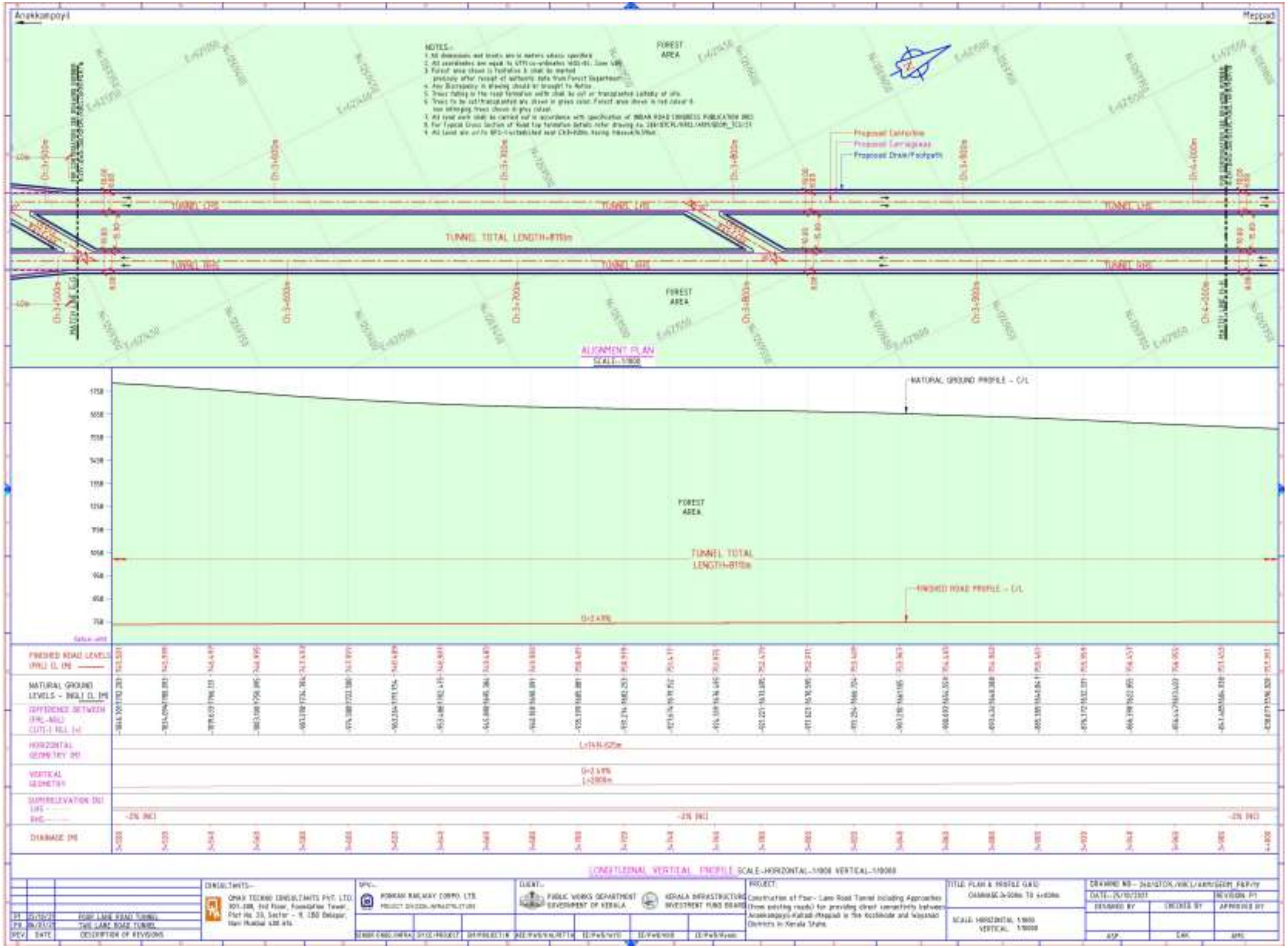

Meppadi
FOREST AREA
Emergency Layby
TUNNEL TOTAL LENGTH
NOTES:
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
FOREST AREA
LONGITUDINAL VERTICAL PROFILE

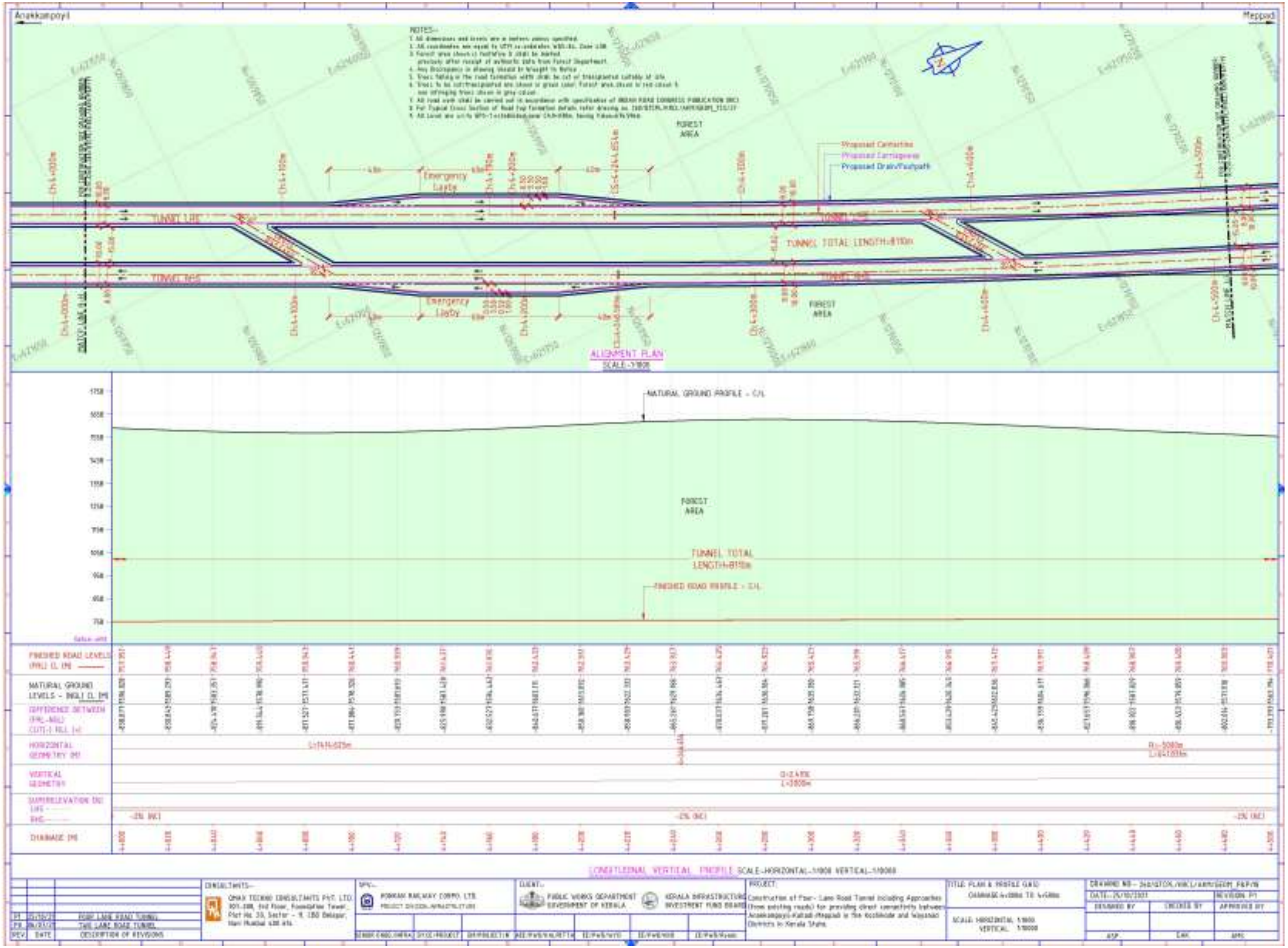

Anakkampoyil
Meppadi
FOREST AREA
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8110m
Emergency Layby
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD PROFILE - C/L
LONGITUDINAL VERTICAL PROFILE

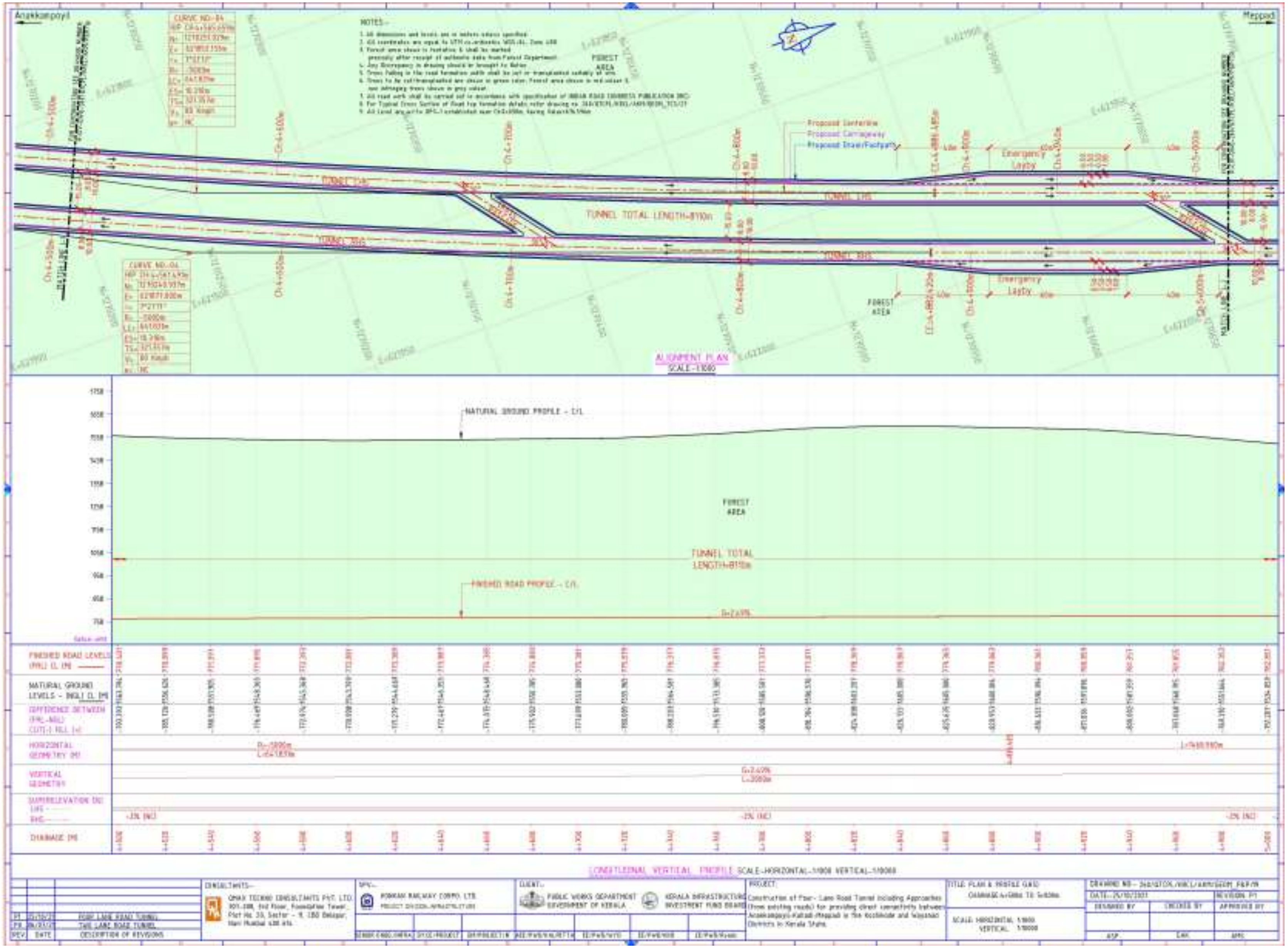

Anakkampoyil
Meppadi
FOREST AREA
TUNNEL TOTAL LENGTH=8110m
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD PROFILE - C/L
LONGITUDINAL VERTICAL PROFILE

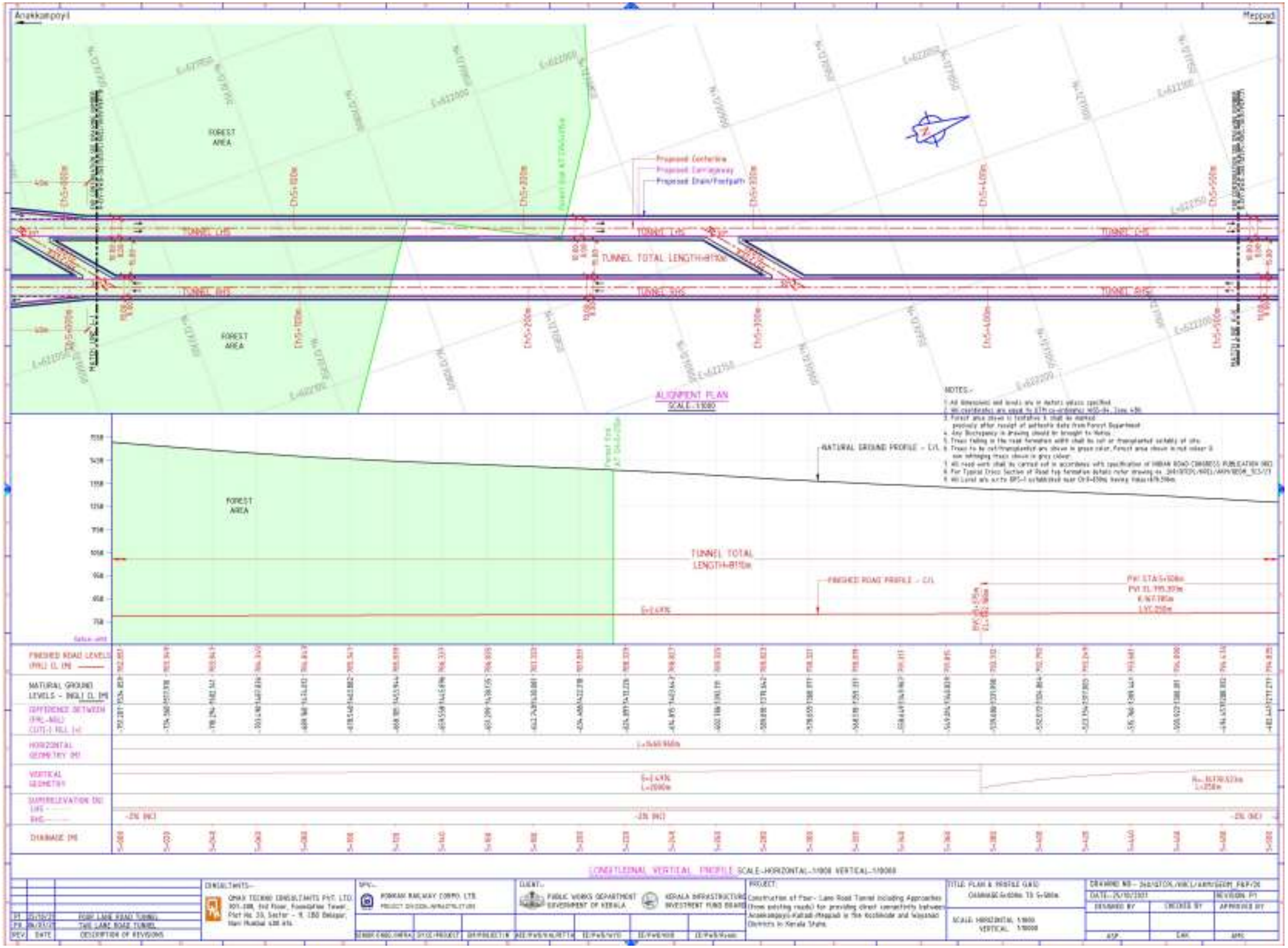

Anakkampoyil
Meppadi
FOREST AREA
TUNNEL TOTAL LENGTH=8110m
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
NOTES:-
FINISHED ROAD LEVELS (FRL) EL (M)
NATURAL GROUND LEVELS - (NGL) EL (M)
DIFFERENCE BETWEEN (FRL-NGL) CUT(-) FILL (+)
HORIZONTAL GEOMETRY (M)
VERTICAL GEOMETRY
SUPERELEVATION (%)
CHAINAGE (M)
LONGITUDINAL VERTICAL PROFILE


TUNNEL TOTAL LENGTH=8110m
FOREST AREA
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
Emergency Layby

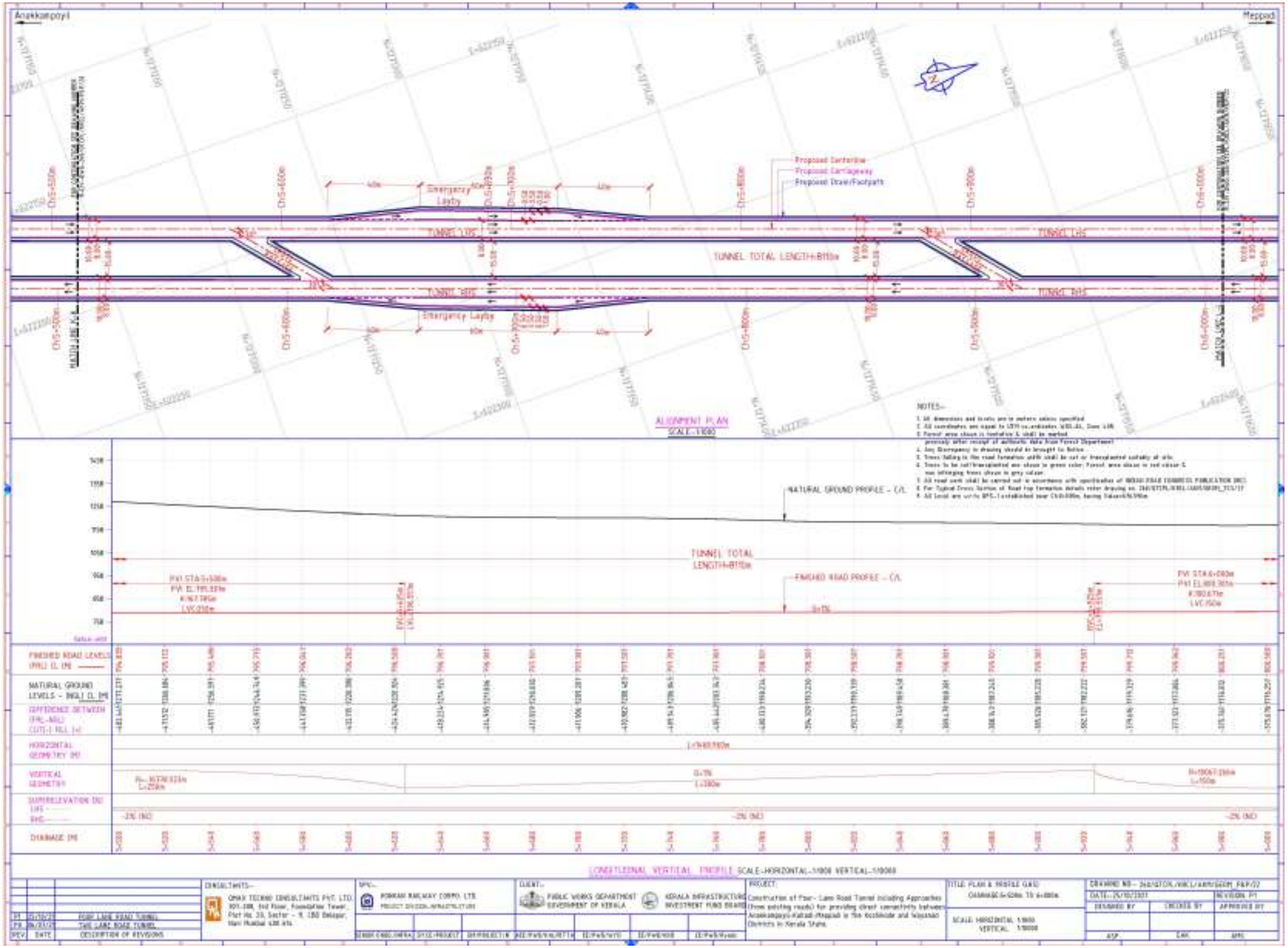

ALIGNMENT PLAN
TUNNEL TOTAL LENGTH=8110m
FOREST AREA
LONGITUDINAL VERTICAL PROFILE

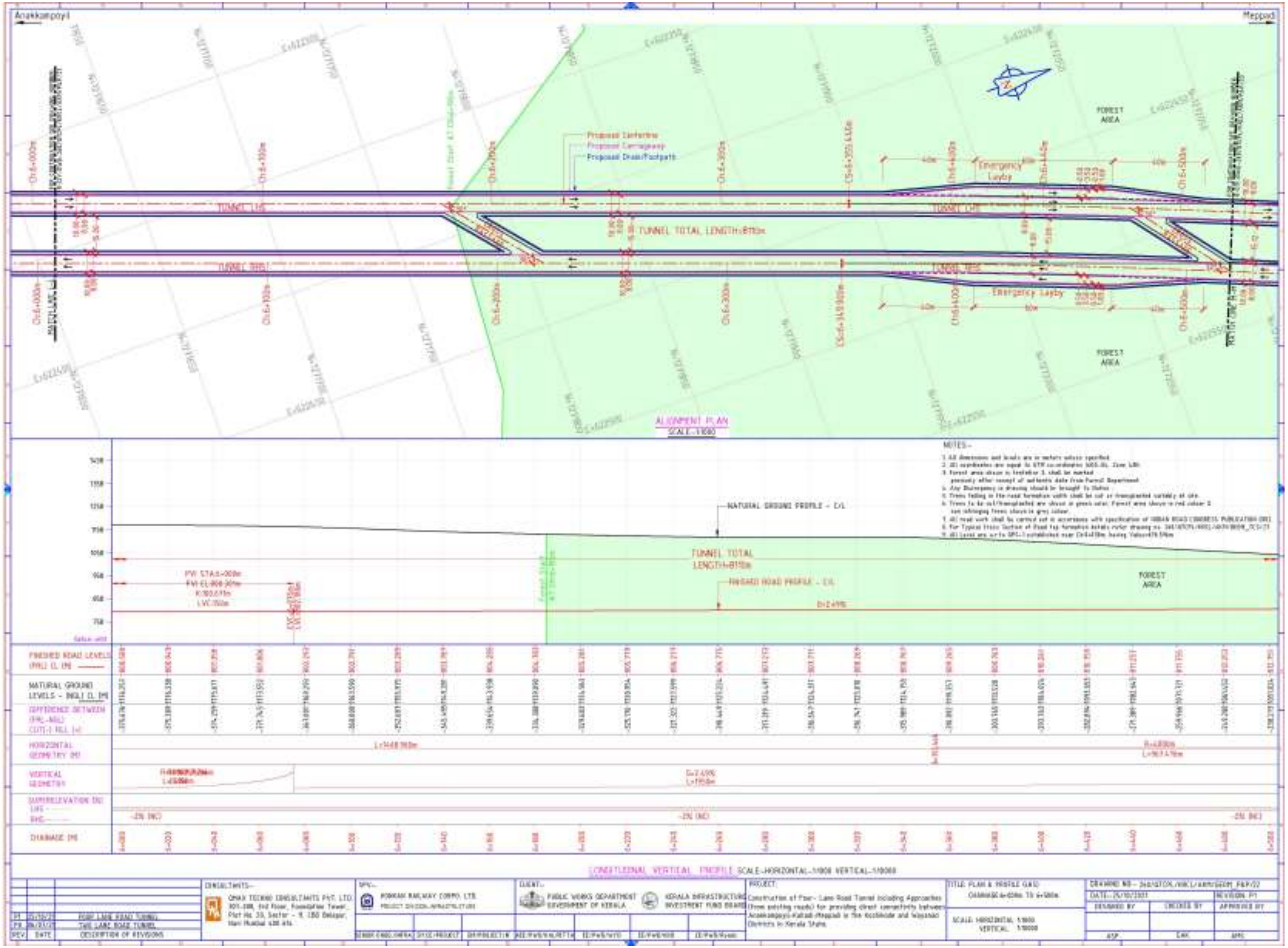

Anakkampoyil
Meppadi
NOTES:-
FOREST AREA
Proposed Centerline
Proposed Carriageway
Proposed Drain/Footpath
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8110m
Emergency Layby
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
FOREST AREA
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD PROFILE - C/L
FINISHED ROAD LEVELS (FRL) CL (M)
NATURAL GROUND LEVELS - (NGL) CL (M)
DIFFERENCE BETWEEN (FRL-NGL) CUT(-) FILL (+)
HORIZONTAL GEOMETRY (M)
VERTICAL GEOMETRY
SUPERELEVATION (%)
CHAINAGE (M)
LONGITUDINAL VERTICAL PROFILE
CONSULTANTS:-
KONKAN RAILWAY CORPN. LTD.
PUBLIC WORKS DEPARTMENT GOVERNMENT OF KERALA
KERALA INFRASTRUCTURE INVESTMENT FUND BOARD
TITLE: PLAN & PROFILE


ALIGNMENT PLAN
SCALE-1:1000
TUNNEL TOTAL LENGTH=8110m
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
FOREST AREA
LONGITUDINAL VERTICAL PROFILE

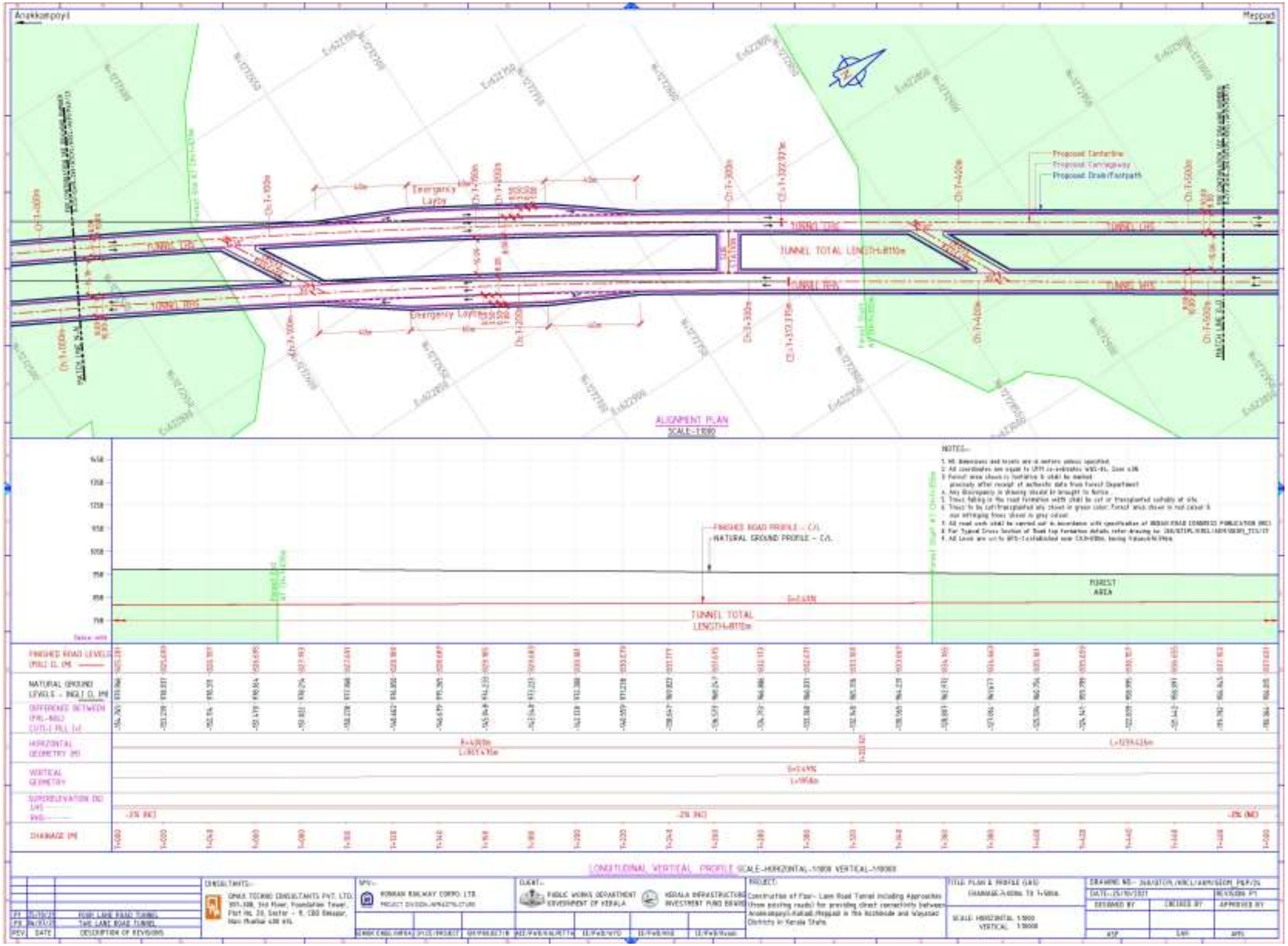


Anakkampoyil
Meppadi
FOREST AREA
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8110m
Proposed Centerline
Proposed Carriageway
Proposed Drain/Footpath
ALIGNMENT PLAN
SCALE- 1:5000
NOTES:-
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD LEVELS (FRL) CL (M)
NATURAL GROUND LEVELS - (NGL) CL (M)
DIFFERENCE BETWEEN (FRL-NGL) CUT(-) FILL (+)
HORIZONTAL GEOMETRY (M)
VERTICAL GEOMETRY
SUPERELEVATION (%)
CHAINAGE (M)
LONGITUDINAL VERTICAL PROFILE
CONSULTANTS:-
SPV:-
KONKAN RAILWAY CORPN. LTD.
CLIENT:-
PUBLIC WORKS DEPARTMENT GOVERNMENT OF KERALA
KERALA INFRASTRUCTURE INVESTMENT FUND BOARD
PROJECT:
TITLE: PLAN & PROFILE

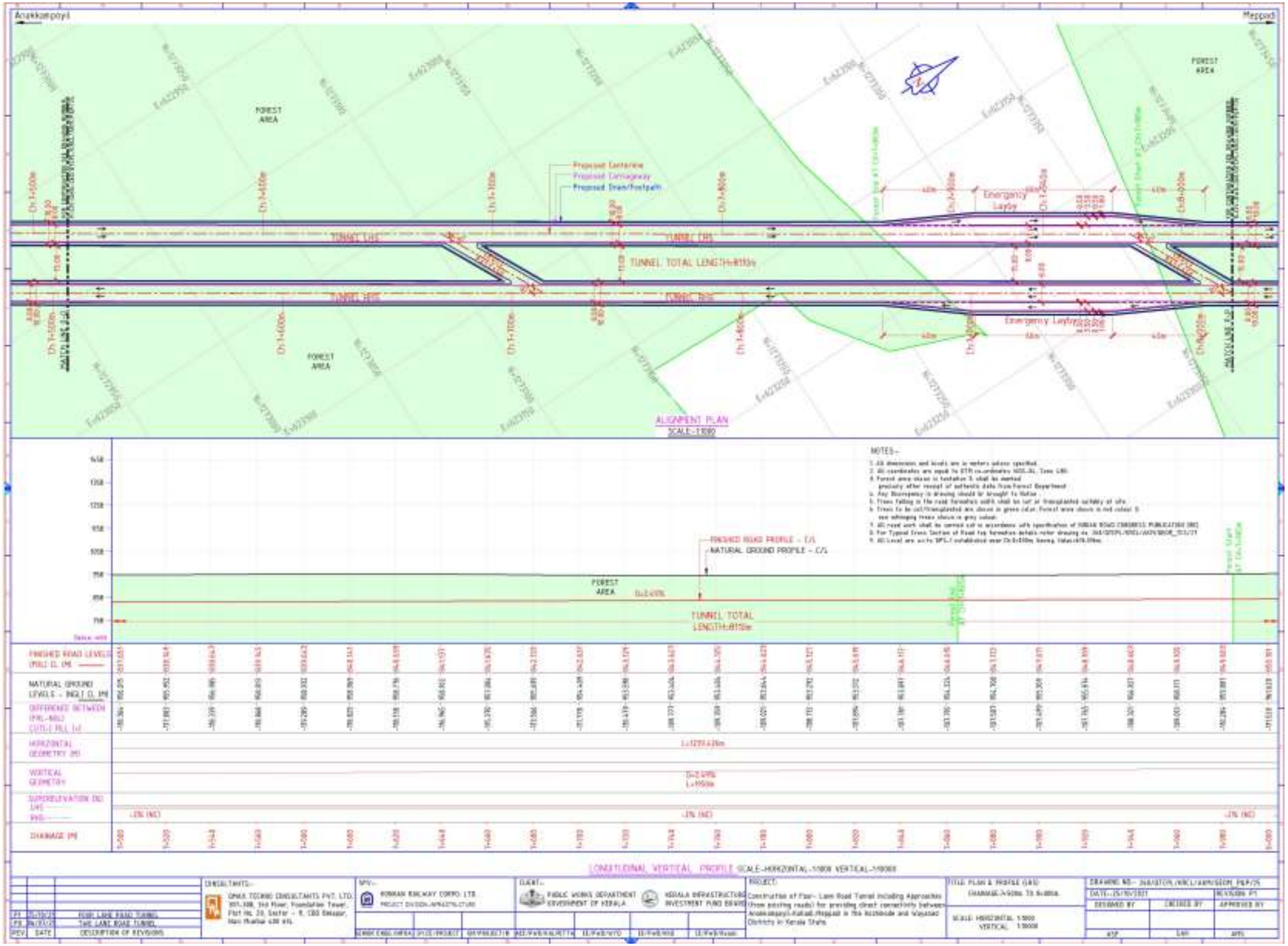

Anakkampoyil
Meppadi
TUNNEL LHS
TUNNEL RHS
Emergency Layby
ALIGNMENT PLAN
NOTES:-
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
LONGITUDINAL VERTICAL PROFILE

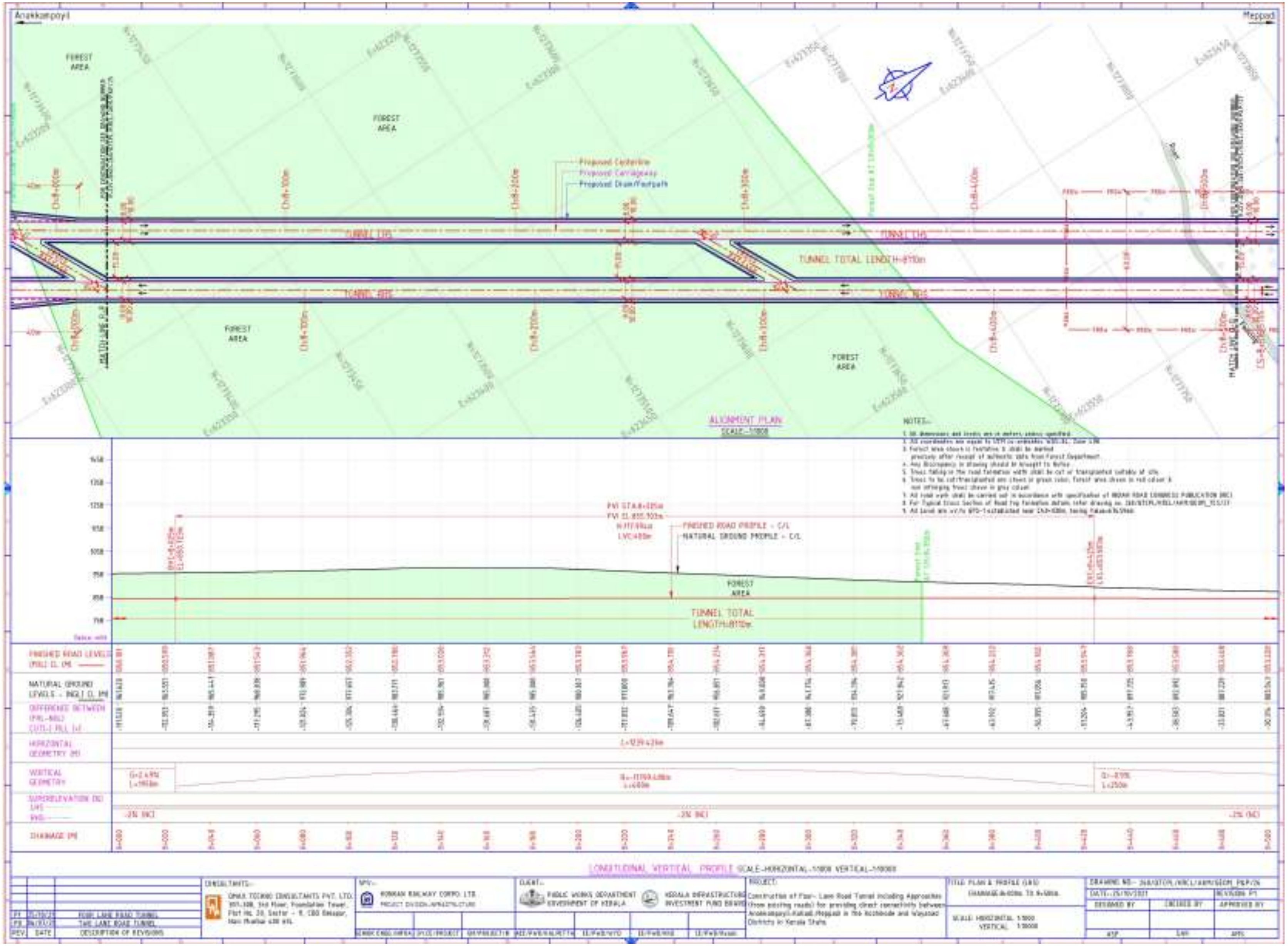


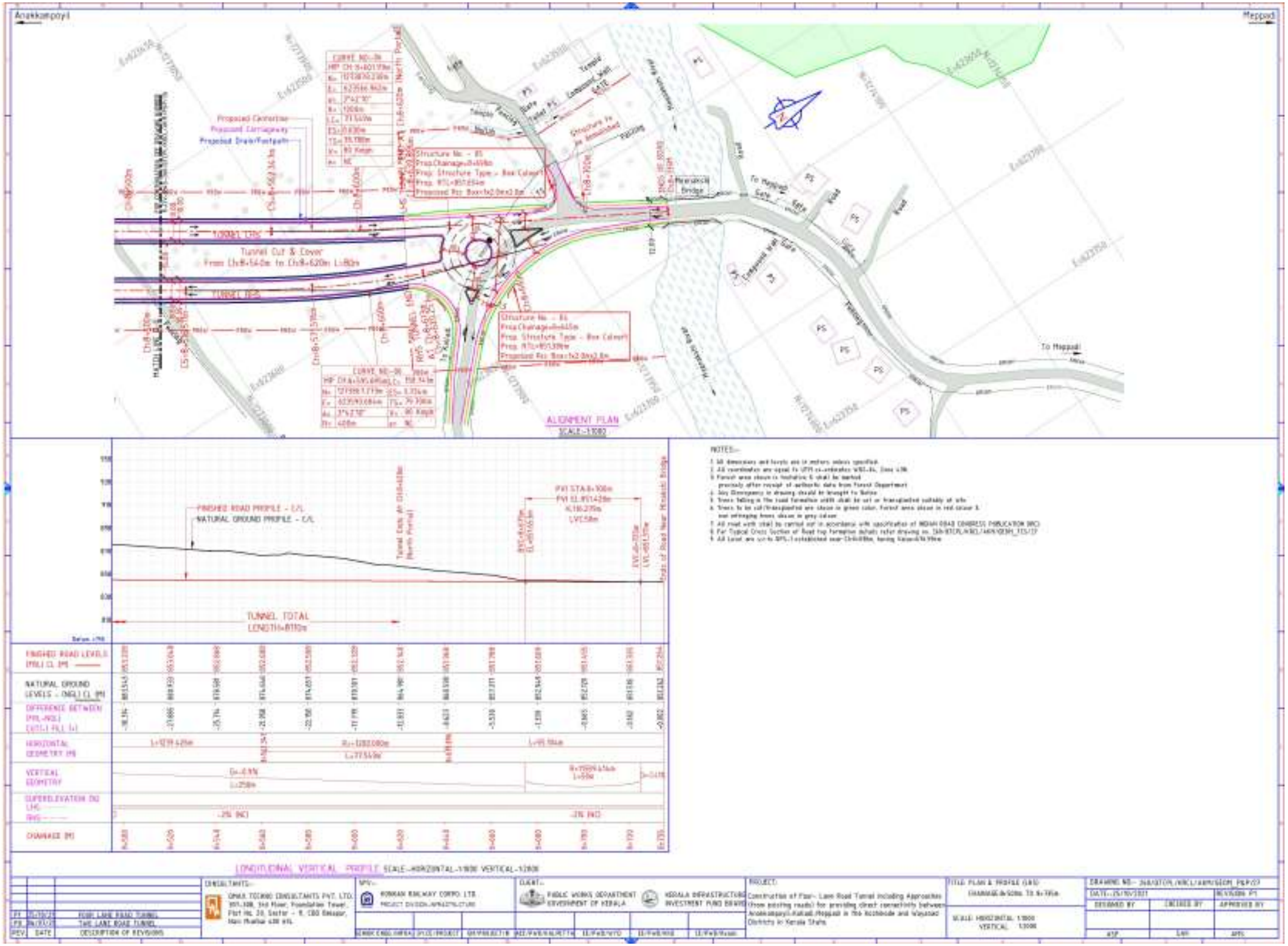
Anakkampoyil
Meppadi
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8110m
FOREST AREA
Emergency Layby
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD LEVELS
NATURAL GROUND LEVELS
HORIZONTAL GEOMETRY
VERTICAL GEOMETRY
SUPERELEVATION
CHAINAGE
LONGITUDINAL VERTICAL PROFILE

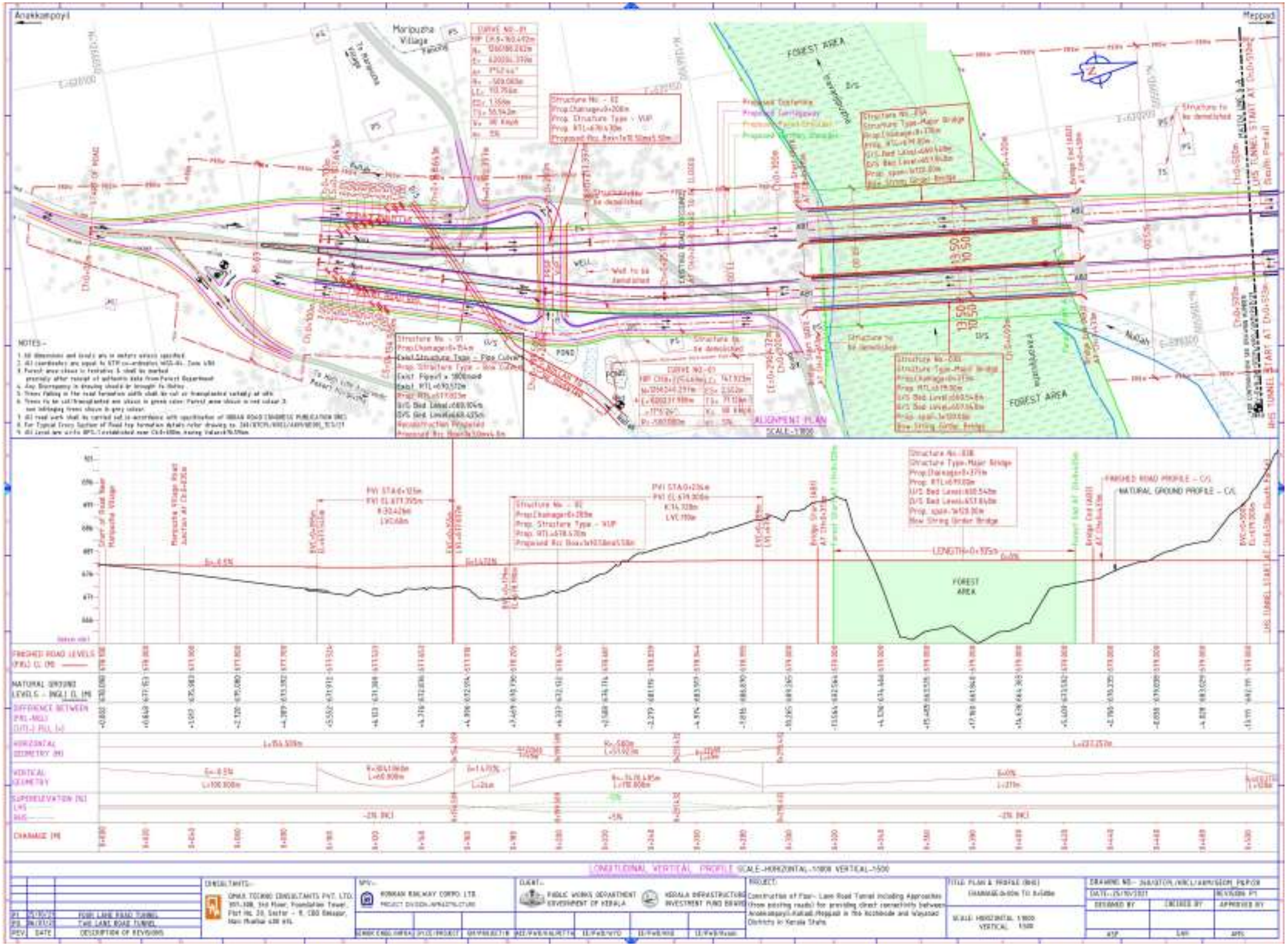


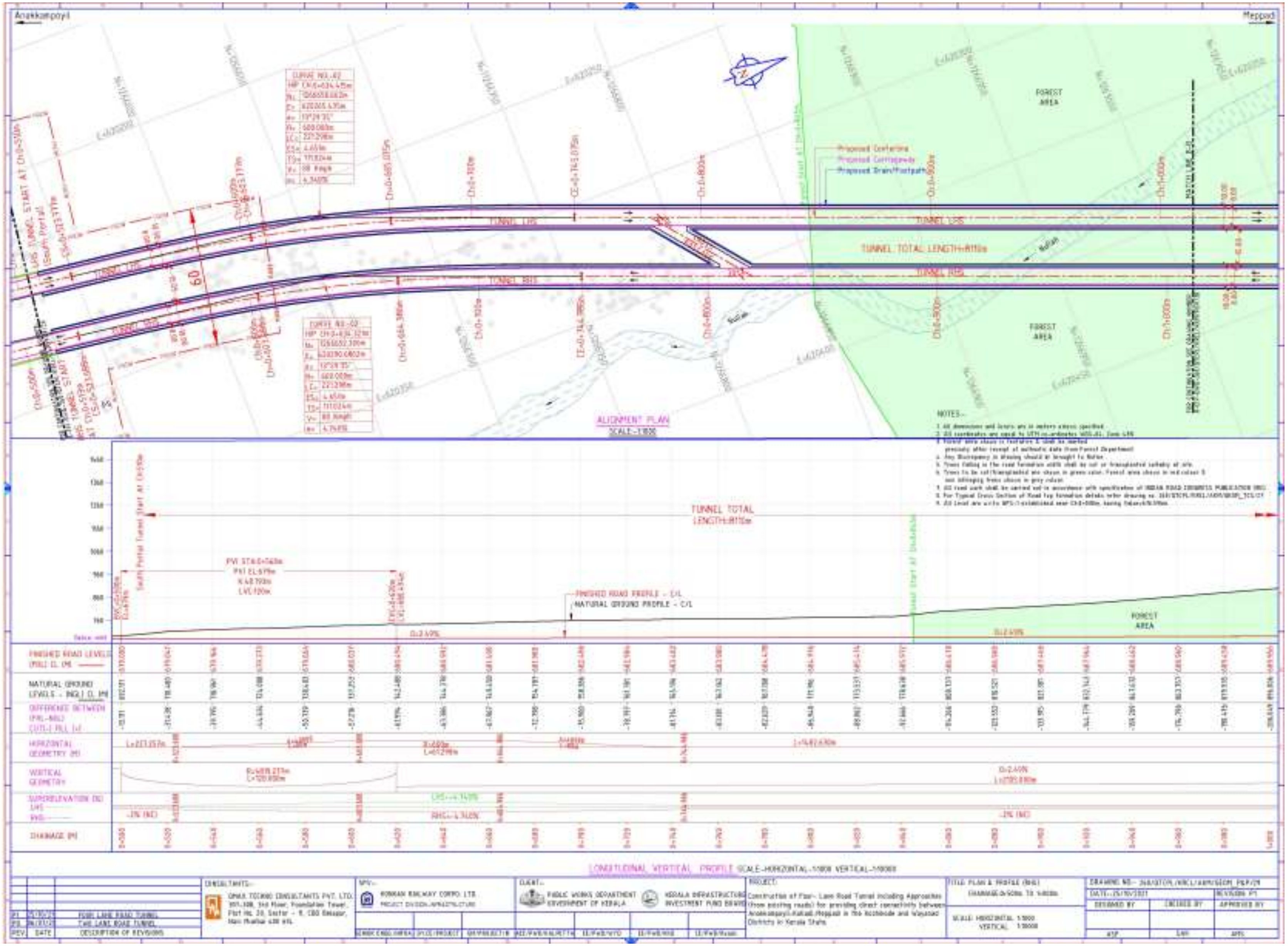
Anakkampoyil
Meppadi
TUNNEL TOTAL LENGTH=8110m
Emergency Layby
Proposed Centerline
Proposed Carriageway
Proposed Drain/Footpath
ALIGNMENT PLAN
NOTES:-
FINISHED ROAD PROFILE - C/L
NATURAL GROUND PROFILE - C/L
FOREST AREA
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD LEVELS
NATURAL GROUND LEVELS
DIFFERENCE BETWEEN (FRL-NGL) CUT(-) FILL (+)
HORIZONTAL GEOMETRY
VERTICAL GEOMETRY
SUPERELEVATION
CHAINAGE
LONGITUDINAL VERTICAL PROFILE
KONKAN RAILWAY CORPN. LTD
PUBLIC WORKS DEPARTMENT GOVERNMENT OF KERALA
KERALA INFRASTRUCTURE INVESTMENT FUND BOARD

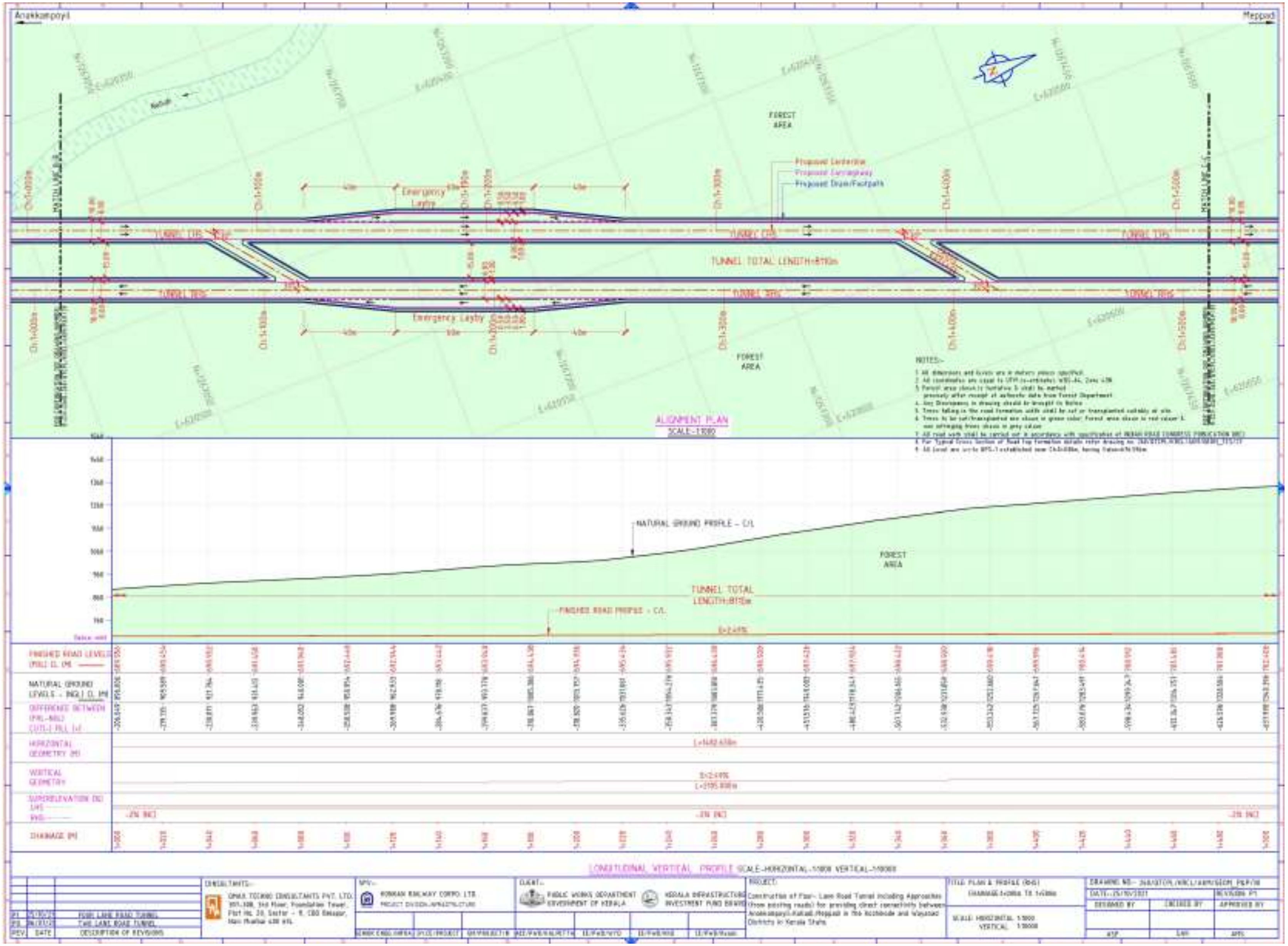

Anakkampoyil
Meppadi
FOREST AREA
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8110m
Emergency Layby
ALIGNMENT PLAN
NOTES:-
FINISHED ROAD PROFILE - C/L
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
LONGITUDINAL VERTICAL PROFILE

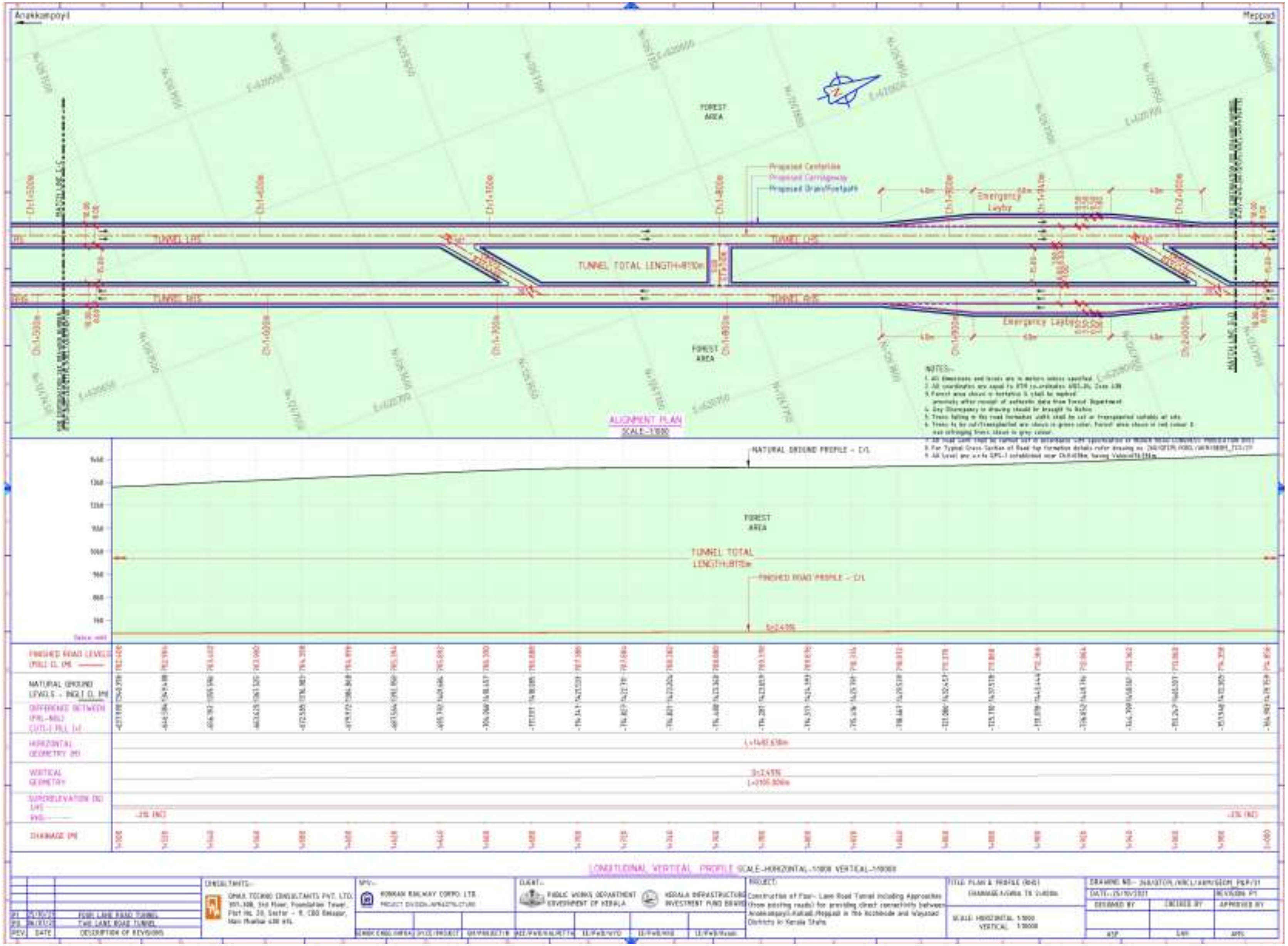

Anakkampoyil
Meppadi
FOREST AREA
Proposed Centerline
Proposed Carriageway
Proposed Drain/Footpath
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8110m
ALIGNMENT PLAN
SCALE-1:1000
NOTES:-
FINISHED ROAD PROFILE - C/L
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD LEVELS (FRL) (L (M)
NATURAL GROUND LEVELS - (NGL) (L (M)
DIFFERENCE BETWEEN (FRL-NGL) CUT(-) FILL (+)
HORIZONTAL GEOMETRY (M)
VERTICAL GEOMETRY
SUPERELEVATION (%)
CHAINAGE (M)
LONGITUDINAL VERTICAL PROFILE
CONSULTANTS:-
SPV:-
KONKAN RAILWAY CORPO. LTD
CLIENT:-
PUBLIC WORKS DEPARTMENT GOVERNMENT OF KERALA
KERALA INFRASTRUCTURE INVESTMENT FUND BOARD
PROJECT:
TITLE: PLAN & PROFILE (LHS)

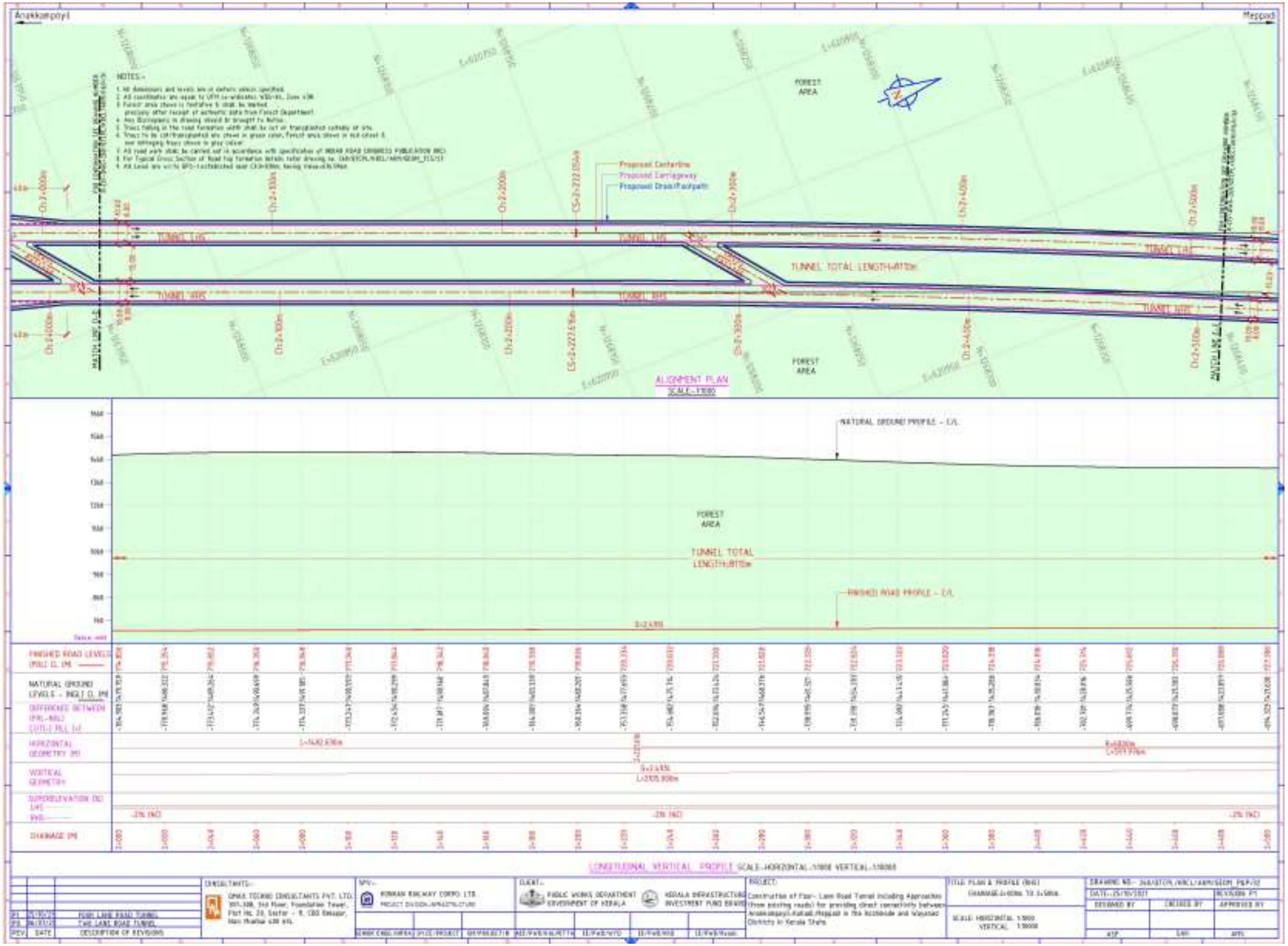

Anakkampoyil
Meppadi
Tunnel Cut & Cover
To Meppadi
ALIGNMENT PLAN
TUNNEL TOTAL
LONGITUDINAL VERTICAL PROFILE

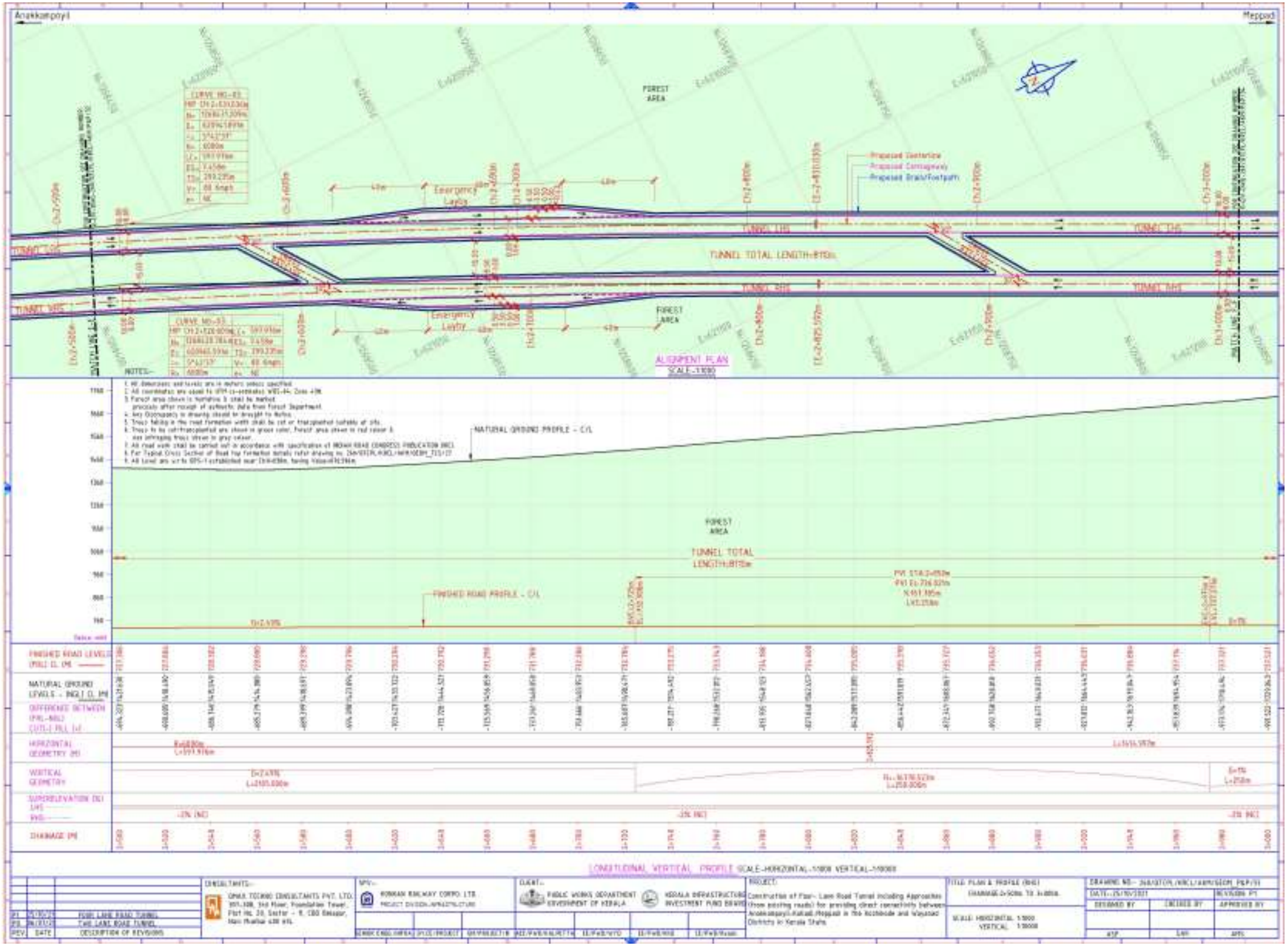


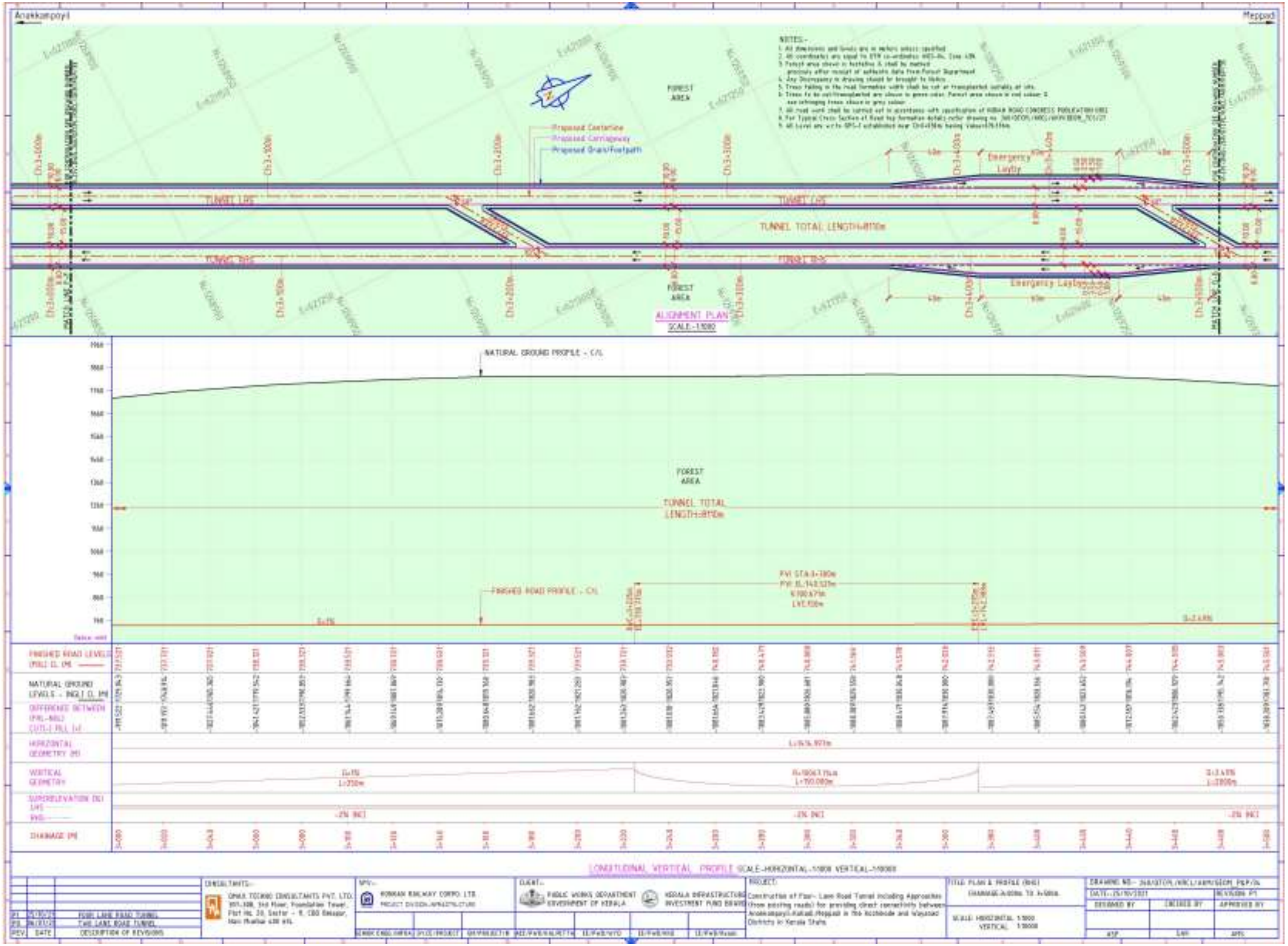

Anakkampoyil
Meppadi
FOREST AREA
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8110m
ALIGNMENT PLAN
LONGITUDINAL VERTICAL PROFILE


Anakkampoyil
Meppadi
FOREST AREA
TUNNEL TOTAL LENGTH=8110m
Emergency Layby
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
LONGITUDINAL VERTICAL PROFILE

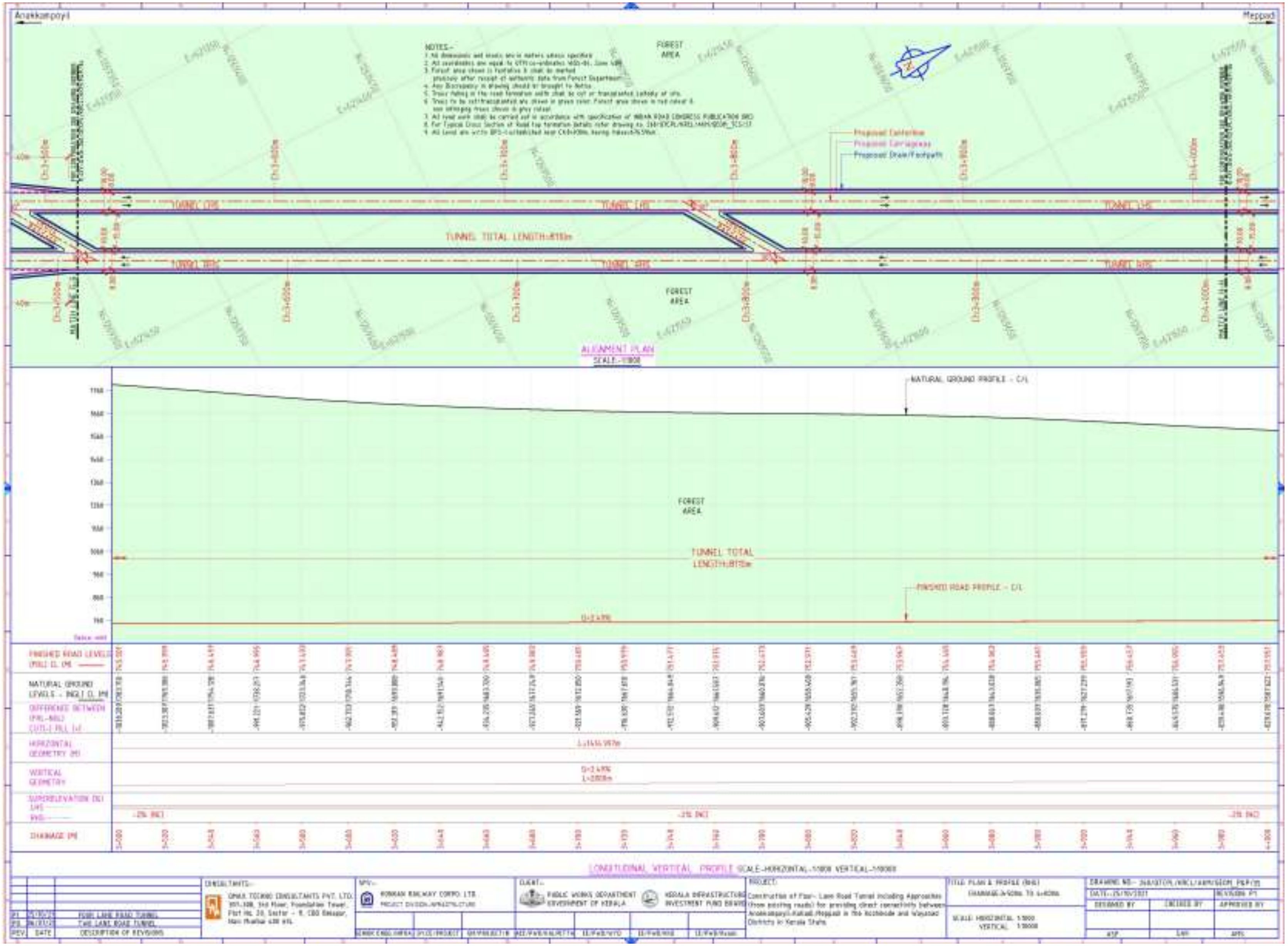

Meppadi
FOREST AREA
Emergency Layby
NOTES:-
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
FOREST AREA
FINISHED ROAD PROFILE - C/L
FINISHED ROAD LEVELS
NATURAL GROUND LEVELS
HORIZONTAL GEOMETRY
VERTICAL GEOMETRY
SUPERELEVATION
CHAINAGE
LONGITUDINAL VERTICAL PROFILE
KONKAN RAILWAY CORPO. LTD
PUBLIC WORKS DEPARTMENT GOVERNMENT OF KERALA
KERALA INFRASTRUCTURE INVESTMENT FUND BOARD

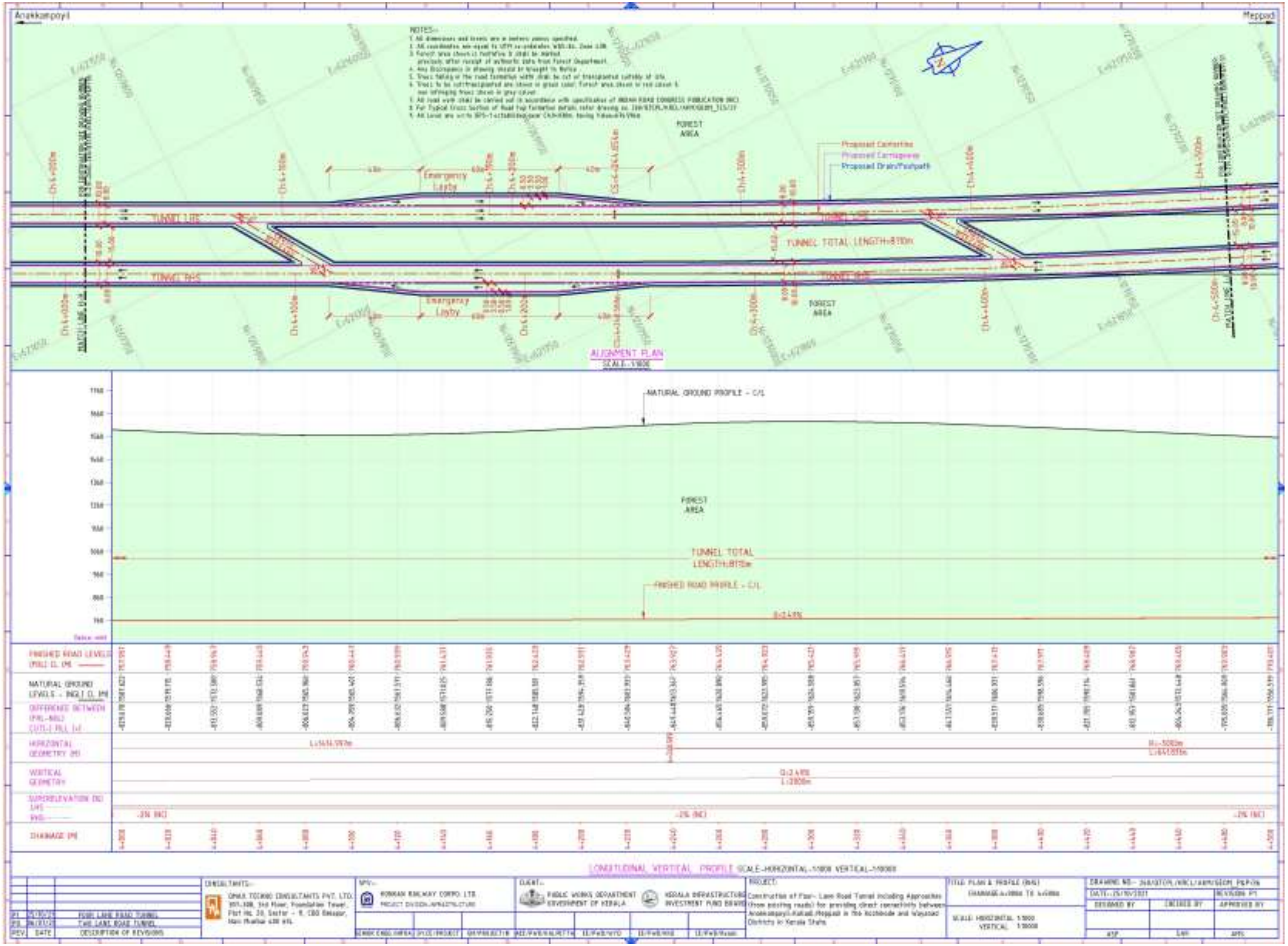


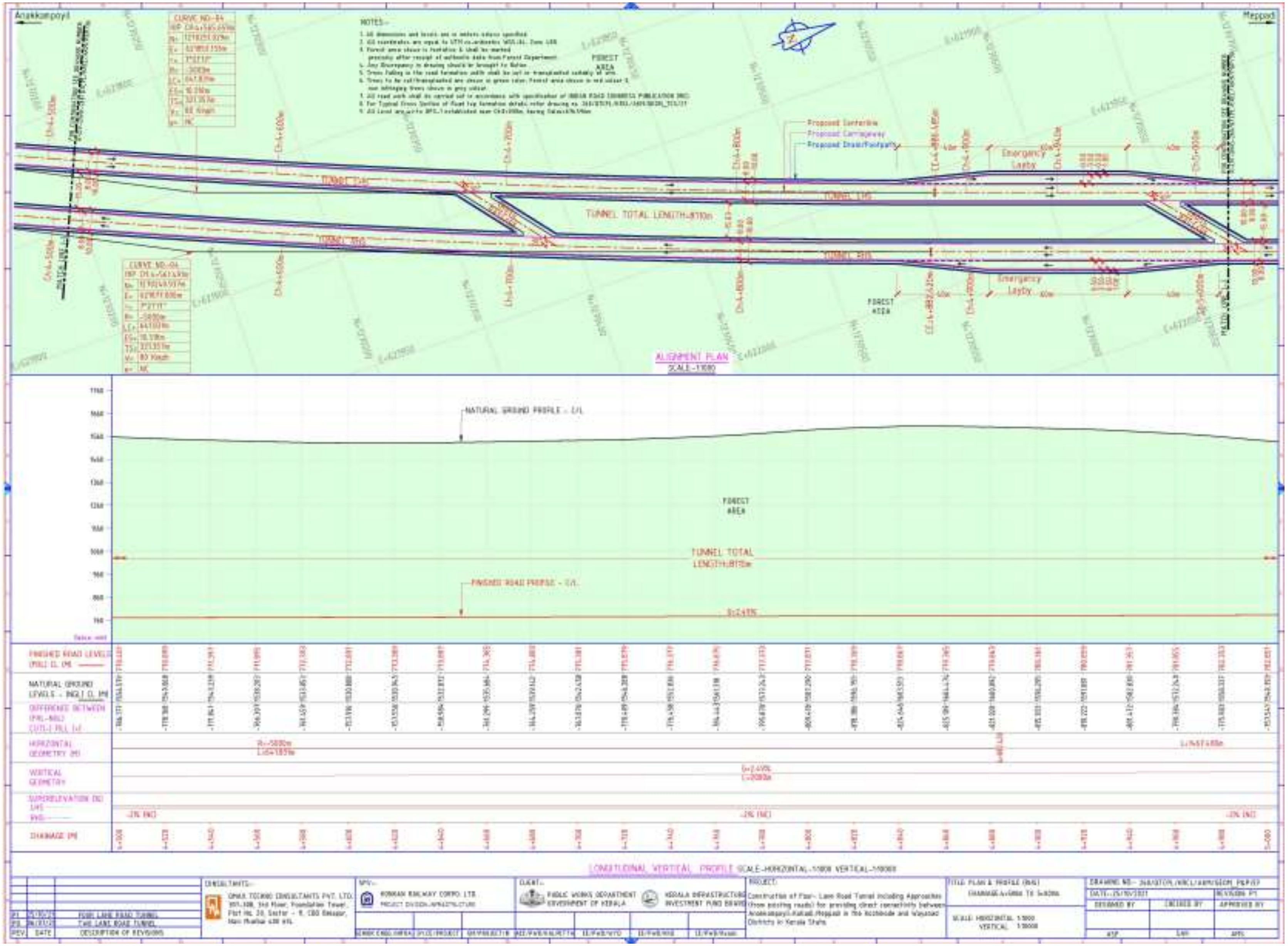

Anakkampoyil
Meppadi
FOREST AREA
TUNNEL TOTAL LENGTH=8150m
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
TUNNEL TOTAL LENGTH=8150m
LONGITUDINAL VERTICAL PROFILE

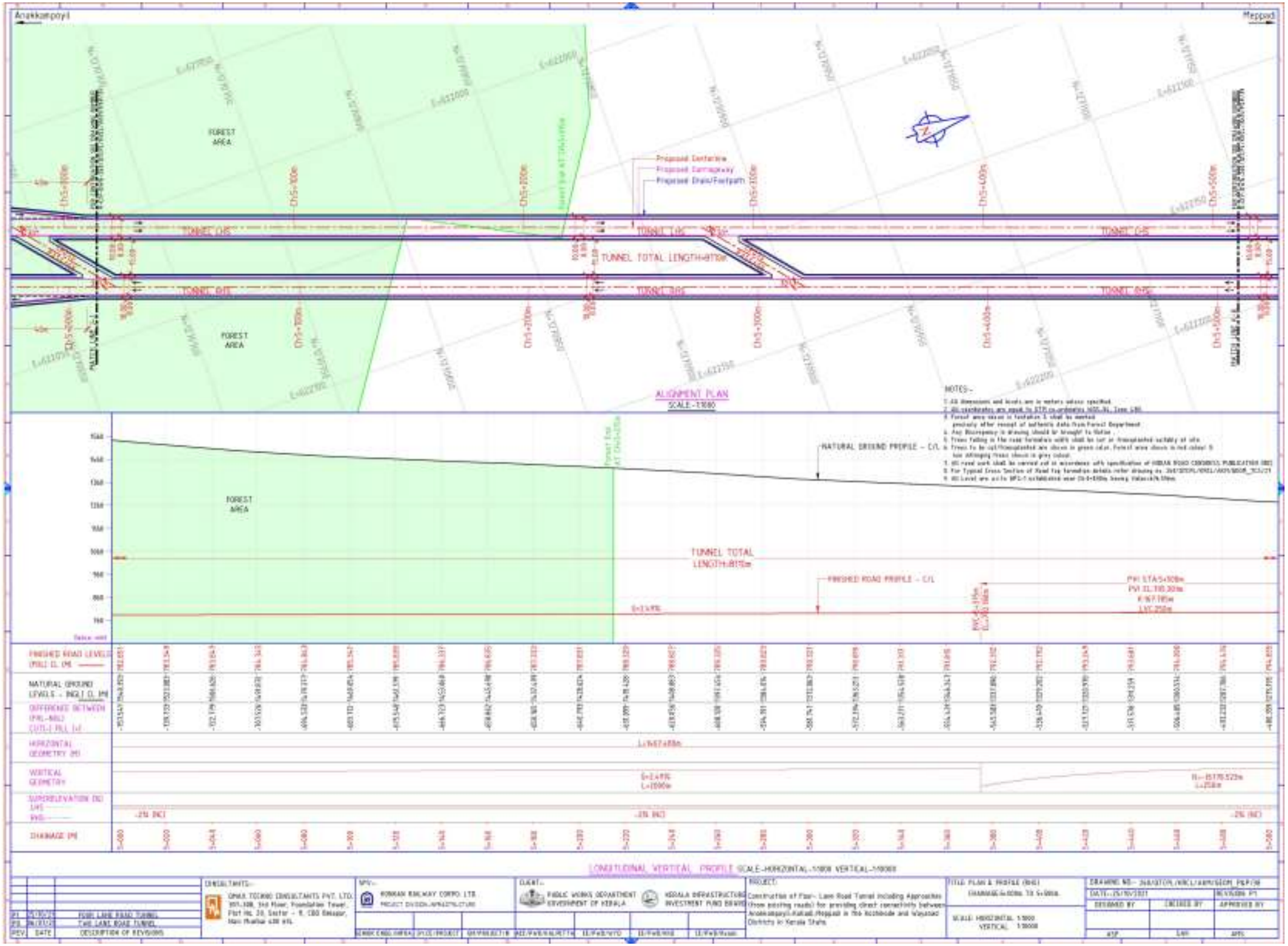


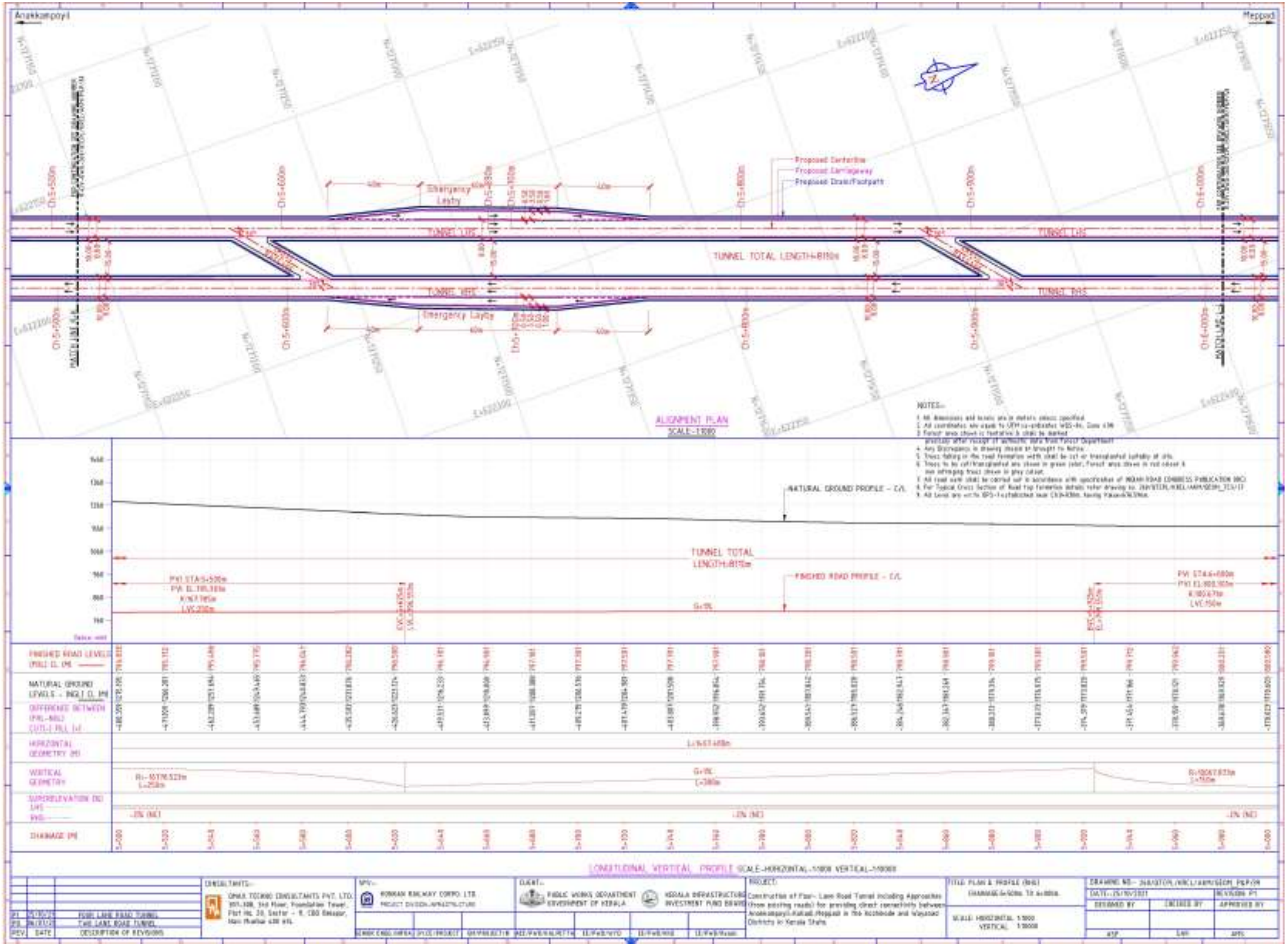
Anakkampoyil
Meppadi
FOREST AREA
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8110m
Emergency Layby
ALIGNMENT PLAN
SCALE-1:1000
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD PROFILE - C/L
LONGITUDINAL VERTICAL PROFILE

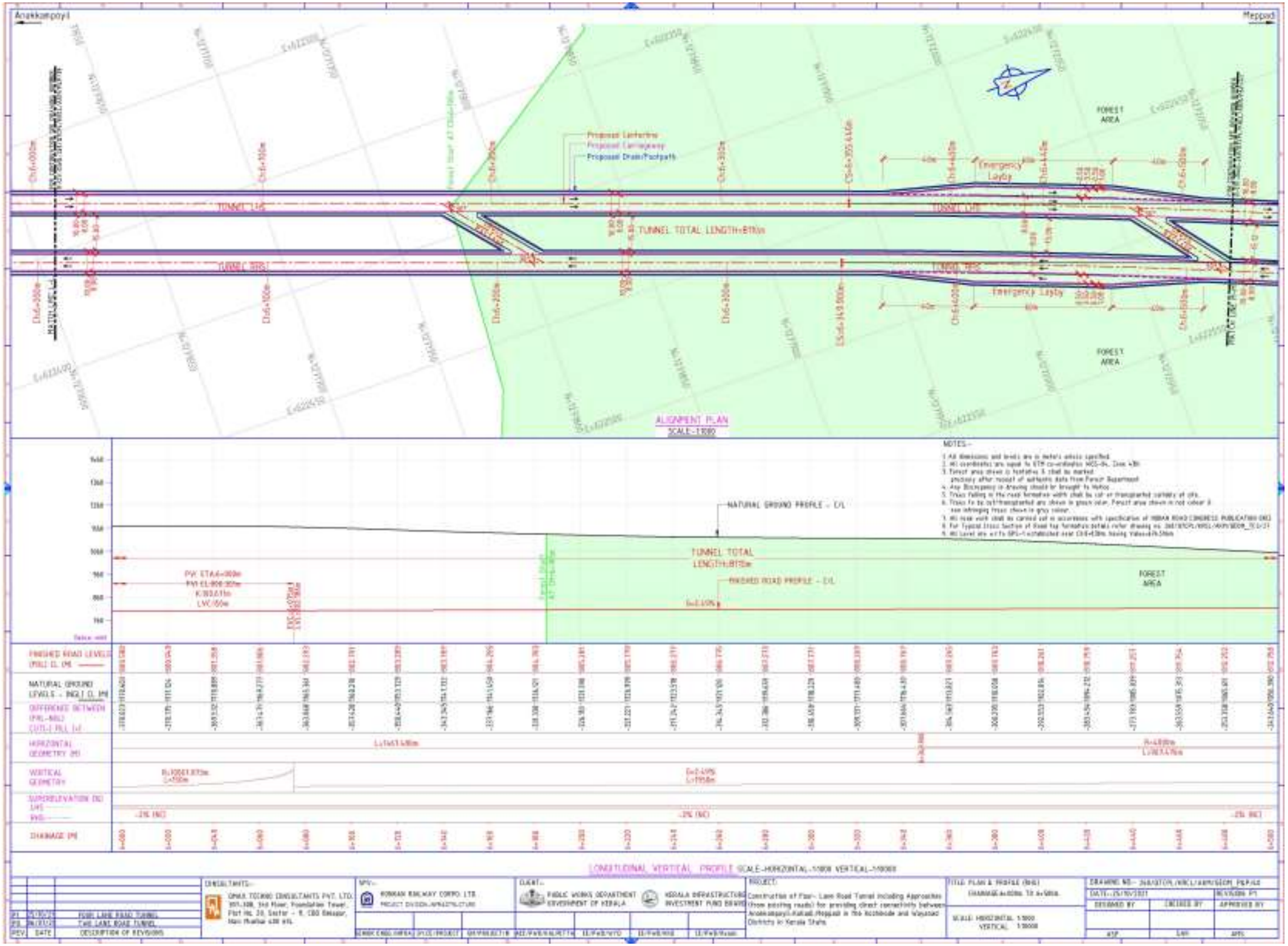


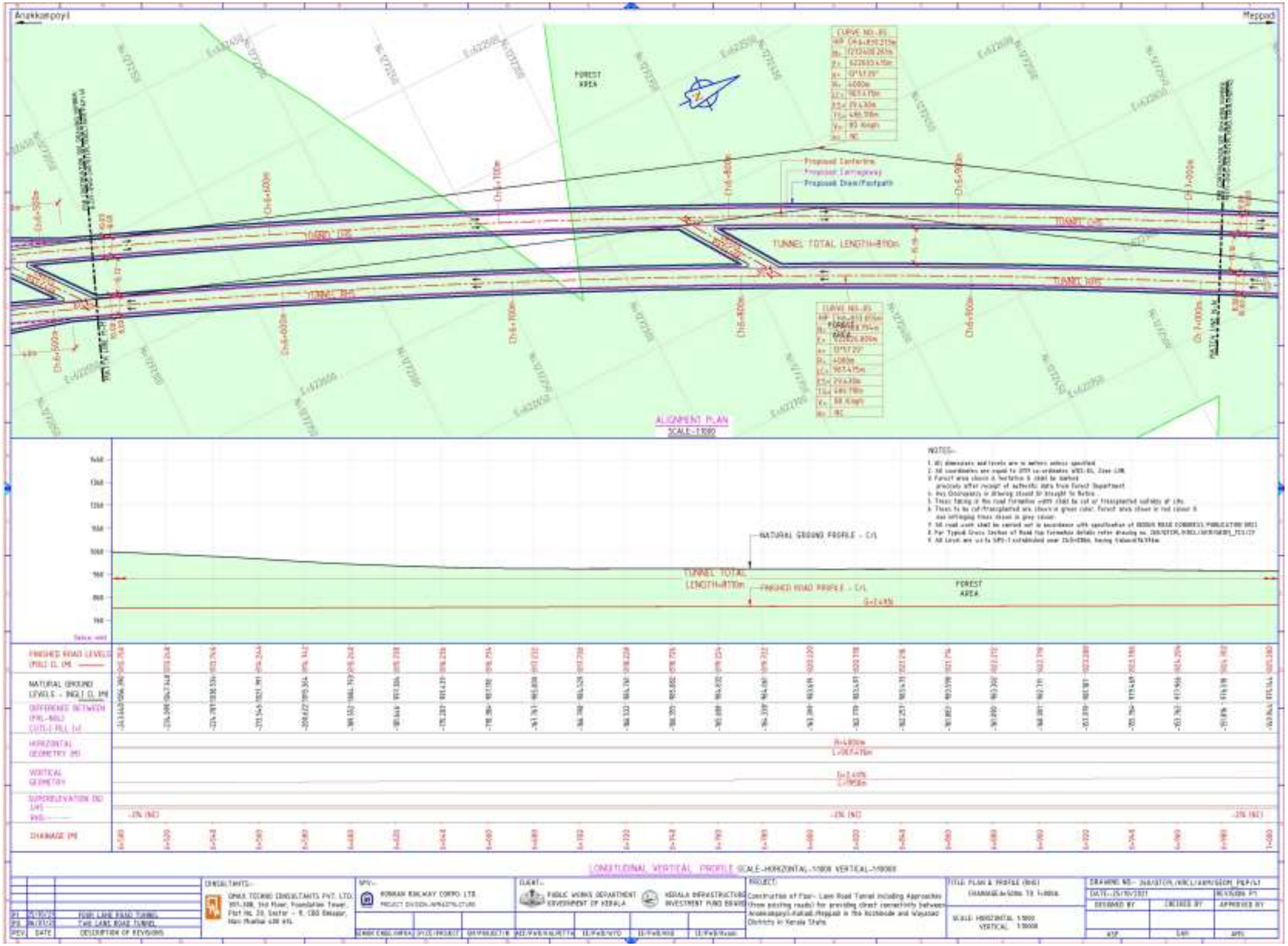

Anakkampoyil
Meppadi
FOREST AREA
Emergency Layby
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8750m
Proposed Centerline
Proposed Carriageway
Proposed Drain/Footpath
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL LENGTH=8750m
FINISHED ROAD PROFILE - C/L
FINISHED ROAD LEVELS
NATURAL GROUND LEVELS
HORIZONTAL GEOMETRY
VERTICAL GEOMETRY
SUPERELEVATION
CHAINAGE
LONGITUDINAL VERTICAL PROFILE

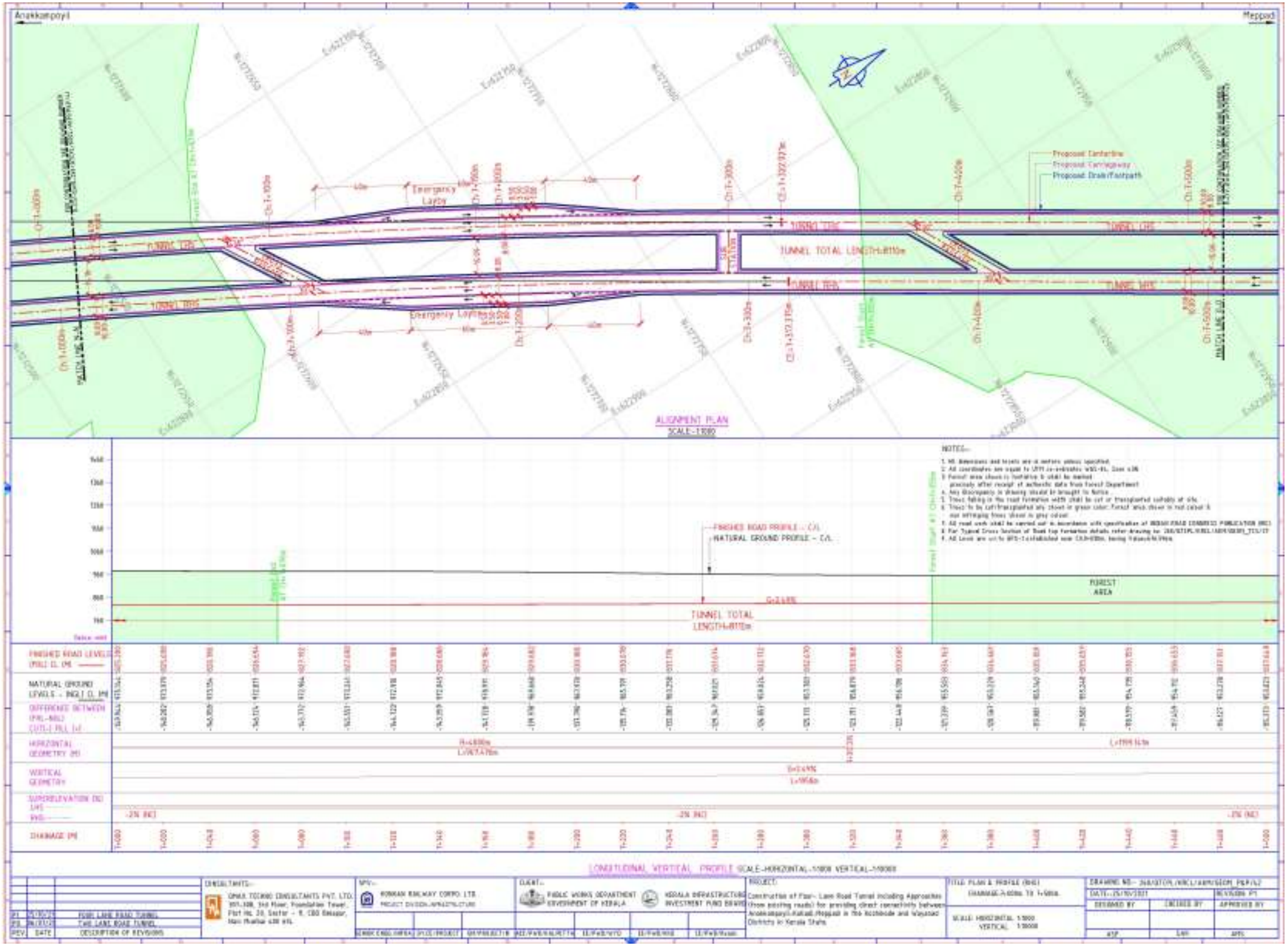

Anakkampoyil
Meppadi
NOTES:-
FOREST AREA
TUNNEL TOTAL LENGTH-8110m
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
FINISHED ROAD LEVELS
NATURAL GROUND LEVELS
HORIZONTAL GEOMETRY
VERTICAL GEOMETRY
SUPERELEVATION
CHAINAGE
LONGITUDINAL VERTICAL PROFILE

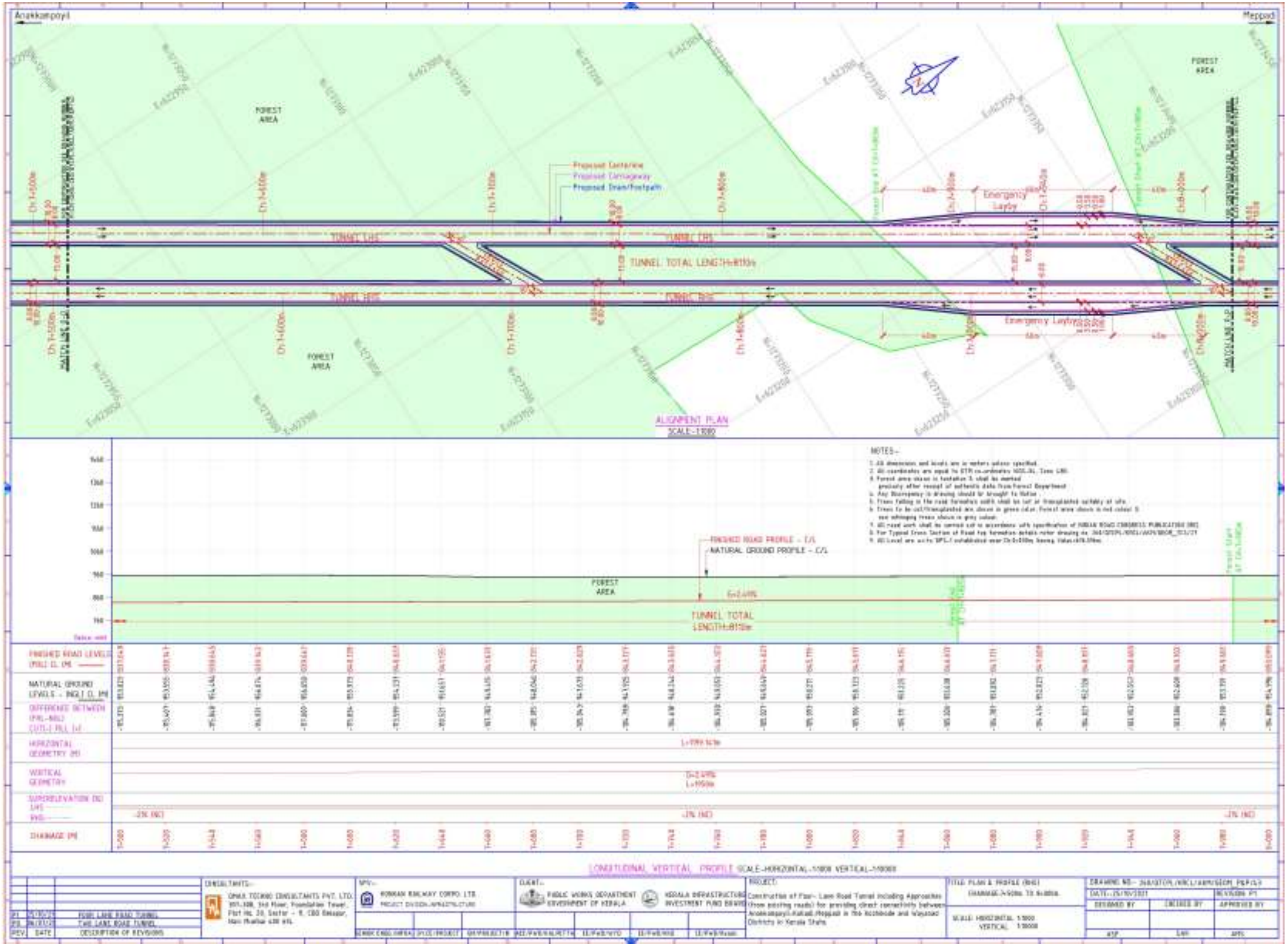

FOREST AREA
TUNNEL LHS
TUNNEL RHS
ALIGNMENT PLAN
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
LONGITUDINAL VERTICAL PROFILE

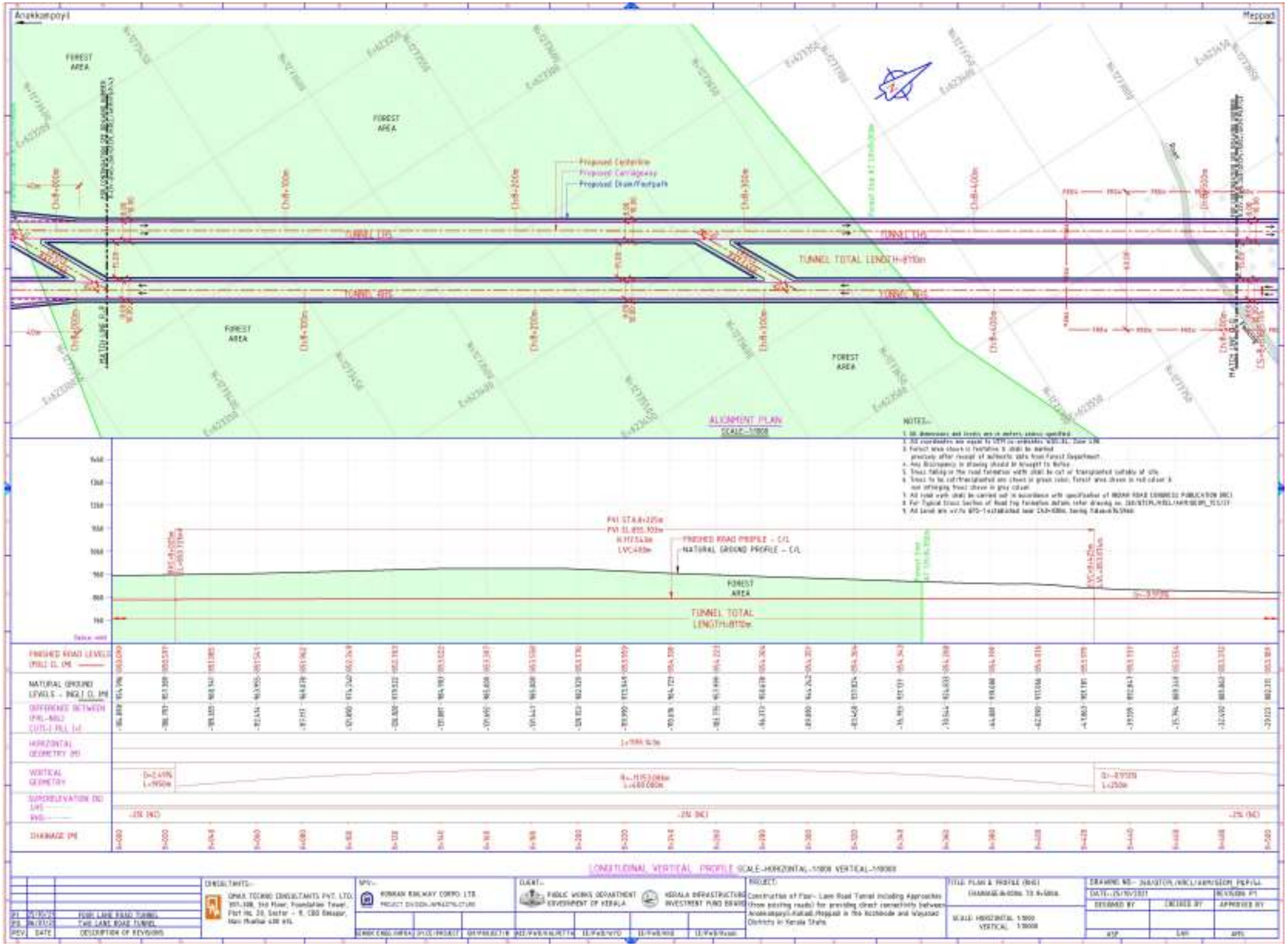

Anakkampoyil
Meppadi
Proposed Centerline
Proposed Carriageway
Proposed Drain/Footpath
Emergency Layby
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH=8110m
MATCH LINE
ALIGNMENT PLAN
NOTES:-
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD PROFILE - C/L
FINISHED ROAD LEVELS (FRL) (L (M)
NATURAL GROUND LEVELS - (NGL) (L (M)
DIFFERENCE BETWEEN (FRL-NGL) CUT(-) FILL (+)
HORIZONTAL GEOMETRY (M)
VERTICAL GEOMETRY
SUPERELEVATION (%)
CHAINAGE (M)
LONGITUDINAL VERTICAL PROFILE
CONSULTANTS:-
SPV:-
KONKAN RAILWAY CORPN. LTD.
CLIENT:-
PUBLIC WORKS DEPARTMENT GOVERNMENT OF KERALA
KERALA INFRASTRUCTURE INVESTMENT FUND BOARD
PROJECT:-
DESCRIPTION OF REVISIONS
DATE
REV

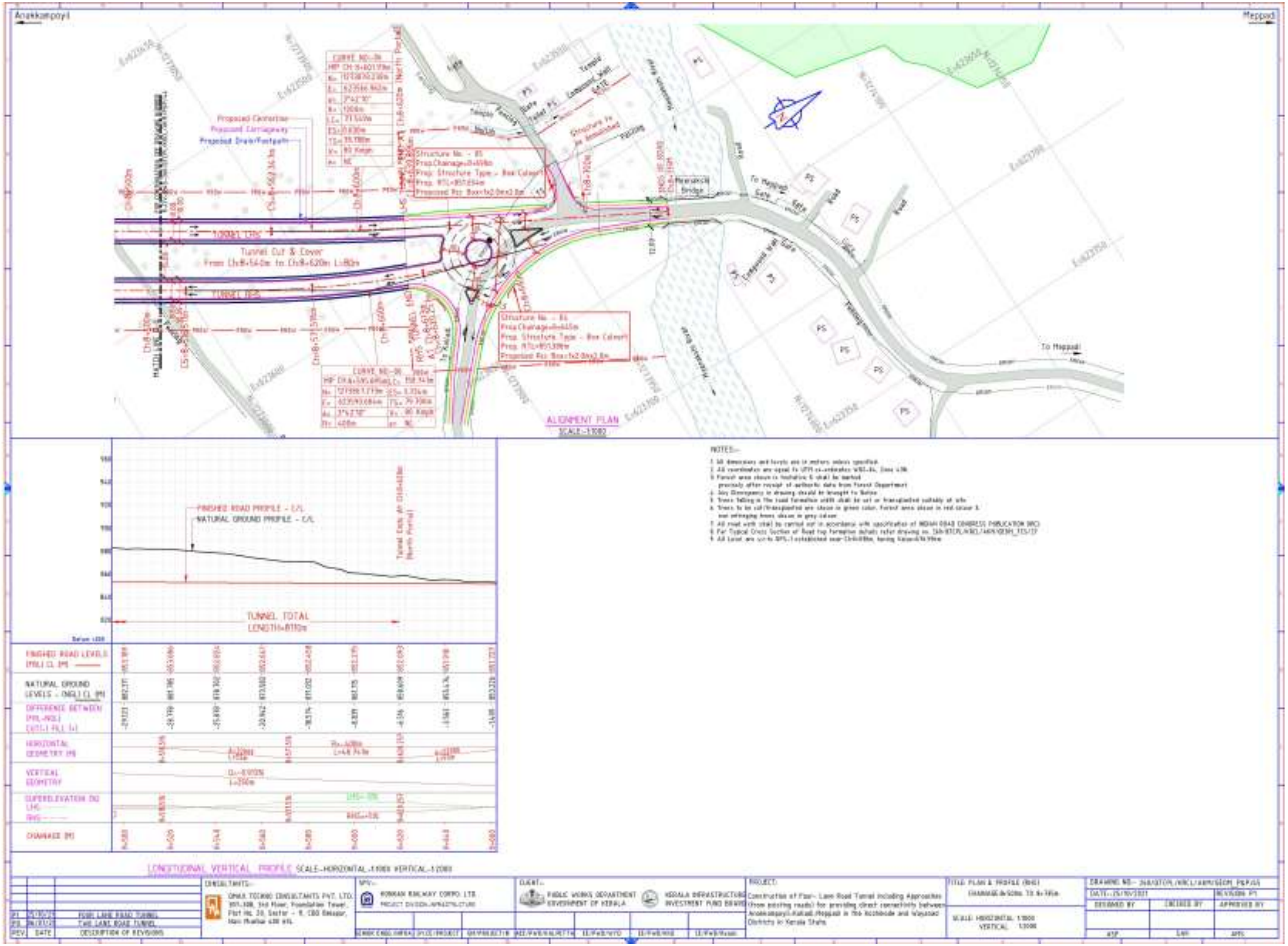

Meppadi
TUNNEL LHS
TUNNEL RHS
FOREST AREA
ALIGNMENT PLAN
NOTES:-
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL
FINISHED ROAD PROFILE - C/L
FOREST AREA


Anakkampoyil
Meppadi
FOREST AREA
Proposed Centerline
Proposed Carriageway
Proposed Drain/Footpath
TUNNEL TOTAL LENGTH=8110m
ALIGNMENT PLAN
SCALE-1:1000
NOTES:-
NATURAL GROUND PROFILE - C/L
FINISHED ROAD PROFILE - C/L
FINISHED ROAD LEVELS
NATURAL GROUND LEVELS
HORIZONTAL GEOMETRY
VERTICAL GEOMETRY
SUPERELEVATION
CHAINAGE
LONGITUDINAL VERTICAL PROFILE

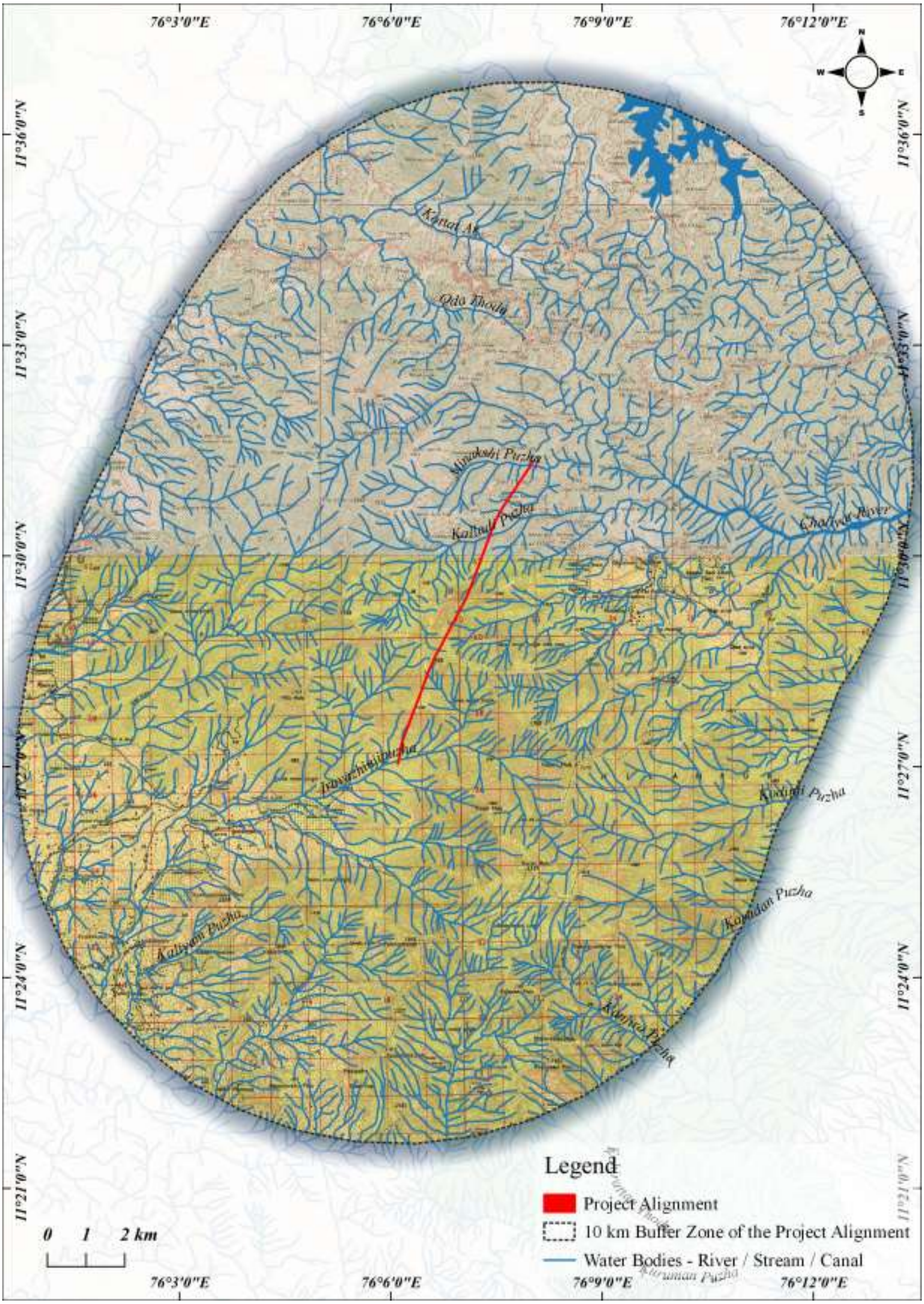

Anakkampoyil
Meppadi
Emergency Layby
TUNNEL TOTAL LENGTH=8110m
ALIGNMENT PLAN
NOTES:-
FINISHED ROAD PROFILE - C/L
NATURAL GROUND PROFILE - C/L
FOREST AREA
TUNNEL TOTAL LENGTH=8110m
FINISHED ROAD LEVELS (FRL) CL (M)
NATURAL GROUND LEVELS - (NGL) CL (M)
DIFFERENCE BETWEEN (FRL-NGL) CUT(-) FILL (+)
HORIZONTAL GEOMETRY (M)
VERTICAL GEOMETRY
SUPERELEVATION (%)
CHAINAGE (M)
LONGITUDINAL VERTICAL PROFILE


Anakkampoyil
Meppadi
FOREST AREA
TUNNEL LHS
TUNNEL RHS
TUNNEL TOTAL LENGTH-8110m
Emergency Layby
ALIGNMENT PLAN
NOTES:-
FINISHED ROAD PROFILE - C/L
NATURAL GROUND PROFILE - C/L
TUNNEL TOTAL LENGTH-8110m
FINISHED ROAD LEVELS
NATURAL GROUND LEVELS
HORIZONTAL GEOMETRY
VERTICAL GEOMETRY
SUPERELEVATION
CHAINAGE
LONGITUDINAL VERTICAL PROFILE
CONSULTANTS:-
SPV:-
KONKAN RAILWAY CORPO. LTD.
CLIENT:-
PUBLIC WORKS DEPARTMENT GOVERNMENT OF KERALA
KERALA INFRASTRUCTURE INVESTMENT FUND BOARD
PROJECT:


Anakkampoyil
Meppadi
FOREST AREA
ALIGNMENT PLAN
NOTES:-
LONGITUDINAL VERTICAL PROFILE


Anakkampoyil
Meppadi
TUNNEL LHS
TUNNEL RHS
Tunnel Cut & Cover
To Meppadi
ALIGNMENT PLAN
NOTES:-
TUNNEL TOTAL
FINISHED ROAD PROFILE - C/L
NATURAL GROUND PROFILE - C/L
LONGITUDINAL VERTICAL PROFILE

Annexure 12: Drainage Profile of the Study Area



Annexure 13: Checklist of Plants Recorded from the Study Area (Project Area and Surroundings)

Sl. No.	Scientific name	Local /common name	Family
A.	**TREES**		
1.	*Acrocarpus fraxinifolius* Wight & Arn.	Narivenga	Fabaceae: Caesalpinioideae
2.	*Actinodaphne wightiana* (Kuntze) Noltie	Kambili	Lauraceae
3.	*Aglaia barberi* Gamble	Karakil	Meliaceae
4.	*Aglaia elaeagnoidea* (A. Juss.) Benth.	Punyava	Meliaceae
5.	*Aglaia lawii* (Wight) Saldanha	Vella-cheelaram	Meliaceae
6.	*Aglaia malabarica* Sasidh.	Chuvanna-akil	Meliaceae
7.	*Ailanthus excelsa* Roxb.	Perumaram	Simaroubaceae
8.	*Ailanthus triphysa* (Dennst.) Alston	Matti, Mattippala	Simaroubaceae
9.	*Alangium salviifolium* (L.f.) Wang.	Ankolam	Alangiaceae
10.	*Alstonia scholaris* (L.) R. Br.	Ezhilampala	Apocynaceae
11.	*Anacardium occidentale* L.	Kasumavu	Anacardiaceae
12.	*Antidesma bunius* (L.) Spreng	Neelathali	Euphorbiaceae
13.	*Antidesma montanum* Blume	Thathalamaram	Euphorbiaceae
14.	*Aporosa cardiosperma* (Gaertn.) Merr.	Vetti, Neervetti	Euphorbiaceae
15.	*Areca catechu* L.	Kamuku, Arecanut	Arecaceae
16.	*Artocarpus altilis* (Thunb.) L.f.	Seemaplavu	Moraceae
17.	*Artocarpus heterophyllus* Lam.	Plavu, Jackfruit tree	Moraceae
18.	*Artocarpus hirsutus* Lam.	Anjili	Moraceae
19.	*Baccaurea courtallensis* (Wight) Muel.-Arg.	Moottilpazham	Euphorbiaceae
20.	*Bischofia javanica* Blume	Mlachathayan, Chola	Euphorbiaceae
21.	*Bixa orellana* L.	Kunkumam	Bixaceae
22.	*Bombax ceiba* L.	Elavu	Bombacaceae
23.	*Briedelia retusa* (L.) A. Juss.	Mulluvenga	Euphorbiaceae
24.	*Butea monosperma* (Lam.) Taub.	Chamatha	Fabaceae: Caesalpinioideae
25.	*Caesalpinia sappan* L.	Chappangam	Fabaceae: Caesalpinioideae
26.	*Camellia sinensis* (L.) Kuntze	Theyila, Tea	Theaceae
27.	*Canarium strictum* Roxb.	Pantham, Kuthirikkam	Burseraceae
28.	*Careya arborea* Roxb.	Pezhu	Lecythidaceae
29.	*Caryota urens* L.	Choondappana	Arecaceae
30.	*Cassia fistula* L.	Kanikkonna	Fabaceae: Caesalpinioideae
31.	*Cinnamomum malabatrum* (Burm.f.) Blume	Vayana	Lauraceae
32.	*Cinnamomum verum* Presl	Karuva	Lauraceae
33.	*Citrus maxima* (Burm.f.) Merr.	Kabilinarakam	Rutaceae
34.	*Cochlospermum religiosum* (L.) Alston	Appakkudukka	Cochlospermaceae
35.	*Cocos nucifera* L.	Thengu, Coconut	Arecaceae
36.	*Cullenia exarillata* Robyns	Vediplavu	Bombacaceae
37.	*Cynometra travancorica* Bedd.	Koori	Fabaceae: Caesalpinioideae
38.	*Dalbergia lanceolaria* L.f.	Velleetti	Fabaceae: Papilionoideae
39.	*Dalbergia latifolia* Roxb.	Eetti	Fabaceae: Papilionoideae
40.	*Dalbergia sissoides* Graham ex Wight &	Veetti	Fabaceae: Papilionoideae

	Arn.		
41.	*Dimocarpus longan* Lour.	Poovatti, Chempoovam	Sapindaceae
42.	*Diospyros bourdillonii* Brabdis	Kakkakarimaram	Ebenaceae
43.	*Diospyros buxifolia* (Blume) Hiern	Elichuzhi	Ebenaceae
44.	*Diospyros candolleana* Wight	Karimaram	Ebenaceae
45.	*Diospyros paniculata* Dalz.	Karivella	Ebenaceae
46.	*Drypetes oblongifolia* (Bedd.) Airy Shaw	Malampayin	Euphorbiaceae
47.	*Drypetes wightii* (Hook.f.) Pax & Hoffm.	Vellakkasavu	Euphorbiaceae
48.	*Elaeocarpus munroi* (Wight) Mast.	Kalrudraksham	Elaeocarpaceae
49.	*Elaeocarpus serratus* L.	Kara, Perinkara	Elaeocarpaceae
50.	*Elaeocarpus tuberculatus* Roxb.	Mukkanni, Karamaram	Elaeocarpaceae
51.	*Erythrina stricta* Roxb.	Mullumurukku	Fabaceae: Papilionoideae
52.	*Erythrina variegata* L.	Murukku	Fabaceae: Papilionoideae
53.	*Eucalyptus globulus* Labill.	Yukali, Eucalyptus	Myrtaceae
54.	*Euonymus indicus* Heyne ex Wallich		Celastraceae
55.	*Ficus auriculata* Lour.	Seema-athi	Moraceae
56.	*Ficus benghalensis* L.	Peral	Moraceae
57.	*Ficus callosa* Willd.	Kadaplavu	Moraceae
58.	*Ficus drupacea* Thunb.	Koli, Chela	Moraceae
59.	*Ficus exasperata* Vahl.	Parakam,Therakam	Moraceae
60.	*Ficus hispida* L.f.	Erumanakku	Moraceae
61.	*Ficus petiolaris* Kunth	Petiolate fig	Moraceae
62.	*Ficus racemosa* L.	Athi	Moraceae
63.	*Ficus tsjahela* Burm.f.	Chela, Karal	Moraceae
64.	*Flacourtia indica* (Burm.f) Merr.	Cherumulli	Flacoutiaceae
65.	*Flacourtia jangomas* (Lour.) Raeusch.	Lavaloli	Flacoutiaceae
66.	*Flacourtia montana* Graham	Vyamkatha	Flacoutiaceae
67.	*Garcinia cowa* Roxb. ex DC.	Kowa	Clusiaceae
68.	*Garcinia gummi-gutta* (L.) Robs.	Kodampuli	Clusiaceae
69.	*Garcinia mangostana* L.	Mangosteen	Clusiaceae
70.	*Garcinia morella* (Gaertn.) Desv.	Chigiri	Clusiaceae
71.	*Gliricidia sepium* (Jacq.) Kunth ex Walp.	Seemakonna	Fabaceae: Papilionoideae
72.	*Gmelina arborea* Roxb.	Kumbil, Kumizhu	Verbenaceae
73.	*Gomphandra coriacea* (Wall.) Sleumer	Chakkimaram	Icacinaceae
74.	*Grevillea robusta* Cunn. ex R. Br.	Silver oak	Proteaceae
75.	*Grewia tiliifolia* Vahl	Chadachi	Tiliaceae
76.	*Haldinia cordifolia* (Roxb.) Ridsd.	Manjakkadambu	Rubiaceae
77.	*Hevea brasiliensis* (Willd. ex A. Juss.) Muell.-Arg.	Rubber	Euphorbiaceae
78.	*Holigarna arnottiana* Hook.f.	Cheru, Charu	Anacardiaceae
79.	*Holoptelea integrifolia* (Roxb.) Planch.	Aaval	Ulmaceae
80.	*Hopea parviflora* Bedd.	Kambakam	Dipterocarpaceae
81.	*Humboldtia brunonis* Wall.	Kattasokam	Fabaceae: Caesalpinioideae
82.	*Humboldtia vahliana* Wight	Karappongu	Fabaceae: Caesalpinioideae
83.	*Hydnocarpus pentandrus* (Buch.-Ham.) Oken	Marotti	Flacoutiaceae
84.	*Hymenodictyon obovatum* Wall.	Malankalli	Rubiaceae
85.	*Ixora brachiata* Roxb. ex DC.	Marathechi	Rubiaceae

86.	*Knema attenuata* (Hook.f. & Thoms.) Warb.	Chorappali	Myristicaceae
87.	*Lagerstroemia microcarpa* Wight	Vellilavu	Lythraceae
88.	*Lagerstroemia speciosa* (L.) Pers.	Vellilavu	Lythraceae
89.	*Lannea coromandelica* (Houtt.) Merr.	Enakkaru, Uthi	Anacardiaceae
90.	*Litchi chinensis* Sonner.	Litchi	Sapindaceae
91.	*Litsea bourdillonii* Gamble	Thali	Lauraceae
92.	*Litsea coriacea* (Heyne ex Meisn.) Hook.f.	Maravettithali	Lauraceae
93.	*Litsea floribunda* (Blume) Gamble	Pattuthali	Lauraceae
94.	*Lophopetalum wightianum* Arn.	Venkotta	Celastraceae
95.	*Macaranga peltata* (Roxb.) Muel.-Arg.	Vatta	Euphorbiaceae
96.	*Madhuca neriifolia* (Moon) H.J. Lam.	Attilippa	Sapotaceae
97.	*Magnolia nilagirica* (Zenk) Figlar	Vellachempakam	Magnoliaceae
98.	*Mallotus philippensis* (Lam.) Muell.-Arg.	Kurangumanjal	Euphorbiaceae
99.	*Mallotus tetracoccus* (Roxb.) Kurz	Porivatta	Euphorbiaceae
100.	*Mangifera indica* L.	Mavu	Anacardiaceae
101.	*Manilkara zapota* (L.) P. Royen	Sappota, Chiku	Sapotaceae
102.	*Melicope lunu-ankenda* (Gaertn.) Hartley	Kambili, Kanala	Rutaceae
103.	*Memeceylon angustifolium* Wight	Kayampoo, Attukanala	Melastomataceae
104.	*Mesua ferrea* L.	Nanku	Clusiaceae
105.	*Mimusops elengi* L.	Elenji	Sapotaceae
106.	*Mitragyna parvifolia* (Roxb.) Korth.	Poochakkadambu	Rubiaceae
107.	*Monoon coffeoides* (Thwsites ex Hook.f. & Thoms.) B. Xue & R.M.K. Sounders	Nedunar, Villa	Annonaceae
108.	*Monoon fragrans* (Dalz.) Bedd.	Kodangi, Chella, Nedunar	Annonaceae
109.	*Monoon longifolia* (Sonn.) B. Xue & R.M.K. Sounders	Aranamaram	Annonaceae
110.	*Moringa oleifera* Lam,	Muringa	Moringaceae
111.	*Myristica beddomei* King	Kattujathi	Myristicaceae
112.	*Myristica fragrans* Houtt.	Jathi, Nut-meg	Myristicaceae
113.	*Myristica malabarica* Lam.	Pathirippovu	Myristicaceae
114.	*Nephelium lappaceum* L.	Rambutan	Sapindaceae
115.	*Nothopegia racemosa* (Dalz.) Ramamoorthy	Naicheru	Anacardiaceae
116.	*Olea dioica* Roxb.	Idala, Edana	Oleaceae
117.	*Pajanelia longifolia* (Willd.) K. Schum.	Azhantha	Bignoniaceae
118.	*Palaquium ellipticum* (Dalz.) Baill.	Vellappali, Pali	Sapotaceae
119.	*Persea americana* Mill.	Butter-fruit, Avocado	Lauraceae
120.	*Persea macrantha* (Nees) Kosterm.	Ooravu, Kulirmavu	Lauraceae
121.	*Phyllanthus acidus* (L.) Skeels	Arinelli	Euphorbiaceae
122.	*Phyllanthus emblica* L.	Nelli, Amla	Euphorbiaceae
123.	*Pimenta dioica* (L.) Merr.	Sarvasugandhi	Myrtaceae
124.	*Poeciloneuron indicum* Bedd.	Vayanavu, Poothamkolli	Clusiaceae
125.	*Pongamia pinnata* (L.) Pierre	Ungu, Pongu	Fabaceae: Papilionoideae
126.	*Psidium guajava* L.	Pera, Guava	Myrtaceae
127.	*Pterocarpus marsupium* Roxb.	Venga	Fabaceae
128.	*Pterosperum reticulatum* Wight & Arn.	Malayuram	Sterculiaceae
129.	*Pterosperum rubiginosum* Heyne ex Wight & Arn.	Chittilaplavu, Ellootti	Sterculiaceae
130.	*Reinwardtiodendron anamalaiensis* (Bedd.) Mabb.	Cheralam	Meliaceeae
131.	*Schleichera oliosa* (Lour.) Oken	Poovanam	Sapindaceae
132.	*Scleropyrum pendandrum* (Dennst.) Mabb.	Irumulli	Santalaceae

133.	*Scolopia crenata* (Wight & Arn.) Clos	Charalu, Mullukara	Flacoutiaceae
134.	*Senna spectabilis* (DC.) H.S. Irwin & Barneby	Manjakkonna	Fabaceae: Caesalpinioideae
135.	*Sterculia foetida* L.	Pottakkavalam,	Sterculiaceae
136.	*Sterculia guttata* Roxb. ex DC.	Kavalam, Peenari	Sterculiaceae
137.	*Sterculia urens* Roxb.	Pottakavalam, Thondi	Sterculiaceae
138.	*Streblus asper* Lour.	Paruva	Moraceae
139.	*Strycnos nux-vomica* L.	Kanjiram	Loganiaceae
140.	*Symplocos acuminata* (Blume) Miq.	Pachotti, Kambilivetti	Symplocaceae
141.	*Syzygium aqueum* (Burm.f.) Alston	Champa, Water apple	Myrtaceae
142.	*Syzygium aromaticum* (L.) Merr. & Perry	Grampu, Clove	Myrtaceae
143.	*Syzygium cuminii* (L.) Skeels	Njaval	Myrtaceae
144.	*Syzygium gardneri* Thwaites	Kattu-njaaval	Myrtaceae
145.	*Syzygium laetum* (Buch.-Ham) Gandhi	Kollinjaval	Myrtaceae
146.	*Syzygium mundagam* (Bourd.) Chithra	Kattuchampa	Myrtaceae
147.	*Syzygium occidentale* (Bourd.) Gandhi	Attuchampa, Karinjara	Myrtaceae
148.	*Tabernaemontana alternifolia* L.	Koonampala	Apocynaceae
149.	*Tamarindus indica* L.	Valanpuli	Fabaceae
150.	*Tectona grandis* L.f.	Thekku, Teak	Verbenaceae
151.	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Neermaruthu, Arjun	Combretaceae
152.	*Terminalia bellirica* (Gaertn.) Roxb.	Kadukka	Combretaceae
153.	*Terminalia chebula* Retz.	Kadukka	Combretaceae
154.	*Terminalia elliptica* Willd.	Thambavu	Combretaceae
155.	*Terminalia paniculata* Roth	Maruthi	Combretaceae
156.	*Tetrameles nudiflora* R. Br.	Cheeni	Datiscaceae
157.	*Theobroma cacao* L.	Cocoa	Sterculiaceae
158.	*Vateria indica* L.	Vellappayin	Dipterocarpaceae
159.	*Xylia xylocarpa* (Roxb.) Taub.	Irul	Fabaceae
160.	*Zanthoxylum rhetsa* (Roxb.) DC.	Mothumurikku	Rutaceae
B.	**SHRUBS**		
161.	*Abelmoschus angulosus* Wall ex Wight & Arn.	Kattukasthuri	Malvaceae
162.	*Abelmoschus moschatus* Medik.	Kasthuri-venda	Malvaceae
163.	*Acalypha fruticosa* Forssk.	Balamunja	Euphorbiaceae
164.	*Acalypha indica* L.	Kuppameni	Euphorbiaceae
165.	*Aeschynanthus perrottettii* A. DC.		Gesneriaceae
166.	*Allophylus cobbe* (L.) Raeusch.	Mukkannan-pezhu	Sapindaceae
167.	*Allophylus serratus* (Roxb.) Kurz	Mukkannan-pezhu	Sapindaceae
168.	*Aporosa acuminata* Thawaites	Neervetti, Aswarnavetti	Euphorbiaceae
169.	*Aralia malabarica* Bedd.	Araliaceae	Araliaceae
170.	*Artemisia nilagarica* (C.B. Clarke) Pamp.	Maasippathri	Asteraceae
171.	*Asclepias curassavica* L.	Chuvanna-erukku	Asclepiadaceae
172.	*Baliospermum solanifolium* (Burm.) Suresh	Nagadanthi	Euphorbiaceae
173.	*Bambusa bambos* (L.) Voss	Mula	Poaceae
174.	*Barleria courtallica* Nees	Venkurinji	Acanthaceae
175.	*Blachia umbellata* (Willd.) Baill.		Euphorbiaceae
176.	*Breynia vitis-idea* (Burm.f.) C.E.C. Fisch.	Kattuniruri	Euphorbiaceae
177.	*Briedelia stipularis* (L.) Blume	Cherukapanachi	Euphorbiaceae

178.	*Cajanus lineatus* (Wight & Arn.) Maesen	Kattuthuvara	Fabaceae: Papilionoideae
179.	*Canthium angustifolium* (Roxb.)	Kattakkara	Rubiaceae
180.	*Canthium coromandelicum* (Burm.f.) Alston	Kattara, Kandakkara	Rubiaceae
181.	*Canthium rheedei* DC.	Edali	Rubiaceae
182.	*Casearia ovata* (Lam.) Willd.	Malampavetta	Flacoutiaceae
183.	*Catunaregam spinosa* (Taunb.) Triveng.	Malankara	Rubiaceae
184.	*Chassalia curviflora* (Wall. ex Kurz) Thwaites	Nila-amalppori	Rubiaceae
185.	*Chromolaena odorata* (L.) King & Robins.	Communistupacha	Asteraceae
186.	*Cinnamomum heyneanum* Nees		Lauraceae
187.	*Cippadessa baccifera* (Roth) Miq.	Kaipanarangi	Meliaceae
188.	*Clerodendrum heterophyllum* (Poir) R. Br.	Veliparuvalam	Verbenaceae
189.	*Clerodendrum indicum* (L.) Kuntze	Bharangi	Verbenaceae
190.	*Clerodendrum infortunatum* L.	Peruvelam	Verbenaceae
191.	*Clerodendrum paniculatum* L.	Krishnakireedam	Verbenaceae
192.	*Coffea arabica* L.	Kappi, Coffee	Rubiaceae
193.	*Dendrocalamus strictus* (Roxb.) Nees	Mula, Kallan-mula	Poaceae
194.	*Dendrophthoe falcata* (L.f.) Etting	Ithil, Ithikkanni	Loranthaceae
195.	*Desmodium gangeticum* (L.) DC.	Orila	Fabaceae: Papilionoideae
196.	*Desmodium motorium* Houtt.	Thozhukanni	Fabaceae: Papilionoideae
197.	*Desmodium triquetrum* (L.) DC.	Adakkapanal	Fabaceae: Papilionoideae
198.	*Embelia tsjeriam-cottam* (Roem. & Schult.) DC.	Ammimuriyan	Myrsinaceae
199.	*Ensete superbum* (Roxb.) Cheesman.	Kalluvazha	Musaceae
200.	*Eugenia argentia* Bedd.		Myrtaceae
201.	*Eugenia mooniana* Wight		Myrtaceae
202.	*Eugenia roxburghii* DC.		Myrtaceae
203.	*Fagraea ceilanica* Thunb.	Modakam	Loganiaceae
204.	*Flemingia strobilifera* (L.) R. Br. ex Ait.f.	Pothorila, Kumbilteri	Fabaceae: Papilionoideae
205.	*Glycosmis macrocarpa* Wight	Panal	Rubiaceae
206.	*Glycosmis mauritiana* (Lam.) Tanaka	Panal, Poonippatti	Rutaceae
207.	*Glycosmis pentaphylla* (Retz.) DC.	Kuttipanal, Panchi	Rutaceae
208.	*Glyptopetalum grandiflorum* Bedd.		Celastraceae
209.	*Gomphostemma heyneanum* Benth.	Theeperuku	Lamiaceae
210.	*Helicanthes elastica* (Desr.) Danser	Ithil	Loranthaceae
211.	*Helicteres isora* L.	Edampiri-valampiri	Sterculiaceae
212.	*Helixanthera wallichiana* (Schult.) Danser		Loranthaceae
213.	*Homonoia riparia* Lour.	Attuvanchi, Neervanchi	Euphorbiaceae
214.	*Hyptis suaveolens* L.	Nattapoochedi	Lamiaceae
215.	*Isonandra lanceolata* Wight	Vellappala	Sapotaceae
216.	*Isonandra perrottetiana* A. DC.	Karimpala	Sapotaceae
217.	*Ixora coccinea* L.	Thetti, Thechi	Rubiaceae
218.	*Ixora elongata* Heyne ex G. Don		Rubiaceae
219.	*Justicia adhatoda* L.	Adalotakam	Acanthaceae
220.	*Justicia betonica* L.	Venkurinji	Acanthaceae
221.	*Lantana camara* L.	Arippoochedi	Verbenaceae
222.	*Lasianthus jackianus* Wight		Rubiaceae
223.	*Leea guineensis* G. Don.		Leeaceae
224.	*Leea indica* (Burm.f.) Merr.	Choriyan-thali, Njekku	Leeaceae
225.	*Ligustrum perrottetii* A. DC.	Pingi	Oleaceae

226.	*Lobelia nicotianaefolia* Roth ex Roem. & Schult.	Kattupukayila	Lobeliaceae
227.	*Ludwigia peruviana* (L) H. Hara		Onagraceae
228.	*Macrosolon capitellatus* (Wight & Arn.) Danser	Ithil	Loranthaceae
229.	*Macrosolen parasiticus* (L) Danser	Chempoo, Ithil	Loranthaceae
230.	*Maesa indica* (Roxb.) Sweet	Kattuvihal, Vannathi	Myrsinaceae
231.	*Meiogyne panosa* (Dalz) Sanclair		Annonaceae
232.	*Melastoma malabathricum* L.	Kadali	Melastomataceae
233.	*Memecylon gracile* Bedd.	Elimaram	Melastomataceae
234.	*Memecylon grande* Retz.	Palluvirisa	Melastomataceae
235.	*Memecylon wayanadense* Ratheesh, Sivu & Pradeep		Melastomataceae
236.	*Miliusa wayanadica* Sujanapal, Ratheesh & Sasidh.		Annonaceae
237.	*Nothapodytes nimmoniana* (J. Graham) Byng & Stull	Peenari, Pulippacha	Icacinaceae
238.	*Ochlandra scriptaoria* (Dennst.) C.E.C. Fisch.	Kolanji, Ottal	Poaceae
239.	*Ochlandra travancorica* (Bedd.) Benth. ex Gamble	Eetta, Eera	Poaceae
240.	*Orophea sivarajanii* Sasidh.		Annonaceae
241.	*Pogostemon mollis* Benth.	Thirikkozhunthi	Lamiaceae
242.	*Polyalthia korintii* (Dunal) Benth. & Hook.f. ex Kook.f. & Thoms.	Korandipanal	Annonaceae
243.	*Polyalththia malabarica* (Budd.) I.M. Turner	Kunukipanal	Annonaceae
244.	*Psuedarthria viscida* (L.) Wight & Arn.	Moovila	Fabaceae: Papilionoideae
245.	*Psychotria flavida* Talbot		Rubiaceae
246.	*Psychotria globicephala* Gamble		Rubiaceae
247.	*Rotula aquatica* Lour.	Kallurvanchi	Boraginaceae
248.	*Saprosma glomerata* (Gard.) Bedd.		Rubiaceae
249.	*Solanum americanum* Mill.	Manathakkali	Solanaceae
250.	*Solanum melongena* L. var. *insanum*	Cheruvazhuthana, Chunda	Solanaceae
251.	*Stachytarpheta cayennensis* (Rich.) Schauer		Verbenaceae
252.	*Stachytarpheta jamaicensis* (L.) Vahl.	Narivalan, Cheravappalli	
253.	*Strobilanthes ciliatus* Nees	Karinkurinji	Acanthaceae
254.	*Strobilanthes rubicundus* (Nees) Anders		Acanthaceae
255.	*Syzygium munronii* (Wight) Chandrab.	Malamchamba	Myrtaceae
256.	*Tarenna asiatica* (L.) Kuntze ex K. Schum.	Kuppippovu, Tharana	Rubiaceae
257.	*Tarenna nilagirica* (Bedd.) Bremek.		Rubiaceae
258.	*Thottea siliquosa* (Lam.) Ding Hou	Alpam	Aristolochiaceae
259.	*Triumfetta pilosa* Roth	Erumachappu	Tiliaceae
260.	*Triumfetta rhomboidea* Jacq.	Oorpam	Tiliaceae
261.	*Uraria rufescens* (DC.) Schind	Valiya Moovila	Fabaceae: Papilionoideae
262.	*Urena lobata* L.	Uram, Oorppam	Malvaceae
263.	*Vernonia albicans* DC.	Puvankuranthal	Asteraceae
264.	*Waltheria indica* L.		Sterculiaceae
265.	*Ziziphus rugosa* Lam.	Malanthodali	Rhamnaceae
C.	**CLIMBERS**		
266.	*Abrus precatorius* L.	Kunni	Fabaceae: Papilionoideae
267.	*Acacia caesia* Wight & Arn.	Incha	Fabaceae: Mimosoideae
268.	*Adenia hondala* (Gaertn.) de Wilde	Muthukku	Passifloraceae
269.	*Ampelocissus latifolia* (Roxb.) Planch	Chembravalli	Vitaceae

270.	*Ancistrocladus heyneanus* Wall ex Graham	Mothiravalli	Ancistrocladaceae
271.	*Argyreia elliptica* (Roth) Choisy	Adumbuvalli	Convolvulaceae
272.	*Aristolochia acuminata* Lam.	Garudakodi	Aristolochiaceae
273.	*Artabotrys zeylanicus* Hook.f. & Thoms.	Manoranjini	Annonaceae
274.	*Bauhinia phoenicea* Wight & Arn.	Thukarakalli	Fabaceae: Caesalpinioideae
275.	*Caesalpinia bonduc* L.	Kazhanji, Kazhanchi	Fabaceae: Caesalpinioideae
276.	*Caesalpinia mimosoides* Lam.	Kalthottavadi, Theemullu	Fabaceae: Caesalpinioideae
277.	*Calycopteris floribunda* Lam.	Pullanji	Combretaceae
278.	*Cardiospermum halicacabum* L.	Karuthakunni, Uzhinja	Sapindaceae
279.	*Cassytha filiformis* L.	Moodillathali	Lauraceae
280.	*Cayratia trifolia* (L.) Domin	Chorivalli	Vitaceae
281.	*Celastrus paniculatus* Willd.	Kilitheenpanji	Celastraceae
282.	*Chonemorpha fragrans* (Moon) Alston	Appuppanthadi	Apocynaceae
283.	*Clematis gouriana* Roxb. ex DC.	Nikidakodi	Ranunculaceae
284.	*Croton caudatus* Geisel.	Umithinnikkodi	Euphorbiaceae
285.	*Cryptolepis buchananii* R. Br. ex Roem. & Schult.	Kattupalvalli	Periplocaceae
286.	*Cuscuta reflexa* Roxb.	Moodillathali, Akasathamara	Convolvulaceae
287.	*Cyclea peltata* (Burm.f.) Hook.f. & Thoms.	Padathali	Menispermaceae
288.	*Dalbergia volubilis* Roxb.	Mrithi	Fabaceae: Papilionoideae
289.	*Desmos chinensis* Lour. var. *lawii*		Annonaceae
290.	*Dioscorea oppositifolia* L.	Kachil, Yam	Dioscoreaceae
291.	*Dioscorea pentaphylla* L.	Noorankizhangu	Dioscoreaceae
292.	*Dioscorea wallichii* Hook.f.	Narukizhangu	Dioscoreaceae
293.	*Dolichos trilobus* L.	Kattumuthira	Fabaceae: Papilionaceae
294.	*Embelia ribes* Burm.f.	Vizhal, Vizhalari	Myrsinaceae
295.	*Entada rheedei* Spreng	Parandavalli	Fabaceae: Mimosoideae
296.	*Hemidesmus indicus* (L.) R. Br. var. *indicus*	Nannari, Naruneendi	Asclepiadaceae
297.	*Hemidesmus indicus* (L.) R. Br. var. *pubescens*	Nannari	Asclepiadaceae
298.	*Ichnocarpus frutescens* (L.) R. Br.	Palvalli	Apocynaceae
299.	*Millettia rubiginosa* Wight & Arn.		Fabaceae: Papilionoideae
300.	*Mikania micrantha* Kunth	Vayara	Asteraceae
301.	*Mimosa diplotricha* C. Wight ex Sanvalle	Anathottavadi	Asteraceae: Mimosoideae
302.	*Momordica dioica* Roxb. ex Willd.	Kattupaval	Cucurbitaceae
303.	*Mucuna bracteata* DC. ex Kurz	Thottapayar	Fabaceae: Papilionoideae
304.	*Mucuna gigantea* DC. ex Kurz	Kakavalli	Fabaceae: Papilionoideae
305.	*Paramignya beddomei* Tanaka		Rutaceae
306.	*Passiflora coccinea* Aubl	Red passion flower	Passifloraceae
307.	*Passiflora edulis* Sims	Passion fruit	Passifloraceae
308.	*Passiflora foetida* L.	Ammommapazham	Passifloraceae
309.	*Piper argyrophyllum* Miq.	Kattukurumulaku	Piperaceae
310.	*Piper hymenophyllum* Miq.	Kattukurumulaku	Piperaceae
311.	*Piper mullesua* Buch.-Ham. ex G. Don.	Kattukurumulagu	Piperaceae
312.	*Piper nigrum* L.	Kurumulaku	Piperaceae
313.	*Pothos scandens* L.	Paruvakodi	Araceae
314.	*Raphidophora pertusa* (Roxb.) Schott	Aanachurukki	Araceae

315.	*Rourea minor* (Gaertn.) Merr.	Kureel	Connaraceae
316.	*Rubia cordifolia* L.	Ellumbarakki, Manchatti	Rubiaceae
317.	*Salacia fruticosa* Heyne ex Lawson	Ponkoranti	Celastraceae
318.	*Sarcostigma kleinii* Wight & Arn.	Odel	Icacinaceae
319.	*Smilax wightii* A. DC.	Chooramullu	Smilacaceae
320.	*Smilax zeylanica* L.	Kareelanchi	Smilacaceae
321.	*Strychnos minor* Dennst.	Cherukanjiravalli	Loganiaceae
322.	*Strychnos wallichiana* Steud. Ex A. DC.	Vallikanjiram	Loganiaceae
323.	*Tylophora indica* (Burm.f.) Merr. var. *glabra*	Vallippala	Asclepiadaceae
324.	*Vanilla planifolia* Andr.	Vanilla	Orchidaceae
325.	*Zanonia indica* L.	Peenarvalli	Cucurbitaceae
326.	*Ziziphus oenoplia* (L.) Mill.	Thodali	Rhamnaceae
D.	**HERBS**		
327.	*Acampe praemorsa* (Roxb.) Blatt. & McCann	Maravazha, Upputhali	Orchidaceae
328.	*Acanthephippium bicolor* Lindl.	Maravazha	Orchidaceae
329.	*Ageratum conyzoides* L.	Appa, Muriyanpacha	Asteraceae
330.	*Ageratum houstonianum* Mill.	Kaliyammanpathiri, Neela-appa	Asteraceae
331.	*Alloteropsis cimmicina* (L.) Stapf		Poaceae
332.	*Alpinia calcarata* (Andrews) Rosc.	Kolinchi	Zingiberaceae
333.	*Alpinia galanga* (L.) Willd.	Kolinchi	Zingiberaceae
334.	*Alpinia malaccensis* (Burm.f.) Rosc.	Kattaratha	Zingiberaceae
335.	*Amorphophallus paeonifolius* (Dennst) Niolson var. *paeonifolius*	Kattuchena	Araceae
336.	*Anaphyllum wightii* Schott	Keerikkizhangu	Araceae
337.	*Andrographis atropurpurea* (Dennst) Alston	Neelakiriyath	Acanthaceae
338.	*Andrographis paniculata* (Burm.f.) Wall. ex Nees	Kiriyath	Acanthaceae
339.	*Arisaema leschenaultii* Blume	Kattuchena	Araceae
340.	*Arisaema tortuosum* (Wall.) Schott	Cobra lily	Araceae
341.	*Aristida setacea* Retz.	Pottappullu	Poaceae
342.	*Arundinella leptochloa* (Nees ex Steud.) Hook.f.		Poaceae
343.	*Arundinella mesophylla* Nees es Steud.		Poaceae
344.	*Asystasia gangetica* (L.) T. Anderson	Upliyam, Upputhali	Acanthaceae
345.	*Bidens biternata* (Lour.) Merr. & Sheriff	Kandavarekuthi	Asteraceae
346.	*Biophytum congestiflorum* Govind.		Oxalidaceae
347.	*Biophytum sensitivum* (L.) DC.	Mukkutti	Oxalidaceae
348.	*Brachycorythis iantha* (Wight) Summerh.		Orchidaceae
349.	*Bulbophylllum acutiflorum* A. Rich.		Orchidaceae
350.	*Bulbophyllum silentvalliensis* M.P. Sharma & S.K. Srivast.		Orchidaceae
351.	*Bulbophyllum sterile* (Lam.) Suresh	Mookittakaya	Orchidaceae
352.	*Chlorophytum indicum* (Willd ex Schult. & Schult.f.) Dress	Virakaitha	Llliaceae
353.	*Chrysopogon aciculatus* (Retz.) Trin.	Snehappullu	Poaceae
354.	*Chrysopogon hackelii* (Hook.f.) C.E.C. Fisch.		Poaceae
355.	*Cleome monophylla* L.	Kattukaduku	Capparaceae
356.	*Cleome viscosa* L.	Aadunarivela	Capparaceae

357.	*Coelogyne nervosa* A. Rich.		Orchidaceae
358.	*Coix lacryma-jobi* L.	Kunthamani	Poaceae
359.	*Colocasia esculenta* (L.) Schott	Chembu, Madantha	Araceae
360.	*Conyza canadensis* (L.) Cronq.	Horseweed	Asteraceae
361.	*Corchorus trilocularis* L.	Arenukam	Tiliaceae
362.	*Costus pictus* D. Don. ex Lindl.	Insulin plant	Costaceae
363.	*Costus speciosus* (Koenig) J.E. Smith	Channakoova	Costaceae
364.	*Crotalaria retusa* L.	Kilukki	Fabaceae: Papilionoideae
365.	*Curcuma aeruginosa* Roxb.	Karimanjal	Zingiberaceae
366.	*Curcuma aromatica* Salisb.	Kasturimanjal	Zingiberaceae
367.	*Curcuma caesia* Roxb.	Karimanjal	Zingiberaceae
368.	*Curcuma zanthorrhiza* Roxb.	Manjakkoova	Zingiberaceae
369.	*Curculigo orchioides* Gaertn.	Nilappana	Hypoxidaceae
370.	*Curculigo trichocarpa* Gaertn.	Nilampana	Hypoxidaceae
371.	*Cymbidium aloifolium* (L.) Sw.		Orchidaceae
372.	*Cymbopogon citratus* (DC.) Stapf	Thailapullu	Poaceae
373.	*Cymbopogon flexuosus* (Nees ex Steud.) Wats.	Theruvappullu	Poaceae
374.	*Cyperus haspan* L.		Cyperaceae
375.	*Cyperus rotundus* L.	Muthanga	Cyperaceae
376.	*Cyrtococcum longipes* (Wight & Arn. ex Hook.f.) A. Camus		Poaceae
377.	*Cyrtococcum oxyphyllum* (Steud.) Stapf		Poaceae
378.	*Dendrobium anilii* P.M. Salim		Orchidaceae
379.	*Dendrobium crepidatum* Lindl.		Orchidaceae
380.	*Dendrobium ovatum* (L.) Kranz		Orchidaceae
381.	*Dendrobium wightii* Hawkes & Heller	Vella-ithil	Orchidaceae
382.	*Digitaria bicornis* (Lam.) Roem. & Schult. ex Loud.		Poaceae
383.	*Digitaria ciliaris* (Retz.) Koeler		Poaceae
384.	*Elatostema acuminatum* (Poir.) Brongn.		Urticaceae
385.	*Eleutheranthera ruderalis* (Sw.) Sch.-Bip		Asteraceae
386.	*Epithema carnosum* Benth. var. *hispida*		Gesneriaceae
387.	*Eria albiflora* Rolfe		Orchidaceae
388.	*Eulalia trispicata* (Schult.) Hanrard		Poaceae
389.	*Eulophia spectabilis* (Dennst.) Suresh	Elappola	Orchidaceae
390.	*Fimbristylis dichotoma* (L.) Vahl		Cyperaceae
391.	*Grona heterophylla* (Willd.) H. Ohashi & K. Ohashi	Muyalppullu	Fabaceae: Papilionoideae
392.	*Gymnostachyum febrifugum* Benth. var. *febrifugum*	Nilamuchala	Acanthaceae
393.	*Habenaria heyniana* Lindl.		Orchidaceae
394.	*Habenaria longicorniculata* Graham.		Orchidaceae
395.	*Habenaria longicornu* Lindl.		Orchidaceae
396.	*Hedychium flavescens* Carey ex Rosc.	Kookkuvala	Zingiberaceae
397.	*Hedyotis diffusa* Willd.	Vayalnelly, Parpadakam	Rubiaceae
398.	*Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult	Shoolampullu	Poaceae
399.	*Impatiens balsamina* L.	Thottachinungi	Balsaminaceae
400.	*Impatiens barberi* Hook.f.		Balsaminaceae
401.	*Impatiens chinensis* L.		Balsaminaceae

402.	*Impatiens diversifolia* Wall. ex Wight & Arn.		Balsaminaceae
403.	*Impatiens jerdoniae* Wight		Balsaminaceae
404.	*Impatiens johnsiana* Ratheesh, Sunil & Anil		Balsaminaceae
405.	*Impatiens minae* Ratheesh, Anil Kumar & Sivad.		Balsaminaceae
406.	*Impatiens modesta* Wight		Balsaminaceae
407.	*Impatiens scapiflora* Heyne ex Roxb.		Balsaminaceae
408.	*Isachne henryi* S.R. Sriniv. & Sreek.		Poaceae
409.	*Ischaemum barbatum* Retz.		Poaceae
410.	*Ischaemum indicum* (Houtt.) Merr. ssp. *indicum* var. *indicum*	Chenkodippullu	Poaceae
411.	*Justicia japonica* Thunb.		Acanthaceae
412.	*Kaempferia galanga* L.	Kacholam	Zingiberaceae
413.	*Kaempferia rotunda* L.	Chengazhineerkizhangu	Zingiberaceae
414.	*Kalanchoe pinnata* (Lam.) Pers.	Elachedi	Crassulaceae
415.	*Kyllinga nemoralis* (J.R. Forst. & G. Forst.) Dandy ex Hutch. & Dalz.	Muthanga	Cyperaceae
416.	*Lagenandra ovata* (L.) Thw.	Karimpola	Araceae
417.	*Lagenandra toxicaria* Dalz.	Andavazha	Araceae
418.	*Limnophila aromatica* (Lam.) Merr.	Manganari	Scrophulariaceae
419.	*Ludwigia hyssopifolia* (G. Don.) Exell.	Neergrampu	Onagraceae
420.	*Luisia tristis* sensu Ratheesh		Orchidaceae
421.	*Murdannia nimmoniana* (J. Graham) Bole & M.R. Almeida var. *nimmoniana*	Neelappullu	Commelinaceae
422.	*Naregamia alata* Wight & Arn.	Nilanarakam	Meliaceae
423.	*Nervilia concolor* (Blume) Schltr.	Orilathamara	Orchidaceae
424.	*Ophiorrhiza mungos* L.	Avilpori	Rubiaceae
425.	*Oplismenus burmannii* (Retz.) P. Beauv.		Poaceae
426.	*Oplismenus compositus* (L.) P. Beauv.	Kozhippullu	Poaceae
427.	*Oxalis corniculata* L.	Puliyarila	Oxalidaceae
428.	*Panicum brevifolium* L.	Thavalappullu	Poaceae
429.	*Panicum notatum* Retz.		Poaceae
430.	*Panicum repens* L.	Torpedo grass	Poaceae
431.	*Papilionanthe cylindrica* (Lindl.) Seidenif.	Butterfly orchid	Orchidaceae
432.	*Pennisetum polystachyon* (L.) Schult,		Poaceae
433.	*Perotis indica* (L.) Kuntze	Kuthiravalanpullu	Poaceae
434.	*Physalis angulata* L.	Njodinjotta	Solanaceae
435.	*Physalis peruviana* L.	Karimpotti	Solanaceae
436.	*Polygonum plebeium* R. Br.	Small knotweed	Polygonaceae
437.	*Remusatia vivipara* (Roxb.) Schott	Marachembu	Araceae
438.	*Rhynchostylis retusa* (L.) Blume	Seethamudi	Orchidaceae
439.	*Scleria lithosperma* (L.) Sw.	Nakkupullu	Cyperaceae
440.	*Scoparia dulcis* L.	Kallurukki	Scrophulariaceae
441.	*Seidenfia rheedi* (Sw.) Szlach	Jeevakam	Orchidaceae
442.	*Setaria intermedia* Roem. & Schult.		Poaceae
443.	*Setaria pumila* (Poir.) Roem. & Schult.	Kambilippullu	Poaceae
444.	*Sonerila cannanorensis* Giri & M.P. Nayar		Melastomataceae
445.	*Sonerila keralensis* Deepthikum. & Pandur.		Melastomataceae
446.	*Sonerila rheedei* Wight & Arn.		Melastomataceae

447.	*Tridax procumbens* L.	Kumminnippacha	Asteraceae
448.	*Zingiber montanum* (Koenig) Link ex A. Dietr.	Kattinchi	Zingiberaceae
449.	*Zingiber officinale* Rosc.	Inchi	Zingiberaceae
450.	*Zingiber wightianum* Thwaites	Malayinchi	Zingiberaceae
451.	*Zingiber zerumbet* (L.) J.E. Smith	Kattukolinchi	Zingiberaceae

Annexure 14: List of Endemic Plants found in the Project Environment

*Exclusive endemic species to the State of Kerala

Sl. No.	Scientific name	Family	Distribution
1.	*Actinodaphne wightiana* (Kuntze) Noltie	Lauraceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
2.	*Aglaia barberi* Gamble	Meliaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala*: *throughout*
3.	*Aglaia malabarica* Sasidh.	Meliaceae	Western Ghats: *Kerala; *Kerala: throughout*
4.	*Aeschynanthus perrottettii* A. DC.	Gesneriaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
5.	*Anaphyllum wightii* Schott	Araceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: throughout*
6.	*Andrographis atropurpurea* (Dennst) Alston	Acanthaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; Kerala: throughout
7.	*Aralia malabarica* Bedd.	Araliaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: throughout*
8.	*Artocarpus hirsutus* Lam.	Moraceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
9.	*Arundinella mesophylla* Nees es Steud.	Poaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: throughout*
10.	*Barleria courtallica* Nees	Acanthaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
11.	*Baccaurea courtallensis* (Wight) Muel.-Arg.	Euphorbiaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
12.	*Bauhinia phoenicea* Wight & Arn.	Fabaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
13.	*Biophytum congestiflorum* Govind.	Oxalidaceae	Western Ghats: *****Kerala; *Kerala: Idukki, Wayanad*
14.	*Brachycorythis iantha* (Wight) Summerh.	Orchidaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: throughout, occasional*
15.	*Bulbophylllum acutiflorum* A. Rich.	Orchidaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: Idukki, Wayanad, Kannur*
16.	*Bulbophyllum silentvalliensis* M.P. Sharma & S.K. Srivast.	Orchidaceae	Western Ghats: *****Kerala; *Kerala: Palakkad, Wayanad*
17.	*Cajanus lineatus* (Wight & Arn.) Maesen	Fabaceae	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
18.	*Chlorophytum indicum* (Willd ex Schult. & Schult.f.) Dress	Liliaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
19.	*Chrysopogon hackelii* (Hook.f.) C.E.C. Fisch.	Poaceae	Peninsular India: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
20.	*Cinnamomum*	Lauraceae	Western Ghats: Karnataka, Kerala; *Kerala:*

	heyneanum Nees		*central region, Wayanad*
21.	*Cinnamomum malabatrum* (Burm.f.) Blume	Lauraceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
22.	*Coelogyne nervosa* A. Rich.	Orchidaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
23.	*Cullenia exarillata* Robyns	Bombacaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
24.	*Cynometra travancorica* Bedd.	Fabaceae: Caesalpinioideae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
25.	*Dendrobium anilii* P.M. Salim	Orchidaceae	Western Ghats: Kerala; ***Kerala: Wayanad***
26.	*Dendrobium ovatum* (L.) Kranz	Orchidaceae	Western Ghats: Maharashtra, Nagar Haveli, Karnataka, Kerala; *Kerala: throughout*
27.	*Desmos chinensis* Lour. var. *lawii*	Annonaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: occasional, throughout*
28.	*Diospyros bourdillonii* Brabdis	Ebenaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
29.	*Drypetes wightii* (Hook.f.) Pax & Hoffm.	Euphorbiaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: throughout*
30.	*Elaeocarpus munroi* (Wight) Mast.	Elaeocarpaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
31.	*Ensete superbum* (Roxb.) Cheesman.	Musaceae	Western Ghats: Maharashtra, Nagar Haveli, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
32.	*Epithema carnosum* Benth.var. *hispida*	Gesneriaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
33.	*Eria albiflora* Rolfe	Orchidaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: Palakkad, Wayanad*
34.	*Eugenia argentia* Bedd.	Myrtaceae	Western Ghats: Kerala; *Kerala: Northern region*
35.	*Euonymus indicus* Heyne ex Wallich	Celastraceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
36.	*Flacourtia montana* Graham	Flacoutiaceae	Western Ghats: Maharashtra, Goa. Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
37.	*Garcinia gummi-gutta* (L.) Robs. var. *gummi-gutta*	Clusiaceae	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
38.	*Gomphostemma heyneanum* Benth. var. *heyneanum*	Lamiaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
39.	*Glyptopetalum grandiflorum* Bedd.	Celastraceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: southern and northern regions*
40.	*Gymnostachyum febrifugum* Benth. var. *febrifugum*	Acanthaceae	Western Ghats: Karnataka, Kerala; *Kerala: throughout*
41.	*Habenaria heyniana*	Orchidaceae	Western Ghats: Maharashtra, Goa, Karnataka,

	Lindl.		Tamil Nadu, Kerala; *Kerala: throughout, occasional*
42.	*Habenaria longicornu* Lindl.	Orchidaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout, occasional*
43.	*Helicanthes elastica* (Desr.) Danser	Loranthaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
44.	*Helixanthera wallichiana* (Schult.) Danser	Loranthaceae	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
45.	*Holigarna arnottiana* Hook.f.	Anacardiaceae	Western Ghats: Maharashtra, Goa. Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
46.	*Hopea parviflora* Bedd.	Dipterocarpaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
47.	*Humboldtia brunonis* Wall.	Fabaceae: Caesalpinioideae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: Northern region*
48.	*Humboldtia vahliana* Wight	Fabaceae: Caesalpinioideae	Western Ghats: Tamil Nadu, Kerala; *Kerala: throughout*
49.	*Hydnocarpus pentandrus* (Buch.-Ham.) Oken	Flacoutiaceae	Western Ghats: Maharashtra, Goa. Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
50.	*Hymenodictyon obovatum* Wall.	Rubiaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
51.	*Impatiens barberi* Hook.f.	Balsaminaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: Wayanad, Idukki*
52.	*Impatiens diversifolia* Wall. ex Wight & Arn.	Balsaminaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
53.	*Impatiens jerdoniae* Wight	Balsaminaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: Idukki, Kannur, Palakkad, Wayanad*
54.	*Impatiens johnsiana* Ratheesh, Sunil & Anil	Balsaminaceae	Western Ghats: *****Kerala; *Kerala: Wayanad*
55.	*Impatiens minae* Ratheesh, Anil Kumar & Sivad.	Balsaminaceae	Western Ghats: *****Kerala; *Kerala: Wayanad*
56.	*Impatiens modesta* Wight	Balsaminaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: throughout*
57.	*Impatiens scapiflora* Heyne ex Roxb.	Balsaminaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
58.	*Isachne henryi* S.R. Sriniv. & Sreek.	Poaceae	Western Ghats: *****Kerala; *Kerala: Wayanad*
59.	*Isonandra perrottetiana* A. DC.	Sapotaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
60.	*Ixora brachiata* Roxb. ex DC.	Rubiaceae	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
61.	*Ixora elongata* Heyne ex G. Don	Rubiaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
62.	*Knema attenuata*	Myristicaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*

	(Hook.f. & Thoms.) Warb.		
63.	*Lagerstroemia microcarpa* Wight	Lythraceae	Western Ghats: Maharashtra, Goa, Nagar Haveli, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
64.	*Lasianthus jackianus* Wight	Rubiaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: Central and northern regions*
65.	*Ligustrum perrottetii* A. DC.	Oleaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
66.	*Litsea bourdillonii* Gamble	Lauraceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
67.	*Litsea coriacea* (Heyne ex Meisn.) Hook.f.	Lauraceae	Western Ghats: Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
68.	*Litsea floribunda* (Blume) Gamble	Lauraceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
69.	*Meiogyne panosa* (Dalz) Sanclair	Annonaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
70.	*Memecylon gracile* Bedd.	Melastimataceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: Southern region, Wayanad*
71.	*Memecylon wayanadense* Ratheesh, Sivu & Pradeep	Melastomataceae	Western Ghats: *****Kerala; *Kerala: Wayanad*
72.	*Miliusa wayanadica* Sujanapal, Ratheesh & Sasidh.	Annonaceae	Western Ghats: *****Kerala; *Kerala: Wayanad, Kannur*
73.	*Millettia rubiginosa*	Fabaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: Central and southern regions, Wayanad*
74.	*Monoon fragrans* (Dalz.) Bedd.	Annonaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
75.	*Myristica beddomei* King	Myristicaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
76.	*Myristica malabarica* Lam.	Myristicaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: throughout*
77.	*Nothopegia racemosa* (Dalz.) Ramamoorthy	Anacardiaceae	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
78.	*Ochlandra scriptaoria* (Dennst.) C.E.C. Fisch.	Poaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
79.	*Ochlandra travancorica* (Bedd.) Benth. ex Gamble	Poaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
80.	*Orophea sivarajanii* Sasidh.	Annonaceae	Western Ghats: *****Kerala; *Kerala: Wayanad, Kannur*
81.	*Palaquium ellipticum* (Dalz.) Baill.	Sapotaceae	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
82.	*Poeciloneuron indicum* Bedd.	Clusiaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
83.	*Pogostemon mollis*	Lamiaceae	Western Ghats: Maharashtra, Karnataka, Tamil

	Benth.		Nadu, Kerala; *Kerala: throughout*
84.	*Polyalththia malabarica* (Budd.) I.M. Turner	Annonaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: throughout*
85.	*Psychotria flavida* Talbot	Rubiaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
86.	*Psychotria globicephala* Gamble	Rubiaceae	Western Ghats: Tamil Nadu, Kerala; *Kerala: Wayanad, Palakkad, Ernakulam, Thiruvananthapuram*
87.	*Pterosperum reticulatum* Wight & Arn.	Sterculiaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
88.	*Pterosperum rubiginosum* Heyne ex Wight & Arn.	Sterculiaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
89.	*Reinwardtiodendron anamalaiensis* (Bedd.) Mabb.	Meliaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
90.	*Salacia fruticosa*	Celastraceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
91.	*Smilax wightii*	Smilacaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: Wayanad, Palakkad, Idukki, Southern region*
92.	*Sonerila cannanorensis* Giri & M.P. Nayar	Melastomataceae	Western Ghats: *Kerala; *Kerala: Wayanad, Kannur*
93.	*Sonerila keralensis* Deepthikum. & Pandur.	Melastimataceae	Western Ghats: *Kerala; *Kerala: Wayanad, Idukki, Thrissur*
94.	*Sonerila rheedei* Wight & Arn.	Melastomataceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: Throughout*
95.	*Strobilanthes ciliatus* Nees	Acanthaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
96.	*Strobilanthes rubicundus* (Nees) Anders	Acanthaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
97.	*Syzygium laetum* (Buch.-Ham) Gandhi	Myrtaceae	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
98.	*Syzygium mundagam* (Bourd.) Chithra	Myrtaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
99.	*Syzygium munronii* (Wight) Chandrab.	Myrtaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
100.	*Syzygium occidentale* (Bourd.) Gandhi	Myrtaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: Southern and central regions, Wayanad*
101.	*Tabernaemontana alternifolia* L.	Apocynaceae	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
102.	*Tarenna nilagirica* (Bedd.) Bremek.	Rubiaceae	Western Ghats: Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
103.	*Terminalia paniculata* Roth	Combretaceae	Western Ghats: Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*
104.	*Vateria indica* L.	Dipterocarpaceae	Western Ghats: Maharashtra, Karnataka, Tamil Nadu, Kerala; *Kerala: throughout*

Annexure 15: Species wise and Girth wise Enumeration of Trees to be Cut

Species-wise and girth-class wise enumeration of trees to be cut and removed from the forestland in the project execution

Sl. No.	Scientific name	Local name	Girth-class (cm)					
			1-30	31-60	61-90	91-120	121-150	>150
1.	*Artocarpus heterophyllus*	Plavu		5	7			
2.	*Macaranga peltata*	Vatta		11		2	2	
3.	*Memeceylon angustifolium*	Kayampoo		2			1	
4.	*Ficus drupacea*	Koli, Chela, Kallal			2		1	2
5.	*Erythrina variegata*	Murukku		1	1			
6.	*Baccaurea courtallensis*	Moottippazham		3				
7.	*Melicope lunu-ankenda*	Kambili		8	7		1	
8.	*Elaeocarpus tuberculatus*	Bhadraksham		5	1			
9.	*Spondias pinnata*	Ambazham		1				
10.	*Persea macrantha*	Kulirmavu		1				
11.	*Mallotus tetracoccus*	Charavatta		1	2			
12.	*Myristica malabarica*	Kattujathi			1			
13.	*Garcinia gummi-gutta*	Kudampuli			1	1		
14.	*Bischofia javanica*	Chorappali			3		1	1
15.	*Reinwardtiodendron anamalaiense*	Cheeralam		2	1			
16.	*Syzygium mundagam*	Kattuchampa		1			1	
17.	*Vateria indica*	Vellappayin		3				
18.	*Elaeocarpus munronii*	Neeli		1	1	1		1
19.	*Olea dioica*	Edala	1		1			
20.	*Mallotus tetracoccus*	Pottama				1		
21.	*Mangifera indica*	Mavu						1
22.	*Ficus tsjahela*	Chola			2			
23.	*Zanthoxylum rhetsa*	Mullilam			1			
24.	*Cynometra travancorica*	Koori			2			
25.	*Palaquium ellipticum*	Pali		1			1	
26.	*Mallotus philippensis*	Sindoori		1	2			
27.	*Flacourtia montana*	Chaliram, Vayyamkatha			1			
	Total		**1**	**47**	**37**	**6**	**7**	**5**

Species-wise and girth-class wise enumeration of trees to be cut and removed from private lands of Anakkampoil and Meppadi areas

Sl. No.	Scientific name	Local name	Girth-class (cm)					
			0-30	31-60	61-90	91-120	121-150	>150
	Anakkanpoil area							
1.	*Artocarpus heterophyllus*	Plavu			1	1	1	1
2.	*Dalbergia sissoides*	Veetti				1		1
3.	*Erythrina variegata*	Murukku		2				
4.	*Gmelina arborea*	Kumbil			1	2		
5.	*Lagerstroemia microcarpa*	Venmizhavu				1	1	2
6.	*Macaranga peltata*	Vatta		4	3	2		
7.	*Mangifera indica*	Mavu, Mango			2	1		
8.	*Pajanelia longifolia*	Azhantha		1	1	1		
9.	*Tectona grandis*	Thekku, Teak			2	1	1	

10.	*Vateria indica*	Vellappayin		1	2	4	1	2
	Total (Anakkampoyil area)			**8**	**12**	**14**	**4**	**6**
	Meppadi area							
1.	*Artocarpus heterophyllus*	Plavu, Jackfruit tree				3		
2.	*Dalbergia latifolia*	Eetti			3			
3.	*Gmelina arborea*	Kumbil				1	1	
4.	*Macaranga peltata*	Vatta		3	2			
5.	*Mangifera indica*	Mavu, Mango			1	1		
6.	*Psidium guajava*	Pera, Guava	1	1				
7.	*Tectona grandis*	Thekku, Teak		9	3	1		
	Total (Meppadi area)		**1**	**13**	**9**	**6**	**1**	

Annexure 16: Photographs of Biodiversity Surveys Conducted

Kozhikode Side








Wayanad Side:







Photographs of Flora & Fauna in the Study Area:











Annexure 17: Lithological Description of Core Samples

Core samples from 8 bore holes drilled as part of geotechnical investigations were logged in detail. The log report is given below. Abbreviations used: CR-Core Rcovery, RQD-Rock Quality Designation. These have relevance during tunnelling.

BH-1

CH 0+60 RL 675.089m Depth 20.00m			
Depth Range (M)		**Lithology**	**Remarks**
0.00	4.50	Laterite with SPTN 10-38 (as per log records)	Water table 1.00m.
4.50	7.50	Laterite with loose weathered rock material, reddish brown. Plastic clay is observed in laterite	
7.50	9.00	Weathered hornblende gneiss with pinkish K - Feldspar	Contact with granite suspected
9.00	20.00	Completely weathered rock with traces of gneiss (as per the log records), core was not available for logging	
NOTE : Completely weathered/ fractured rock			

BH-2

CH 0+160 RL 670.588m Depth 15.00m			
Depth Range (M)		**Lithology**	**Remarks**
0.00	3.50	weathered rock (as per log records)	Water table 0.30m
3.50	4.50	weathered hard rock fragments	
4.50	7.50	Hornblende gneiss with specks of biotite in contact with charnockite	
7.50	8.50	Contact of hornblende gneiss with dark grey, medium grained charnockite. Foliation planes in hornblende gneiss at 2-8 mm apart, tight to isoclinal folds.	RQD 10% ,
8.50	9.50	Weathered hornblende gneiss followed to depth by massive charnockite of dark grey colour, medium grained. Appears a zone of fracturing	RQD 10%
9.50	10.50	Gneissic charnockite with hornblende, dark grey colour, open folds are seen.	CR -60% RQD 20%
10.50	11.50	Gneissic charnockite, medium to coarse grained with coarse grains (4mm across) of pyroxenes.	RQD - 20%
11.50	12.50	Gneissic charnockite, medium to coarse grained	CR -80%, RQD 40%
12.50	13.50	Fractured gneissic charnockite, symptoms of weathering	
13.50	15.00	Gneissic charnockite, medium to coarse grained, dark grey, hard. Foliation defined by hornblende and felsic layers (2-5mm apart).	CR 60%, RQD 30%
NOTE : Fractured, heterogeneous rock with symptoms of weathering along fracture zones.			

BH-3

CH 0+315 RL 691.031m Depth 19.50m			
Depth Range (M)		**Lithology**	**Remarks**
0.00	1.50	weathering products with clay/sand	water table- not encountered
1.50	9.50	Hornblende gneiss with foliation (H dipping at 45 degree. Fractured along foliation plane.	Core recovery - (CR)- Poor
9.50	18.00	Hornblende gneiss with foliation dipping at 45 degree. Fractured along foliation plane.	CR Poor, RQD - Very Poor. Coremissing after 13.50m
18.00	19.50	Weathered pink granite with hornblende with feeble foliation. Appears a migmatisation product of massive charnockite	

BH-3A

CH 0+310 RL 679.031m Depth 30.00m		
Depth Range (M)	**Lithology**	**Remarks**
	Core boxes poorly kept. The boxes contain samples of weathered charnockite showing fracturing and alteration to hornblende gneiss. Pieces of Charnockite contain specks of muscovite and charnockite shows transition to Dolerite dyke.	Water table – not encountered CR - Poor , RQD – Poor.

BH- 4

CH 0+430 RL 674.089m Depth 19.50m			
Depth Range (M)		**Lithology**	**Remarks**
0.00	4.00	Weathered rock fragments /sandy,	water table – 9m
4.00	5.00	weathered fragments of charnockite, medium grained , dark grey colour	
5.00	6.00	weathered fragments of charnockite, medium grained , dark grey colour, with fragments of granitic material	granite intrusion
6.00	9.00	Massive charnockite at the top , partially weathered in portions/parts. Towards depth gneissic charnockite fractured. In between weathered pink granite (0.50m) followed by gneissic charnockite towards depth.	6.00-7.00 CR - poor, RQD 10%; followed downwards by CR - 70%;RQD - 60%
9.00	10.00	Gneissic and massive charnockite dark coloured with coarse grains of pyroxene (1x3mm across), gneissocity is feeble, pyroxene layers 10 mm apart, no garnet.	CR -83%, RQD 82%

10.00	11.00	Medium to coarse grained charnockite greasy in appearance, pyroxene upto 1mm across, light grey coloured, fractured towards bottom, symptoms of weathering along fracture. Towards depth coarse grained massive charnockite	CR-100% RQD - 95 %
11.00	13.00	Charnockite, massive, dark coloured, medium grained. Becomes gneissic along fractures with coarsening of grain size and alteration to hornblende gneiss, angle of foliation 45 degree.	CR - 80%, RQD -20%.
13.00	14.00	Broken pieces of charnockite intruded by granitic material, coarsening of quartz, hornblende grains in the granitic part	CR - Poor, RQD - 10%,
14.00	15.00	Charnockite, massive, greasy , medium to coarse grained. Hornblende gneiss is observed in contact with granitic material of grey colour.	CR 40%, RQD 30%.
15.00	17.00	Massive charnockite, appearance of garnet	CR - 90%, RQD -30%
17.00	18.50	Hornblende gneiss, felsic at the top, followed by coarse grained massive charnockite, fractured	CR - 60%, RQD - 10%
NOTE : borehole encountered massive and gneissic charnockite often intruded by grey granite. In contact with the granite, hornblende gneiss is observed. It is intensely fractured. Weathering is intense upto 9.00m depth, in fracture zones CR and RQD are low.			

BH-5

CH 0+510 RL 701.343m Depth 14.50m			
Depth Range(M)		**Lithology**	**Remarks**
0.00	13.00	Weathering products, brownish in colour	Water table 0 .20m
13.00	14.50	Dolerite, dark, fine grained, heavy with transition to medium grain size at bottom. Contact rock appears to be charnockite, Symptoms of weathering along fracture planes	CR- Medium, QRD - Poor.
NOTE: Borehole encountered dolerite within fractured charnockite, symptoms of weathering along fracture planes.			

BH-6

CH -0+555 RL 723.949m Depth 38.00m			
Depth Range (M)		**Lithology**	**Remarks**
0.00	29.50	Core was not available. Material report Vol 3 by M/ S Q- Max Consultants (June 2021), states that the core is of highly to moderately weathered charnockite.	Water Table 20.50m
29.50	32.50	Gneissic charnockite, dark grey, fine to medium grained, fractured. Foliation angle 70 degree with thin layers.	CR -90 % ,RQD 20%.
32.50	33.50	Charnockite, dark grey , medium grained with intrusion of granitic material	CR-80 % ,RQD 20%
33.50	36.50	Charnockite, dark grey, fine grained with	CR -90 %, RQD

		incipient foliation along contact with granitic material with appearance of hornblende	70%.
NOTE: of the total depth of 38m core was available for depth interval 29.50- 36.50m. Weathering profile up to depth of 29.50m, followed by gneissic charnockite and fine to medium grained charnockite towards bottom. Migmatisation is evident. RQD is broadly poor except at the termination depth.			

BH-7

CH 8+555 RL 875.753m Depth 40.10m			
Depth Range (M)		**Lithology**	**Remarks**
0.00	24.00	weathering profile (core not available for logging)	water table 13.50m
24.00	27.00	24.00- 24.20m - Fracture zone Charnockite gneiss with garnet and specks of muscovite, foliation due to parallel arrangement of hornblende- pyroxene (1-4mm thick) and felsic material (5- 12mm thick) layers. Foliation angle 60^o with respect to vertical axis of the core. Pegmatite intrusion is seen.	Possibly close to muscovite pegmatite body.
27.00	32.50	Charnockite gneiss with garnet, dark grey medium to coarse grained, hard and heavy, foliation layers 2-15mm apart.	
32.00	35.00	charnockite gneiss, dark grey , medium grained, foliation bands are thinner than in the previous interval. Muscovite specks are seen.	Proximity to muscovite pegmatite.
35.00	37.00	Charnockite - Pegmatite contact zone. Large crystals of amphibole (8mm across) in quartz - feldspar matrix. Quartz grain size – 20 mm across. Further down grain size becomes less	
37.00	38.00	Charnockite gneiss , transition to hornblende gneiss with appearance of pinkish K - Feldspar	Nearby granite body suspected
NOTE: This borehole is located close to the Meppadi portal. Deep weathering profile up to 24m is characterstic of the geological sequence. Occurance of charnockite gneiss with transition to hornblende gneiss in depth zones in contact with granite is discerned. Presence of muscovite and garnet in depth zones (24-27m and 32.50 -35.00 m) is attributed to the intrusion of muscovite pegmatite in the near vicinity. At 24.00- 24.20 m interval, highly fractured rock fragments are observed. Coarsening of grain size of pyroxene, hornblende, quartz etc is indicative of intrusion of granitic / pegmatitic fluids. As such, though CR and RQD factors are good (70% and above), fragility of the underlying strata needs to be factored in the construction stage.			

BH-8

CH 6+650 RL 975.00m Depth 26.00m			
Depth Range (M)		**Lithology**	**Remarks**
0.00	8.50	Core was not available for most of the depth interval and the available core was haphazardly	Water table 3.50m

		kept without tags. From the description of the consultants (M/s Q Max techno consultants private limited), depth interval 0.00 - 9.50m consisted of moderately weathered grey gneiss.	
8.50	9.50	The available core is of pink granite with feeble foliation and beads of hornblende, resembling quartzo-feldspathic gneiss.	
9.50	26.00	Charnockite gneiss with hornblende, foliation marked by parallel arrangement of pyroxene, hornblende and felsic minerals. Foliation planes seperated by 2-10mm. In contact with the neosome, porphyroblasts of garnet (5mm across) are seen	CR - 90 % RQD 90%
NOTE: This is at the bank of Kalladi puzha along the alignment. Weathering profile up to 8.5m followed by gneissic charnockite with hornblende and intermittent neosome (pink granite) emplacement resulting in retrogression.			

Annexure 18: Activity-Impact Identification Matrix

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
A.	**Project Preparation Phase**				
A.1.	Preparation of Detailed Project Report	Land	Loss of productive land	Major	-ve, P
			Impacts due to siting of project related facilities	Major	-ve, P
			Soil erosion	Major	-ve, P
			Destabilization of slope	Medium	-ve, P
			Soil contamination due to spillage of oil and lubricants	Medium	-ve, P
			Blocking of natural drainages and filling of water bodies leading to water logging / flooding of adjacent low lying areas	Major	-ve, P
		Water	Contamination of water due to spillage of oil and lubricants and surface runoff with sediments from construction camps	Medium	-ve, P
			Contamination of water due to sewage from construction camps, labour camps, toll plazas, rest areas and truck lay byes	Medium	-ve, P
			Contamination of water due to foundation work for bridges.	Medium	-ve, T
			Alterations to natural drainage patterns	Major	-ve, P
			Reduced ground water recharge due to impervious pavement	Major	-ve, P
			Exploitation of ground water for construction.	Major	-ve, P
		Air	Increase in air pollution	Major	-ve, P
		Noise	Increase in noise levels	Major	-ve, P
		Biological	Loss of trees	Major	-ve, P
			Impact on forests and natural habitats	Major	-ve, P
		Socio-economic	Loss of land, structures and livelihoods	Major	-ve, P
			Loss of cultural properties	Major	-ve, P
			Shifting of community utilities and CPRs	Major	-ve, T
			Loss of access due to cutting of hill slopes / embankment construction	Major	-ve, P
			Road accidents	Major	-ve, P
		Solid Waste management	Generation of debris	Medium	-ve, P

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
B.	**Pre-Construction Phase**				
B.1.	Land Acquisition	Land	No impact	-	-
		Water	No impact	-	-
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	No impact	-	-
		Socio-economic	Loss of land, buildings and livelihood, loss of cultural properties and common property resources (CPRs)	Major	-ve, P
		Solid waste management	No impact	-	-
B.2.	Relocation of utilities	Land	No impact	-	-
		Water	No impact	-	-
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	No impact	-	-
		Socio-economic	Damages to utilities and inconvenience to public	Medium	-ve, T
		Solid waste management	No impact	-	-
B.3	Identification of site for construction camp	Land	Loss of topsoil, soil contamination due to spillage of fuel, lubricants and hazardous chemicals	Medium	-ve, T
		Water	Surface water pollution due to run off from the site containing oil and silt, and waste water from vehicle washing area and sewage from toilets.	Medium	-ve, T
		Air	Air pollution due to fugitive dust and gaseous emissions from hot mix plant and diesel generator .	Medium	-ve, T
		Noise	Noise pollution due to generator, machineries and movement of vehicles	Medium	-ve, T
		Biological	Loss of trees, Impact on forests and wildlife habitats	Medium	-ve, T
		Socio-economic	Inconvenience to local traffic in access roads to construction camp	Medium	-ve, T

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
		Solid waste management	No impact	-	-
B.4.	Identification of site for labour camps	Land	Loss of top soil and soil productivity due to soil compaction	Medium	-ve, T
		Water	Unsafe disposal of domestic sewage to nearest water body.	Medium	-ve, T
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Cutting of trees / collection of fire wood and non-timber forest produce (NTFP) from forest, hunting of wild animals, occurrence of forest fire.	Minor	-ve, T
		Socio-economic	Impact on Public health and law and order	Medium	-ve, T
		Solid waste management	No Impact	-	-
B.5.	Identification of site for quarrying and stone crushing operations	Land	Loss of productive land, destabilization of slopes due to modification of natural conditions	Major	-ve, P
		Water	Surface water pollution due to run off from the site	Minor	-ve, T
		Air	Increased air pollution due to fugitive dust	Medium	-ve, T
		Noise	Increase in noise levels	Medium	-ve, T
		Biological	Loss of trees, Impact on forests and wildlife habitats	Minor	-ve, T
		Socio-economic	Risk for local inhabitants and passengers through nearby roads, railways, ropeways and waterways. Inconvenience to local traffic in access roads to quarry and crusher	Medium	-ve, T
		Solid waste management	Impacts due to improper disposal of overburden from quarry site.	Minor	-ve, T
B.6.	Identification of borrow sites	Land	Loss of productive land, loss of top soil, soil erosion, alterations in local topography, flooding of land due to collapse of river bund / irrigation tank bund.	Major	-ve, P
		Water	Collapse of irrigation tank bund and loss of irrigation water.	Minor	-ve, T
		Air	Increased air pollution due to fugitive dust	Minor	-ve, T
		Noise	Increase in noise levels	Minor	-ve, T
		Biological	Loss of trees, Impact on forests and wildlife habitats	Minor	-ve / T

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
		Socio-economic	Inconvenience to local traffic in access roads to borrow area, Occurrence of water borne diseases due to accumulation of water in borrowed lands.	Medium	-ve / T
		Solid waste management	No impact	-	-
B.7.	Identification of water sources	Land	No impact	-	-
		Water	Ground water depletion	Major	-ve, P
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	No impact	-	-
		Socio-economic	Reduction in water available for agriculture and domestic purposes	Major	-ve, P
		Solid Waste Management	No impact	-	-
B.8.	Identification of site for debris / excess soil / muck disposal	Land	Loss of soil productivity, soil contamination, soil erosion	Medium	-ve, P
		Water	Surface water pollution due to run off from the debris and soil	Minor	-ve, T
		Air	Air pollution due to fugitive dust during dumping of debris and soil	Medium	-ve, T
		Noise	Noise pollution due to movement of vehicles and dumping of debris.	Minor	-ve, T
		Biological	Loss of vegetative cover, impact on wildlife habitats	Medium	-ve, P
		Socio-economic	Obstruction to movement of local inhabitants, affect the safety and aesthetical beauty of the locality.	Minor	-ve, P
		Solid waste management	No impact	-	-
C.	**Construction Phase**				
C.1.	**Site Preparation Activities**				
C.1.1.	Setting up of construction camp	Land	Soil contamination due to spillage of fuel and lubricants, soil erosion due to surface run off.	Medium	-ve, P
		Water	Contamination of water due to spillage of oil and lubricants and surface runoff	Medium	-ve, T

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
			with sediments from construction camps. Contamination of water due to sewage from construction camps		
		Air	Air pollution due to fugitive dust and gaseous emissions from hot mix plant and diesel generator	Medium	-ve, T
		Noise	Increase in noise level due to diesel generator, other machineries and vehicles	Medium	-ve, T
		Biological	Loss of vegetation	Medium	-ve, P
		Socio-economic	Occupational health and safety impacts for workers	Medium	-ve, P
		Solid Waste management	Unscientific disposal of debris / solid waste	Medium	-ve, P
C.1.2.	Setting up of labour camp	Land	Loss of soil productivity	Medium	-ve, T
		Water	Pollution of water bodies with sewage	Medium	-ve, T
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Loss of vegetation	Minor	-ve, T
			Deforestation	Minor	-ve, T
		Socio-economic	Health impact due to fire accidents, Increase in communicable diseases	Medium	-ve, P
		Solid Waste management	Unhygienic environment due to unsafe disposal of waste generated.	Minor	-ve, T
C.1.3.	Setting up of Quarry and Crusher	Land	Loss of top soil	Major	-ve, P
		Water	Surface water pollution due to run off with sediments from the site	Medium	-ve, T
		Air	Air pollution due to fugitive dust and emissions from diesel generator	Major	-ve, T
		Noise	Noise pollution due to Crusher	Major	-ve, T
		Biological	Loss of vegetation	Medium	-ve, P
		Socio-economic	Occupational health and safety impacts for workers, Risk for local inhabitants and passengers through nearby roads	Medium	-ve, P
		Solid Waste Management	No impact	-	-

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
C.1.4.	Setting up of borrow area	Land	Loss of topsoil, soil erosion	Major	-ve, P
		Water	Pollution of water bodies due to surface run off.	Medium	-ve, T
		Air	Air pollution due to fugitive dust.	Medium	-ve, T
		Noise	No impact	-	-
		Biological	Loss of trees	Medium	-ve, P
		Socio-economic	Risk for local inhabitants due to trespassing	Medium	-ve, T
		Solid Waste Management	No impact	-	-
C.1.5.	Preparation of debris / muck disposal site	Land	Loss of productive land, erosion of disposed soil	Major	-ve, P
		Water	Surface water pollution due to run off from the site	Minor	-ve, T
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Loss of trees	Minor	-ve, P
		Socio-economic	Risk for local inhabitants due to trespassing	Minor	-ve, T
		Solid waste management	No impact	-	-
C.1.6.	Clearing, Grubbing and Stripping	Land	Destabilization of slopes, soil erosion.	Medium	-ve, T /P ?
		Water	No impact	-	-
		Air	Change in micro climate	Minor	-ve, T
		Noise	Increase in noise levels	Minor	-ve, T
		Biological	Loss of vegetative cover and impact on fauna	Major	-ve, P
		Socio-economic	Loss of tree shade. Safety of pedestrians and passers by.	Minor	-ve, T
		Solid waste management	Unscientific / unsafe disposal of tree waste	Minor	-ve, T
C.1.7.	Cutting of Earth	Land	Loss of topsoil, water logging due to alterations in natural drainage patterns.	Major	-ve, P
		Water	Blocking of cross drainage and water logging, contaminating water bodies	Major	-ve, P

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
		Air	Increased air pollution due to fugitive dust/ emissions.	Medium	-ve, T
		Noise	Increase in noise levels	Medium	-ve, T
		Biological	No impact	-	-
		Socio-economic	No impact	-	-
		Solid waste management	Unscientific/ unsafe disposal of over burden	Medium	-ve, P
C.1.8.	Filling	Land	Loss of topsoil, alteration of natural drainage patterns.	Major	-ve, P
		Water	Diversion of natural surface water flows, alterations/blocking of cross drainage and water logging.	Medium	-ve, P
		Air	Increased air pollution due to fugitive dust / emissions.	Medium	-ve, T
		Noise	Increase in noise levels	Medium	-ve, T
		Biological	No impact	-	-
		Socio-economic	Flooding of adjacent low lying land	Medium	-ve, P
		Solid waste management	No impact	-	-
C.1.9.	Stripping	Land	Loss of topsoil, removal of vegetation.	Major	-ve, P
		Water	Pollution of water bodies due to irresponsible handling of stripped earth.	Medium	-ve, P
		Air	Increased air pollution	Major	-ve, T
		Noise	Increase in noise levels	Medium	-ve, T
		Biological	No impact	-	-
		Socio-economic	No impact	-	-
		Solid waste management	No impact	Medium	-ve, T
C.1.10.	Demolition	Land	No impact	-	-
		Water	No impact	-	-
		Air	Increased air pollution due to fugitive dust	Medium	-ve, T

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
		Noise	Increase in noise levels due to demolition activity	Medium	-ve, T
		Biological	No impact	-	-
		Socio-economic	No impact	-	-
		Solid waste management	Unscientific / unsafe disposal of debris	Medium	-ve, P
D.2.	**Construction Activities**				
D.2.1.	Tunnel construction activities including boring and blasting of rocks	Land	Increased risks of landslides and other Geological/ seismic hazards	Major	-ve, P
			Contamination of soil due to spillage of oil, lubricants and hazardous chemicals	Medium	-ve, T
		Water	Contamination water due to spillage and careless handling of oil and lubricants	Medium	-ve, T
		Air	Increase in air pollution due to operation of machineries.	Medium	-ve, T
		Noise	Increase in noise level due to operation of machineries.	-	-
		Biological	Loss of vegetation	-	-
		Socio-economic	Occupational health and safety impacts for workers	Major	-ve, P
				Major	-ve, P
		Solid waste management	Unscientific / unsafe disposal of debris / waste	Major	-ve, P
D.2.2.	Use and servicing of fossil fuel powered plant; Oil storage; Concrete production and use	Land	Soil Pollution	Major	-ve, P
		Water	Oil Spill	Medium	-ve, T
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Riverine microhabitat alterations; Loss of otter dens; and Loss of breeding and nursery grounds for fishes and invertebrates	Medium	-ve, T
		Socio-economic	No impact	Major	-ve, P
				Major	-ve, P
		Solid waste management	Unscientific / unsafe disposal of debris / waste	Major	-ve, P
D.2.3.	Operation of	Land	Complete elimination of productive capacity of soil, spillage of fuel, lubricants	Medium	-ve, T

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
	construction camp		and hazardous chemicals.		
		Water	Surface water pollution due to run off and waste water / sewage disposal from the camps.	Medium	-ve, T
		Air	Increase in air pollution due to operation of machineries.	Medium	-ve, T
		Noise	Increase in noise level due to operation of machineries.	-	-
		Biological	Loss of vegetation	-	-
		Socio-economic	Occupational health and safety impacts for workers	Major	-ve, P
				Major	-ve, P
		Solid waste management	Unscientific / unsafe disposal of debris / waste	Major	-ve, P
D.2.4.	Functioning of labour camp	Land	Contamination of soil due to waste water	Medium	-ve, T
		Water	Surface water pollution due to run off from the site	Medium	-ve, T
		Air	Air pollution due to burning of dry waste/ fire wood.	Minor	-ve, T
		Noise	No impact.	-	-
		Biological	Loss of trees, Impact on forests, spread of forest fire	Minor	-ve, T
		Socio-economic	Increase in communicable diseases Increase in crime rate Indulgence in hunting and collection of forest produces.	Medium	-ve, T
			Collection of firewood if camp is near the forest Chances of forest fires	Medium	-ve, T
			Occurrence of accidents	Medium	-ve, T
		Solid waste management	Unhygienic environment due to unsafe disposal of solid waste generated.	Minor	-ve, T
D.2.5.	Quarrying and operation of crushers	Land	Loss of soil productivity, soil contamination	Major	-ve, P
		Water	Surface water pollution due to run off from the site	Medium	-ve, P
		Air	Air pollution due to fugitive dust.	Medium	-ve, T
		Noise	Noise pollution due to stone blasting	Medium	-ve, T
		Biological	No impact	-	-
		Socio-	Safety of labourers	Medium	-ve, P

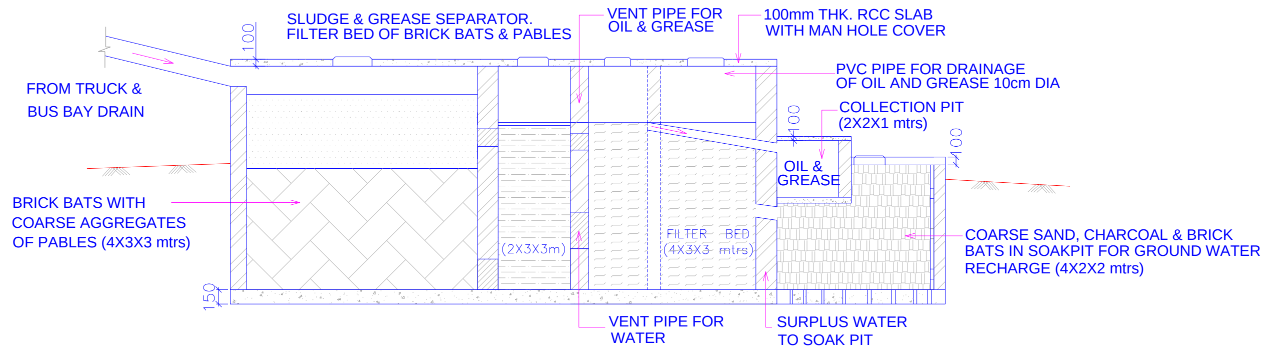
Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
		economic			
		Solid waste management	No impact	-	-
D.2.6.	Borrowing of earth	Land	Loss of fertile lands, loss of topsoil, soil contamination, removal of vegetation, soil erosion, destabilization of slopes due to modification of natural conditions.	Major	-ve, P
		Water	Alterations in local drainage pattern, diversion of natural surface water flows, blocking of cross drainage and water logging.	Medium	-ve, P
		Air	Increased air pollution due to fugitive dust	Medium	-ve, T
		Noise	Increase in noise levels	Medium	-ve, T
		Biological	No impact	-	-
		Socio-economic	Occupational health and safety impacts	Medium	-ve, P
				Major	-ve, P
		Solid waste management	No impact	-	-
D.2.7.	Extraction of Surface water	Land	No impact	-	-
		Water	Over exploitation of surface water	Major	-ve, P
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	Impact on fauna in lakes and rivers	Major	-ve, P
		Socio-economic	Reduction in water available for agriculture and domestic purposes	Major	-ve, P
		Solid waste	No impact	-	-
D.2.8.	Transportation of materials	Land	Spillage of fuel, lubricants and hazardous chemicals.	Major	-ve, P
			Damage of haul road due to over usage.	Major	-ve, P
		Water	Contamination of water due to washing of vehicles, construction equipments and machineries	Major	-ve, P
		Air	Increased air pollution due to fugitive dust	Major	-ve, T
		Noise	Increase in noise levels	Medium	-ve, T
		Biological	No impact	-	-

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
		Socio-economic	Inconvenience to local travelers. Increase in accidents	Medium	-ve, T
		Solid waste management	No impact	-	-
D.2.12.	Construction of bridges, culverts	Land	Spillage of fuel, lubricants and hazardous chemicals	Major	-ve, P
		Water	Water pollution due to infusion of slurry into the water body during foundation construction. Impact on water quality due to remnants of construction materials.	Major	-ve, P
		Air	Increased air pollution	Medium	-ve, T
		Noise	Increase in noise levels	Medium	-ve, T
		Biological	Impact on aquatic biota due to disposal of construction material	Major	-ve, P
		Socio-economic	Disruption of Traffic	Medium	-ve, T
			Occurrence of accidents	Major	-ve, P
		Solid waste management	Unscientific / unsafe disposal of debris	Medium	-ve, P
D.2.13.	Debris / muck disposal	Land	No impact	-	-
		Water	No impact		
		Air	No impact	-	-
		Noise	No impact	-	-
		Biological	No impact	-	-
		Socio-economic	No impact	-	-
		Solid waste management	No impact	-	-
D.2.14.	Roadside plantation and landscaping	Land	Beautification, vegetation cover, protects soil erosion	Medium	+ve
		Water	Facilitates ground water recharge	-	-
		Air	Improvement in air quality	-	-
		Noise	Reduces noise pollution to adjacent areas.	-	-
		Biological	Increase in vegetation cover	-	-

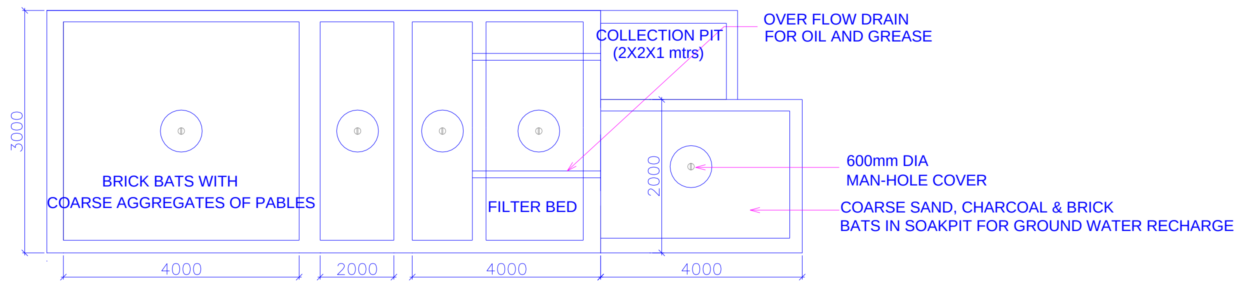
Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
		Socio-economic	Improved aesthetics	-	-
		Solid waste management	Unscientific / unsafe disposal of debris	Medium	-ve
E.	**Post Construction Phase**				
E.1.	Redevelopment of construction camp sites	Land	Rejuvenation of land	Major	+ve
		Water	Increased water recharge	Major	+ve
		Air	Improvement in air quality	Medium	+ve
		Noise	No impact	-	-
		Biological	Increased vegetation	Medium	+ve
		Socio-economic	No impact	-	-
		Solid waste management	No impact	-	-
E.2.	Redevelopment of quarry sites	Land	Rejuvenation of land	Major	+ve
		Water	Increased water recharge	Major	+ve
		Air	Improvement in air quality	-	-
		Noise	No impact		
		Biological	Increased vegetation	Medium	+ve
		Socio-economic	Involvement of local community and enhancement of their livelihood	Medium	+ve
		Solid waste management	No impact	-	-
E.3.	Redevelopment of borrow sites	Land	Rejuvenation of land	Major	+ve
		Water	Increased water recharge	Major	+ve
		Air	Improvement in air quality	Medium	+ve
		Noise	No impact	-	-
		Biological	Increased vegetation	Medium	+ve
		Socio-	Involvement of local community and enhancement of their livelihood	Medium	+ve

Sl. No.	Activity	Environmental Attribute	Potential Impact	Degree of impact (Major/Medium/Minor)	Nature of impact (+ve/-ve, T/P)
		economic			
		Solid waste management	No impact	-	-
E.4.	Redevelopment of labour camp sites	Land	Rejuvenation of land	Major	+ve
		Water	Increased water recharge	Major	+ve
		Air	Improvement in air quality	Medium	+ve
		Noise	No impact	-	-
		Biological	Increased vegetation	Medium	+ve, P
		Socio-economic	No impact	-	-
		Solid waste management	No impact	-	-
E.5.	Operationalisation of the project stretch	Land	Improvement of road geometry and pavement condition	Major	+ve, P
		Water	Water logging during monsoon will not take place.	Major	+ve, P
		Air	Reduced dust generation from road. Increased vehicular emissions due to increased traffic	Medium	-ve and +ve, P
		Noise	Increase in the ambient noise levels, especially during night time along the project road.	Medium	-ve, T
		Biological	Improved biodiversity and aesthetics	Medium	+ve, P
		Socio-economic	Less chances of accidents.	Major	+ve, T
			Safety	Major	+ve, P
		Solid waste management	No impact	-	-

Annexure 19: Schematic Diagram of Oil Interceptor and Soak Pit



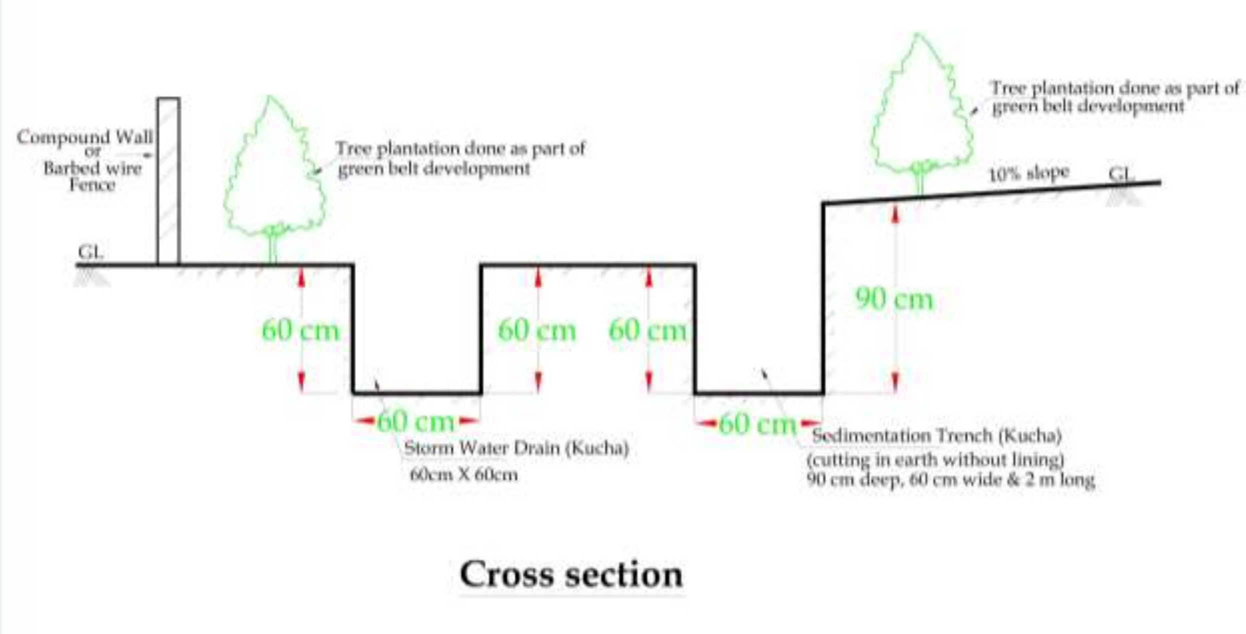
SECTION OF OIL INTERCEPTOR

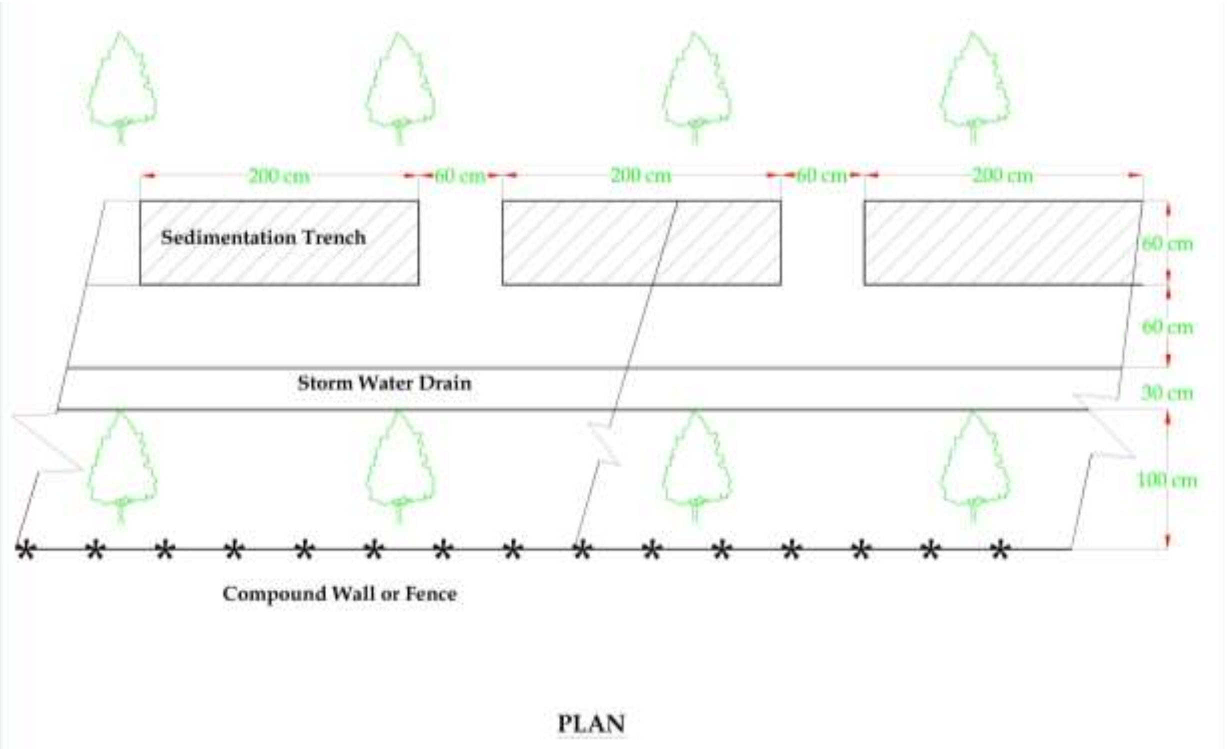


PLAN OF OIL INTERCEPTOR

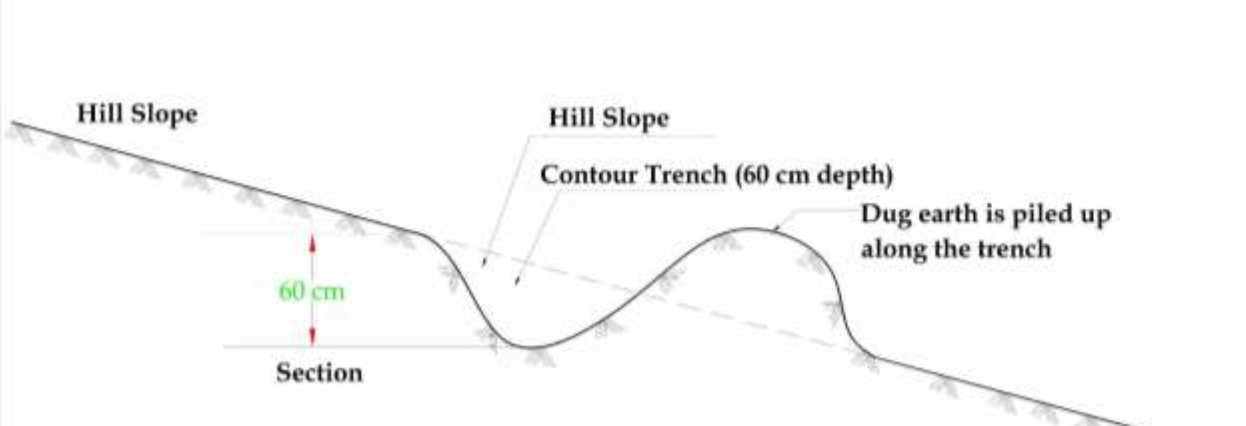
(Readymade Oil Interceptor may also be used)

Annexure 20: Typical design of Sedimentation Trenches, Strom Water Drain and Green Belt





Sedimentation Trenches and Storm Water Drain



Contour Trench

Annexure 21: Guidelines for Siting, Management and Redevelopment of Labor Camps

Introduction

Staff Quarters include accommodation or quarters for Engineers/Supervisors and labour camp include accommodation for workers/labour; basic amenities such as mess, kitchen, potable water supply, first aid room, garbage collection and disposal facility, sanitation (toilets, bathrooms, washing areas and water supply for such needs) and circulation areas should be include in both labour quarters and staff quarters. Staff quarters include the facilities of drawing/ reading room.

Involvement of Local Communities

The Contractor preferably will use unskilled labor drawn from local areas to provide maximum benefit to the local community.

Selection of Labour Camp

The Labour camp sites shall be identified based on the following guidelines. The site shall be located

- To the extent possible, agricultural lands and fertile lands shall be avoided
- A minimum of 200m of any major surface water course or body
- Not within 500m of either side of locations (Wild life Sanctuary/ Mangroves/ Ecologically sensitive areas like forest)
- At a minimum distance of 1km away from any major settlement or village.
- At a minimum distance of 300m of any major surface water course or body

If this is not possible the base camps should be located away from the settlements with the following precautions

- Base camp should be enclosed with boundary wall.
- Movement of the workers should be registered during the nighttime.
- There should not be any disturbance to the local community.

Layout

The lay-out of a labour camp site has to be carefully planned and prepared keeping in view the various activities proposed for a particular site. The lay-out plan will contain details pertaining to, but not limited to, the cardinal points, wind direction, dimensions, surrounding features and proposed activities. This shall be submitted with complete details provided in the prescribed reporting format to the SC for written approval before any physical work (includes storage of materials, equipment etc.) is undertaken on a particular site.

Finalization of Selected Site/s

The location, layout and basic provision of facilities at each labour camp site will be submitted to SC. The Construction or hiring of such facilities shall commence only after the written approval from the SC. who can approve the selected site after considering the compliance with the EMP clauses including the activities proposed for such a site. No agreements or payments shall be made to the land owner/s prior to receipt of a written approval from the SC and PIU. Any consequence of rejection prior to the approval shall be the responsibility of the Contractor and shall be made good at his own cost.

Facilities at Labour Camp

The Contractor will provide, erect and maintain necessary (temporary) facilities (as follows) for the staff/workers/labour to the standards and scales mentioned in the EMP and relevant legislation.

Accommodation

Contractor will follow all relevant provisions of the Factories Act, 1948 and the Building and the other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labour camp. The Contractor will maintain necessary living accommodation and ancillary facilities (including provision of clean fuel to prevent damage to forests and to prevent fuel wood cutting and burning by labour) in functional and hygienic manner. Any non-compliance or damage shall be made good by the contractor at his own cost.

Potable Water

The contractor will also provide availability of potable water within the precincts of every workplace in a cool and shaded area, which is easily accessible as per standards set by the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996.The contractor will ensure the fulfillment of the following conditions at all work places for the benefit of workers:

- .Supply of sufficient quantity of potable water (as per IS) in labor camp site at suitable and easily accessible places shall be made. Such facilities shall be regularly maintained from health and hygiene point of view.
- All potable water storage facilities will be on a safely raised platform that is at least 1m above the surrounding ground level.
- In the camp sites, water purifier units shall be installed for providing potable water.
- As far as possible shallow well will not be used as potable source of water. However, if water is drawn from any existing well, irrespective of its location from any polluting sources, regular disinfection of the water source (which may include application of lime, bleaching power and potassium permanganate solution) has to be ensured at weekly/fort nightly interval.
- All open wells will be entirely covered and will be provided with a trap door to prevent accidental fall and contamination from dust, litter etc. A reliable pump will be fitted to each covered well.
- A drain shall be constructed around the well to prevent flow of contaminated water into the well from road, camp or other sources.
- The trap door will be kept locked and opened only for cleaning or inspection, which will be done at least once in a month.

- Water quality testing of all potable water sources will be done every month as per parameters prescribed in IS 10500:1991.

Monitoring

Environmental Officer of SC will be required to inspect the labour camp once in a week to ensure compliance to these health and hygienic standards prescribed in the EMP. The camp-in-charge will be responsible for day today monitoring.

Sanitation and Sewage System

The contractor will ensure that –

- The sewage system for the camp are designed, built and operated in such a fashion that no health hazards occurs and no pollution to the air, ground water or adjacent water courses takes place.
- Separate toilets and bathrooms for women workers wherever required, screened from those of men, are provided with markings in vernacular language.
- All such facilities must have adequate water supply with proper drainage and disposal facility.
- All toilets in camp are with dry earth systems which are to be maintained, cleaned and disinfected daily using proper disinfectants. The location of such provisions should not affect the air, surface water and ground water of the locality or the agricultural fields’ located near-by.
- Portable toilets may be brought to use and the night soil from such units has to be disposed through designated septic tanks so as to prevent pollution of the surrounding areas.
- In the main camp, no night soil or sewerage shall be disposed of at any place other than the septic tanks constructed at the site.
- All these facilities shall be inspected on a weekly basis to check the hygiene standards.

Waste Disposal

The Contractor will provide garbage bins in the camps and ensure that these are regularly emptied and disposed off in a hygienic manner as per the Comprehensive Solid Waste Management Plan approved by the Environmental Officer of SC.

No incineration or burning of wastes shall be carried out by the Contractor. The disposal of kitchen waste and other biodegradable matter shall be carried out in pits covered with a layer of earth within the camp site. The contractor may use the compost from such wastes as manure in the plantation sites.

Discarded plastic bags, paper and paper products, bottles, packaging material, gunny bags, hessian, metal containers, strips and scraps of metal, PVC pipe scrubber and poly urethane foam, auto mobile spares, tubes, tires, belts, filters, waste oil, drums and other such materials shall be either reused or will be sold /given out for recycling

Day Crèche Facility

At every labour site, provision of a day crèche shall be made so as to enable women to leave behind their children while going to work. At least one attendant shall be provided to take care of the children at the crèche. At Labour camp where 20 or more women are employed, there shall be at least one shelter for use of children under the age of 6 years belonging to such women. Shelters shall not be constructed to a standard lower than that of thatched roof, mud walls and floor with wooden planks spread over mud floor and covered with matting. Such areas shall be safely barricaded (not sharp sheets or barbed wires that may injure a child) from rest of the camp for the safety of children. Shelters shall be provided with suitable and sufficient openings for light and ventilation. There shall be adequate provision to keep the place clean. The size of a crèche may vary according to the number of children on a camp site.

Health care Facilities

Health problems of the workers should be taken care of by providing basic health care facilities through a health centre set up at the labour camps. The health centre will have at least a doctor (part time), nurses, duty staff, medicines and minimum medical facilities to tackle first-aid requirements for minor accidental cases. Some arrangements will be made with the nearest hospital to refer patients of major illnesses or critical cases.

The health centre will carryout quarterly awareness programme of HIV – AIDS with the help of AIDS control society. Posters will be exhibited in the health care clinic.

Monitoring and Reporting

The SC and PIU shall closely monitor and record compliance with regard to setting up and operation of labour camp in the agreed formats and shall immediately take action in case non-compliance is observed. The SC needs to be specifically vigilant during the initial stages so as to avoid issues pertaining to improper site selection and poor lay-out planning.

Re development Plan

How to finalize the restoration plan:-

Contractor will prepare site restoration plan, which will be submitted for approval to the Resident Engineer of SC. The Resident Engineer and the Environmental Officer of SC will be jointly responsible for approving and monitoring these plans. The contractor needs to submit his plan at least 60 days prior to ‘substantial handing over of the site. All cleanup and restoration operations shall be completed by the contractor prior to demobilization.

The contractor will clear all temporary structures; dispose all garbage, night soils and POL waste as per the approved Comprehensive Waste Management Plan. All disposal pits or trenches will be filled in disinfected and effectively sealed off. Residual topsoil, if any will be distributed or spread evenly at plantation sites, on adjoining/near-by barren land or affected agricultural land adjacent to the RoW that has been impacted on account of accidental spillage. Once the Contractor finishes his job, this can be handed over to the concerned local bodies or for local communities.

The possible alternate uses of the Labour camp would be

- Local communities of this area can use the same source to meet their water needs.

- If road passes through a plain water scarcity prone area and if no nearby water source has been identified, transportation is uneconomic, then contractor should go for Underground water option. If it is feasible and will not lead to a serious depletion of the ground water.

The Resident Engineer shall ensure that all clean-up and restoration operations are completed satisfactorily and written approval is given to the contractor before the 'works completion' is issued/recommended. The PIU shall ensure through site inspection that the Contractor and SC have complied with all these provisions.

Annexure 22: Guidelines for Siting, Management and Redevelopment of Construction Camps

A. Overview

Construction camp should be facilitated with office space; laboratory; vehicle repair and maintenance workshop/s; fuel pumps and associated areas; parking spaces; potable water supply, first aid room, garbage collection and disposal facility, sanitation (toilets and water supply for such needs), material stack yards or storage areas, circulation areas, hot-mix plants, batching plants, crushers and any other space/area associated with similar activities.

B. Provisions for Locating the Site/s

The contractor shall identify the location of the construction camp/s, on the basis of EMP clauses. As mentioned in these clauses, the Contractor shall stick on to the extent possible, barren land or waste lands instead of agricultural lands and fertile land shall be preferred during site selection. All such sites must be above the HFL with adequate drainage facility. In areas prone to floods, cyclones, cloud bursts or heavy rainfall, selection of the site shall be made keeping in mind the safety of the camp and its habitants.

Also the Contractor should take care the following criteria for locating the site

- A minimum of 500 m away from any major settlement or village
- A minimum of 200 m of any major surface water course or body
- Not within 500 m of either side of locations (Wild life Sanctuary/ Mangroves/ Ecologically sensitive areas)
- Topsoil conservation at camp site
- Number of laborers on site
- Provision of electricity
- Drinking water facility
- Fuel for cooking
- Existing land use
- Land use in vicinity

C. Finalization of Selected Site/s

The selected site/s shall be approved by Environmental Officer of SC and PIU after considering the compliance with the EMP clauses including the activities proposed for such a site. No agreements or payments shall be made to the land owner/s prior to receipt of a written approval from the SC and PIU. Any consequence of rejection prior to the approval shall be the responsibility of the Contractor and shall be made good at his own cost.

D. Designing of Construction Camp

The lay-out of a construction camp site has to be carefully planned and prepared keeping in view the various activities proposed for a particular site. The lay-out plan will contain details pertaining to, but not limited to, the cardinal points, wind direction, dimensions, surrounding features and proposed activities. This shall be submitted with complete details provided to the SC for written approval before any physical work (includes storage of materials, equipment etc.) is undertaken on a particular site. The SC will carefully examine the proposals in light of the various EMP and regulatory provisions and provide suggestions, as necessary. Both the Resident Engineer and the Environmental Officer shall be responsible for satisfactory and timely completion of this EMP requirement.

E. Principles Governing a Lay out plan

Some of the Principles governing the lay out plan are listed below

- The prevailing wind direction shall be kept in mind while planning out the lay-out of internal facilities.
- No trees shall be cut and the existing ones need to be integrated into the lay-out plan with proper planning.
- The stripping, stacking and preservation of top soil will be mandatory in case of farm lands and fertile areas and absolutely no material stacking or equipment installment or vehicle parking or any other activity shall be allowed prior to the satisfactory completion of this activity.
- The proposed top soil stacking areas along with the quantity shall be clearly depicted on the lay-out plan.
- Proper circulation paths and parking spaces need to be provided.
- Fuel pumps, storage facility for inflammable and hazardous chemicals/ materials shall be provided at safe distance from office inside the camp.
- Electric safety practices shall be integrated / incorporated during the lay-out plan preparation.
- All sites must be graded and rendered free from depressions such that water does not get stagnant.
- Appropriate drainage shall be provided for fencing of the camp site is necessary.
- New plantation needs to be taken-up along the boundaries using guidance from the Forestry and Wildlife Expert.

F. Basic Amenities/Facilities Required

The Contractor will provide, erect and maintain necessary (temporary) facilities for the staff/workers/labour to the standards and scales mentioned in the EMP and relevant legislation.

(i) Drinking Water

Safe drinking water is to be provided to the dwellers of the construction camps – periodic tests shall be conducted by the Contractor and independently by the PIU to ascertain this.

(ii) Sanitation Facilities

Sanitation arrangements in the construction camp/s shall be provided as per the clauses mentioned in EMP. The toilets shall be provided and kept in clean and drained condition. Drains and ditches should be treated with bleaching powder on a regular basis. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Compliance with the relevant legislation must be strictly adhered to. The SC shall take immediate action in case of any non-compliance and the Contractor shall rectify the situation as per EMP and regulatory requirements at his own cost.

(iii) Day Crèche Facility

At every construction site, provision of a day crèche shall be made so as to enable women to leave behind their children while going to work. At least one attendant shall be provided to take care of the children at the crèche. At construction sites where 20 or more women are employed, there shall be at least one shelter for use of children under the age of 6 years belonging to such women.

Shelters shall not be constructed to a standard lower than that of thatched roof, mud walls and floor with wooden planks spread over mud floor and covered with matting. Such areas shall be safely barricaded (not sharp sheets or barbed wires that may injure a child) from rest of the camp for the safety of children. Shelters shall be provided with suitable and sufficient openings for light and ventilation. There shall be adequate provision to keep the place clean. The size of a crèche may vary according to the number of children on a camp site.

(iv) Monitoring and Reporting

The SC and PIU shall closely monitor and record compliance with regard to setting up and operation of construction camp/s in the agreed formats and shall immediately take action in case non-compliance is observed. The SC needs to be specifically vigilant during the initial stages so as to avoid issues pertaining to improper site selection and poor lay-out planning.

G. Re development Plan

How to finalize the restoration plan:-

Contractor will prepare site restoration plan, which will be submitted for approval to the Resident Engineer of SC. The Resident Engineer and the Environmental Officer of SC will be jointly responsible for approving and monitoring these plans. The contractor needs to submit his plan at least 60 days prior to ‘substantial handing over of the site. All cleanup and restoration operations shall be completed by the contractor prior to demobilization.

The contractor will clear all temporary structures; dispose all garbage, night soils and POL waste as per the approved Comprehensive Waste Management Plan. All disposal pits or trenches will be filled in disinfected and effectively sealed off. Residual topsoil, if any will be distributed or spread evenly at plantation sites, on adjoining/near-by barren land or affected agricultural land adjacent to the RoW that has been impacted on account of accidental spillage. Once the Contractor finishes his job, this can be handed over to the concerned local bodies or for local communities.

The possible alternate uses of the Construction camp would be

- Local communities of this area can use the same source to meet their water needs.
- If road passes through a plain water scarcity prone area and if no nearby water source has been identified, transportation is uneconomic, then contractor should go for Underground water option. If it is feasible and will not lead to a serious depletion of the ground water.

To do list in the restoration plan

- The Contractor shall restore all haul roads constructed for transporting the material from the quarries or any other sources to the construction sites to the original state.
- All construction zones including river-beds, drainage channels, culverts, road-side areas, camps, hot mix plant sites, crushers, batching plant sites and any other area used/affected by the project will be left clean and tidy, at the Contractor's expense, to the entire satisfaction of Environmental Officer of SC and PIU.
- The CSC shall be entrusted the responsibility of reviewing the quarry site for the progress of implementation of Redevelopment plan. These shall include the following two cases;

Redevelopment of quarries opened by the contractor for the project.

Redevelopment of existing quarries operated by other agencies.

(In the first case, the Contractor shall be responsible for the Redevelopment plan prior to completion after five years, during the defect liability period. The CSC shall be responsible for reviewing this case of redevelopment prior to the issuing the defect liability certificate. In the second case, the redevelopment of exhaust quarry shall be the responsibility of the agency providing the permit to ensure the implementation of Redevelopment Plan.)

The Resident Engineer shall ensure that all clean-up and restoration operations are completed satisfactorily and written approval is given to the contractor before the ‘works completion’ is issued/recommended. The PIU shall ensure through site inspection that the Contractor and SC have complied with all these provisions.

Annexure 23: Guidelines for Siting, Management and Redevelopment of Quarrying and Stone Crushing Operations

A) General

A quarry is a type of open-pit mine from which rock or minerals are extracted. Quarries are generally used for extracting building materials, such as dimension stone, construction aggregate, riprap, sand, and gravel. They are often collocated with concrete and asphalt plants due to the requirement for large amounts of aggregate in those materials.

B) Quarry Selection

The selection of quarry is soul responsibility of the contractor. The selection should adhere to the rules & regulations of the authorities.

In the case of existing quarries and additional quarries, the contractor has to ensure that all actions in these quarries are in accordance with the environmentally sound and acceptable manner.

If any adverse effect on environment, habitat and concern of safety noticed, appropriate measures should be taken as suggested by Supervision Consultant or should arrange an alternative for road construction materials.

The licensee of the quarry shall submit detailed documents regarding the following before the work commencing on the area to the Engineer (Supervision Consultant):

- existing land use of the area
- approximate quantity of the material
- type of material available
- total area involved
- details of ownership – leased or purchased
- statement of the owner that the actual agreement (not in terms of monitory compensation) is agreeable for him
- details of environmental damages
- top soil conservation
- action plan for leveling and landscaping in order to bring the area in conformity to the neighbouring land uses and the access road rehabilitation

C) Criteria for Site selection

- The quarry should not damage any building, work, property or rights of other persons and no land shall be used for surface operations which are already occupied by persons other than the Government.
- The quarry does not alter any right of way, well or tank. Water course, if any, from a higher slope, should be properly diverted out of quarry and shall be safely channeled out of any nearby human settlement.

- There shall be no quarrying of sand in any river bed or adjoining area or any other area which is located within 500 meters radial distances from the location of any bridge, water supply system, infiltration well or pumping installation of any of the local bodies or Central or State Government Department or any area identified for locating water supply schemes by any of the Government Department or other bodies.
- Mining operations shall not be allowed within a 50 m distance from the railway line, boundaries of reservoir, canal, high tension electric line or other public utilities unless the permission from the concerned authority.
- In the case of village roads no quarrying should be done within 10 m of the road and without the permission of district or state govt. authority.
- Quarrying should be distanced from inhabited area for a distance of 500 m.
- No blasting shall be allowed within a 500 m distance from railway line, public road and human settlements.
- Stone crushing unit should be distanced for a 500 m from the NH or SH or residential area or places of public and religious interests.
- The stone crusher unit must keep at least 1 km distance from the adjacent unit in order to avoid dust pollution.

D) Quarry Operation

Quarrying involves not only extraction of material (rock) but also crushing and screening that makes the rock suitable for use as construction material. The Contractor after getting the approval from competitive authority, should submit the detailed plan for quarrying including safety aspects, mode of operation, excavation of materials, storage of materials and transportation, haul road management, pollution control measures and site management plan. Apart from the EMP, the following measures also are adopted:

- No quarrying operation shall be done without the approval from the concerned authority.
- The equipment used in quarry should be wear faced, which extends the equipment life and reduce the demand for spare parts;
- sprinklers to spray water for dousing the dust generation, noise suppressers and rubberized mounting to reduce noise and vibration, mist spray units at crusher points for settling the generation of dust at the time of crushing, grading, loading, tarpaulins or covers over transport vehicles carrying, cement, sand, coarse and fine aggregate, in order to reduce the impact on environment
- The layout of a quarry should provide a gravity flow of material from the face to the crusher, from the crusher to the storage bin and from the bin to the hauling equipment.
- Use enclosures around crushing and screening plants. Use solid barriers, such as bund walls and topographical features, rather than vegetation. Noise barriers or bunds to be

constructed based on the nature of noise generation along residential areas falling less than 2 km. from the quarry and crusher site.

- Provide ear muffs / plugs / personnel protection equipment to workers working near machines, blasting & boring sites and crusher operations.
- Time restrictions should follow in order to avoid the conflict between the surrounding communities or population.
- Speed of the vehicles around the quarry should be restricted to a low speed in order to reduce the noise pollution and dust generation.
- In case of blasting, the storage and the operation should be as per the regulations.
- Drilling machine shall be fitted with dust suppression, collection and disposal arrangements.
- During quarrying operations, water should be sprayed at least once in a day over the roads at the quarry site and near by areas to minimize the dust pollution Deep wetting of drilling zones also be done by water sprinkling.
- Measures have to be taken to reduce the dust generation during drilling operation.
- The top soil should be preserved for re using in plantation sites.
- Without the prior approval from the competent authority no tree shall be removed.
- If the said land or part of it is in forest area, then the licensee should take care of the conservation methods to preserve the top soil and need to assist the authority for afforestation programme along the site.
- Drainage shall be provided in order to prevent water logging and flooding in and around the area.
- The Contractor shall construct sediment barriers/silt traps at applicable locations to prevent the loss of excavated material and subsequent siltation due to the runoff.
- Slope stabilization methods should be implemented.
- The overburden should be reused or disposed properly.
- Quarry areas should be protected from illegal dumping of waste by third parties. No quarry waste shall be dumped within a 100 m either side of the road.
- The concerned authority – PIU / SC should regularly review the environmental, health and safety aspects.

E) Quarry Management Plan

The Quarry area contains a significant hard rock resource and it is important that it should be able to be extracted without adverse effects to or from other land uses, especially residential land use. Some of the techniques can be adopted for managing the quarry area is as follows:

- The boundary of the quarry should be demarcated using fence in order to avoid the future dispute over land.
- All the drainage constructed should be linked to existing drainages in order to stop the soil erosion from hill slopes.
- Process water discharged from the site will be recycled through a series of settlement ponds for re-use.
- Overland flows from outside the quarry will be diverted away from the quarry workings via clear water cut-off drains.
- Erosion and sediment control measures including the location and design of sediment ponds, silt, grit traps, and clean and dirty water diversions for treating runoff from the quarry should be taken to consideration.
- Adequate measures, such as provision of septic tanks /sanitary pit latrines shall be taken at quarry sites for workers.
- The overburden should kept as minimum to maximize the commercial efficiency of the quarry, it can be utilized for creating earth bunds to mitigate the noise and visual impacts and also for the site rehabilitation process.
- Delay the time of explosion to avoid damages to structure and livelihood. Conduct education programs with the locals regarding the potential impacts of blasting, blasting warning systems, schedules etc.
- All drivers should be trained in driver safety and restrict traffic movements on the access road around times that children walk to and from school.
- Fuel storage and refilling areas shall be located at least 50m away from all cross drainage structures and important water bodies or as directed by the Supervising Consultant’s Engineer.
- Ensure that all equipment maintenance activities, including oil changes, are conducted within demarcated maintenance areas; never dispose spent oils on the ground, in water courses, drainage canals or in sewer systems.
- Machinery should be cleaned prior to working on site to reduce the opportunity of the spread of weed seeds.
- Plant local plant species and productive vegetation as part of the restoration plan.

F) Redevelopment of Quarry area

The main objective of the redevelopment of quarries is to make the area a safe and secure place. If possible it can be converted to a leisure place if it is possible to redevelop in such a way.

The contractor should prepare redevelopment plan for the quarry site through the Environmental officer of the supervision Consultant by considering the environmental, safety and technical standards. The plan should be submitted along with the proposal for quarry site and should be approved by the regulatory authority.

The contractor should restore all haul roads constructed for transporting the material from quarry. The quarry can be filled with construction debris or waste and has to give a vegetative cover. If it is not possible to fill, then excavated slopes should be smoothened and the depression shall be filled in a manner to look not like similar to the original. The immediate surroundings of the quarry should be developed as a low maintenance reserve with significant plantation of native trees and shrubs and with longer grasses and tussocks forming the open spaces. The used quarry can be re vegetated to merge with the surrounding area or it can be utilized for water harvesting methods. Plantation along the boundary, erosion control measures etc should be taken as part of the redevelopment plan.

Annexure 24: Guidelines for Siting, Management and Redevelopment of Borrow Areas

A. Borrow Area Selection

Borrow areas for the project will be selected by the Contractor. All provisions stipulated in the EMP and other contract specifications shall be strictly adhered to. The finalization of all such locations depends upon the approval given by the Supervision Consultant on technical and environmental grounds (including haul road network). This includes on-site verification by the SC to cross-check the correctness of details provided by the Contractor in the prescribed format. Only after receipt of the written approval from the SC, the Contractor shall enter into a formal agreement with land owner.

If any environmental, safety or community concerns come into light during the site verification process, either appropriate mitigation measure/s shall be provided, as suggested by the Environmental Officer of SC or alternative arrangements for locating other sources of supply of material for road construction will be made by the Contractor. Compliance with environmental requirements/legal provisions with respect to excavation and rehabilitation of borrow areas, as stipulated by the Ministry of Environment and Forests, Government of India, Indian Roads Congress guidelines and local authorities shall be adhered to the Contractor, for which he shall bear the sole responsibility.

B. Criteria for Site Selection

The contractor in addition to the established practices, rules and regulation shall also use the following criteria before finalizing the locations of borrow areas

- The borrow area should not be located in agriculture areas especially in paddy fields unless unavoidable i.e. barren land is not available. In case borrowing needs to be done on an agricultural land, top-soil stripping, stacking and preservation is a must. Damage to productive and fertile areas has to be minimum. This includes appropriate planning of haul roads.
- Burrow pits shall not be located within a distance of 100 m from any NH, SH or other roads.
- Site should be located 30m away from the toe of the embankment along road side.
- Site should be located not less than 30m from the toe of the bank along the river side or irrigation tank bund.
- Borrow area should be located at a minimum distance of 30m from the toe of the irrigation tank bund.
- Borrow site shall be located at a minimum distance of 500 m in down-wind direction of villages and settlements.
- No borrow pits shall be located within 250 m from schools, colleges, playgrounds, religious structures and health centers.
- No borrow area shall be opened within 500 m from a reserved or protected forest area, protected sites, wildlife movement zone and cultural heritage site.
- Loss of vegetation is almost nil or minimum.

- Borrow area near any surface water body will be at least 100 m away from the toe of the bank or high flood level, whichever is maximum. After identification of borrow area location/s, the Contractor will fill the prescribed reporting format and submit the same for approval to the "Site Engineer" at least 7 working days before commencement of earth works. A written approval from SC shall be necessary before any activity/work is commenced.
- Borrow pit location shall be located at least 0.8 km from villages and settlements. If unavoidable, they should not be dug for more than 30 cm and should be drained.

C. Finalization of the selected area

The Contractor shall submit the following information to the Engineer for approval at least 7 working days before commencement of compaction

- The value of maximum dry density and optimum moisture content obtained in accordance with IS: 2720 (Part 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.
- A graph of density plotted against content from which, each of the values in (i) above of maximum dry density and optimum moisture content are determined.
- The Dry density-moisture content – CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part-7), heavy corresponding to IS: 2420 (Part-8) and intermediate in between the two) for each of the fill material be intends to use in the sub-grade.

After receiving the approval the contractor will begin operations keeping in mind the following points.

- Haulage of material to the areas of fill shall proceed only when sufficient spreading and compaction plants is operating at the place of deposition.
- No excavated acceptable material other than surplus to requirements of the Contract shall be removed from the site. Contractor should be permitted to remove acceptable material form the site to suit his operational procedure, and then be shall make good any consequent deficit of material arising there from.
- Where the excavation reveals a combination of acceptable and un-acceptable materials, the Contractor shall, unless otherwise agreed by the Engineer, carryout the excavation in such a manner that the acceptable materials are excavated separately for use in the permanent works without contamination by the un-acceptable materials. The acceptable material shall be stockpiled separately.
- The Contractor shall ensure that he does not adversely affect the stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

D. Borrow Area Management

Before the start of operations, the area to be borrowed shall be marked by the contractor with wooden or stone pegs to ensure that the land required for slope stabilization or bund creation is maintained. Supervision Consultant has to ensure that this marking is done on the ground to avoid issues at a later date. Any disregard of this condition shall be made good at the contractor's and/or consultant's own expense.

The following principles shall be adhered to during borrow area operations in specific conditions:

Borrow Areas located in Agricultural Lands

- A 15 cm topsoil layer will be stripped off from the borrow pit and this will be preserved in stockpiles in a designated area with a height not exceeding 2 m and side slopes not steeper than 1:2 (Vertical: Horizontal).
- Borrowing of earth will be allowed up to a depth of 1.5 m from the existing ground level only.
- Ridges of not less than 8m width will be left at intervals not exceeding 300 m.Small drains will be cut through the ridges, if necessary, to facilitate drainage.
- The slope of the edges will be maintained not steeper than 1:4 (vertical: Horizontal).
- Rehabilitation shall be satisfactorily undertaken immediately after the use has ceased and at least three weeks prior to monsoon.
- Preserved top soil has be spread uniformly over the section of the farmland used as a borrow area.

Borrow Areas located in Elevated Lands

- A 15 cm topsoil will be stripped off from the borrow pit and this will be preserved in stockpiles in a designated area for height not exceeding 2m and side slopes not steeper than 1:2 (Vertical: Horizontal).
- Silt fencing at the base of the top soil stockpile shall be provided for preventing wash out or loss of top soil.
- The borrowing shall not be permitted beyond a depth of 1.5 m below the adjacent ground level.
- Preserved top soil has be spread uniformly over the land used as a borrow area.

Borrow Areas near Riverside and Structures

- A 15 cm topsoil will be stripped off from the borrow pit and this will be preserved in stockpiles in a designated area for height not exceeding 2 m and side slopes not steeper than 1:2 (Vertical: Horizontal).
- Silt fencing at the base of the top soil stockpile shall be provided for preventing wash out or loss of top soil.

- Borrow areas should be at least 250 m away from the toe of the embankment, flood control structures, culverts, bridges, unlisted cultural property etc., to prevent any damage to the stability of such structures.
- The borrowing shall not be permitted beyond a depth of 1.5 m below the adjacent ground level.
- Preserved top soil has be spread uniformly over the land used as a borrow area.

Borrow Areas near Settlements and Roads

- A 15 cm topsoil will be stripped off from the borrow pit and this will be preserved in stockpiles in a designated area for height not exceeding 2 m and side slopes not steeper than 1:2 (Vertical: Horizontal).Borrow areas should be at least 250 m away from the settlements including schools, colleges, hospitals, playgrounds and religious structures.
- Borrow area should be at least 100 m away from the toe line of an access road or a highway.
- Preserved top soil has be spread uniformly over the land used as a borrow area, is being rehabilitated as a farmland or a plantation area. Or else it should be used in the plantation zone along the highway.
- Bunds and temporary fencing (using barbed wire) along with plantation should be provided in case the borrow area is developed as a pond to ensure safety of the residents and the cattle. However, the depth shall not exceed 1.5 m.

E. Rehabilitation or Re-development of Borrow Areas

The objective of the borrow area rehabilitation is to return the borrowing sites to a safe and environmentally sound condition. The concept entails enhancing benefits (including those linked to livelihood) for the community and individuals. Top soil preservation (and its re-use) and proper stabilization of slopes are the fundamental requirements of the rehabilitation process. Re-development plan shall be prepared and submitted along with reporting format by the contractor before the borrowing operation is permitted by the Supervision Consultant. The redevelopment is to be prepared in consultation with land owner/s (whether public, private or institutional) and by within the environmental and safety requirements of the EMP. Some key points on borrow area rehabilitation are presented in the table provided below. However, the contractor is free to prepare other rehabilitation scheme/s subject to the approval by the Environmental Officer of the Supervision Consultant

Type/Form of Rehabilitation	Re-use of Top Soil	Actions required for Rehabilitation
Farm land	Yes	• Leveling • Slope Stabilization along the edges if there is a level difference
Ponds including creation of new ones and enhancing capacity of	No	• Slope Stabilization (angle/benching) • Access / Approach Ramp

Type/Form of Rehabilitation	Re-use of Top Soil	Actions required for Rehabilitation
existing ones (for irrigation; pissiculture and general uses by people and/or cattle)		• Bund creation and Temporary Fencing • Plantation in the periphery
Water recharging areas/percolation tanks (depth up to one meter)	No	• Slope Stabilization • Small bund creation
Leveled lands that can be developed later for various uses (such as residential areas, parking lots, community grounds etc.)	Generally No	• Leveling • Top soil re-use depends on the type of developmental work envisaged
Construction waste disposal sites (for non-toxic/non-hazardous wastes) (reinstated with top-soil with plantation over the rehabilitated site)	No	• Depression after filling-in of wastes to be leveled-up • Top soil re-use depends on the type of developmental work envisaged
Plantation Zones	Yes	• Leveling • Selection of Species as per OSRP Project Guidelines
Water holes for animals and birds (outside forest and protected areas)	No	• Gentle Slopes on all sides • Plantation in the periphery • Depth upto 1.5 m.

Top soil that cannot be re-used in rehabilitation of borrow areas shall be used in the plantation belt/zone along the road. Rehabilitation works shall be undertaken immediately upon the exhaustion of the approved quantity and shall not be delayed. The Supervision Consultant shall take appropriate action in case delays are observed.

F. Documentation

The reporting format for seeking approval for the borrow area on environmental and safety aspects shall include a pre-operation photograph. Likewise, at the end of the operation, photographic documentation after rehabilitation works are completed shall be maintained both by the contractor and the Supervision Consultant. Certification/documentation including approval for rehabilitation works and thereafter hand-over to the owner shall be properly maintained by the contractor, Supervision Consultant and PIU.

Annexure 25: Guidelines for Siting and Management of Debris Disposal Site

A comprehensive waste management plan shall be prepared by the contractor prior to initiation of any works. This plan should at least contain the following information:

- Estimated quantity of waste
- Type of wastes
- Disposal Plan shall be in line with the work progress.

Purpose

- To provide standardized procedures for the clearance, removal and disposal of debris caused by major debris generating construction work.
- To establish the most efficient and cost effective methods to resolve debris disposal issues.

Criteria for Site Selection

The locations of waste disposal have to be selected such that:

- Residential areas should be located on the up-wind direction of the site.
- The site is minimum 500 m away from sensitive locations like settlements, ponds/lakes or other water bodies, wetlands, protected areas, forests, wildlife movement areas, seasonal streams, rivers, canals, flood plains, educational institutions, medical centers, religious sites, cultural or heritage sites and play grounds.
- No hazardous and contagious waste material will be disposed at such locations.
- The selected site meets with the local regulatory requirements (including those of SPCB, Municipalities etc.).
- The sites selected by the contractor shall be assessed and approved by the environmental, health and safety grounds by the Environmental Officer of the Supervision Consultant. The Resident Engineer shall be responsible to ensure that approval/s for work programme are not provided without the environment, health and safety plan submission.
- While disposing debris / waste material, the contractor will take into account the wind direction and location of settlements to ensure against any dust problems.
- Proper barricading is made to prevent spread of the waste material through action of wind, water, scavengers or rat pickers.

- Surplus fly ash, bottom ash and lime, if any transported for use on this corridor shall not be left open and dumped at any disposal site. Contractor shall take care of such residual materials for use at any other location/s of new embankment construction wok with proper protection measures

Precautions to be Adopted during Disposal of Debris/Waste Material

The contractor shall take the following precautions during transportation and disposal disposing of debris/waste material:

- The pre-designated disposal locations will be a part of Comprehensive Solid Waste Management Plan to be prepared by Contractor in consultation and with approval of Environmental Officer of SC and approval of local competent authority.
- The contractor will take full care to ensure that public or private properties are not damaged/ affected during the site clearance for disposal of debris and the traffic is not interrupted.
- All arrangements for transportation during dismantling and clearing debris, considered incidental to the work, and it will be planned and implemented by the Contractor as approved and directed by the Environmental Officer of SC and PIU.
- In the event of any accidental spill or spread of wastes onto adjacent parcels of land, the contractor will immediately remove all such waste material/s and restore the affected area to its original state to the satisfaction of the Engineer-in-charge of works.
- Disposal sites will be finalized prior to initiation of any work on a particular section of the road. Contractor will ensure that any spoils/materials unsuitable for embankment fill shall not be disposed off near any water course; water body; agricultural land; natural habitats like grass lands, wet lands, flood plains, forests etc. pasture; eroded slopes; and in ditches, which may pollute the surrounding including water sources.
- Contractor will ensure effective water sprinkling during the handling and transportation of materials when dust is likely to be created.
- Materials having the potential to produce dust will not the loaded not beyond the side and tail board level and will be covered with a tarpaulin in good condition.
- Any diversion required for traffic during disposal of debris shall be provided with traffic control signals and barriers after discussion with the local people and as approved by the Engineer-in-charge of works.

- During the debris disposal, contractor will take care of surrounding features and avoid any damage to trees and properties.
- All disposal sites shall be identified by the Contractor and a rehabilitation plan (including details about pollution prevention and safety measures) for each such site shall be submitted in the approved format. These shall be verified and approved by the Environment Officer of SC in consultation with the Local Competent Authority after joint site visits, prior to disposal of any debris or waste materials. The Contractor shall then enter into an agreement with the concerned land owner/s and a copy of this document shall be submitted to PIU through Environment Officer of SC.

Way of waste disposal at work site.

- The Contractor will provide garbage bins in the camps and ensure that these are regularly emptied and disposed off in a hygienic manner as per the Comprehensive Solid Waste Management Plan approved by the Environmental Officer of SC.
- No incineration or burning of wastes shall be carried out by the Contractor.
- The disposal of kitchen waste and other biodegradable matter shall be carried out in pits covered with a layer of earth within the camp site. The contractor may use the compost from such wastes as manure in the plantation sites.
- Discarded plastic bags, paper and paper products, bottles, packaging material, gunny bags, Hessian, metal containers, strips and scraps of metal, PVC pipes, rubber and poly urethane foam, auto mobile spares, tubes, tires, belts, filters, waste oil, drums and other such materials shall be either reused or will be sold /given out for recycling.

Guidelines to be followed by the contractor for disposing bituminous waste

- At locations identified for disposal of residual bituminous wastes, the disposal will be carried out over a 60 mm thick layer of rammed clay so as to eliminate the possibility of leaching of wastes into the ground water.
- The Contractor will suitably dispose off unutilized non-toxic debris either through filling up of borrows areas located in wasteland or at pre-designated disposal sites, subject to the approval of the Environmental Officer of SC.
- Debris generated from pile driving or other construction activities along the rivers and streams drainage channels shall be carefully disposed in such a manner that it does not flow into the surface water bodies or form puddles in the area.

Guidelines to be followed by the contractor for disposing non bituminous waste

- Non-bituminous wastes other than fly ash may be dumped in borrow pits (preferably located in barren lands) where such borrow pits are not suitable to develop as economic source like pisci-culture or a source of irrigation. Such borrow pits can be filled up with non-bitumen wastes and then covered with a minimum 30 cm layer of the soil, where plantation of trees and shrubs will be taken-up by the Contractor as a part of site rehabilitation.
- The species suitable for such re-habitation work shall be at least one-year-old saplings of Alstonea, Zizyphus, Bel, Papal, Banyan Babool, Chirounji, Arjuna, Karanja, Samania etc.

Reuse of debris generated from dismantling structures and road surface

Debris generated due to the dismantling of existing road will be suitably reused in the proposed construction as follows

- Eighty percent (80%) of the sub-grade excavated from the existing road surface, excluding the scarified layer of bitumen, shall be reused in the civil works after improving the soil below the subgrade through addition of sand and suitable cementing material for qualitative up-gradation.
- The dismantled scraps of bitumen will be utilized for the paving of cross roads, access roads and paving works in construction sites and campus, temporary traffic diversions, haulage routes, parking areas along the corridor or in any other manner approved by the Environmental Officer of SC.

Rehabilitation of Waste Disposal Sites

- Along with the format seeking permission/approval for the disposal site/location from the Engineer/Supervision Consultant, the contractor shall also submit a rehabilitation plan for the area.
- The dump sites shall be suitably rehabilitated by planting local species of shrubs and other plants. The species (region specific) shall be chosen from the list suggested in the EA/EMP. Local species of trees should be selected so that the landscape is coherent and is in harmony with the surrounding environment.
- Rehabilitation can also include conversion into farm land, playground, parking area, block plantation area etc.
- Some of the dumpsites could be used either for plantation or for growing agricultural products such as ginger, turmeric or oranges etc.
- Care should always be taken to maintain the hydrological flow in the area.

Annexure 26: Guidelines for Top Soil Conservation and Reuse

The top soil from all sites including road side widening and working area, cutting areas, quarry sites, borrow areas, construction camps, haul roads in agricultural fields (if any) and areas to be permanently covered shall be stripped to a specified depth of 15 cm and stored in stock piles for reuse. A portion of temporarily acquired area and/or ROW edges will be earmarked for storing top soil. The locations for stacking will be pre-identified in consultation and with approval of environmental officer of SC. The following precautionary measures will be taken by the contractor to preserve the stock piles till they are re-used:

Stockpiles will be such that the slope doesn’t exceed 1:2 (vertical to horizontal), and height is restricted to 2 mts.

a) To retain soil and allow percolation of water, the edges of pile will be protected by silt fencing.

b) Multiple handling kept to a minimum to ensure that no compaction occurs.

c) Such stockpiles shall be cover3ed with empty gunny bags or will be planted with grasses to prevent the loss during rains.

Such stockpiled topsoil will be utilized for:

- Covering reclamation sites or other disturbed areas including borrow areas (not those in barren areas).
- Top dressing and raising turfs in embankment slopes
- Filling up of tree pits
- For developing median plantation
- In the agricultural fields of farmers, acquired temporarily that needs to be restored.

Residual top soil, if there is any, shall be utilized for the plantations works along the road corridor.

The utilization as far as possible shall be in the same area from where top soil was removed.

The stripping, preservation and reuse shall be carefully inspected, closely supervised and properly recorded by the SC.

Annexure 27: Guidelines to Ensure Worker's Safety during Construction

In order to ensure worker's safety while undertaking various operations / stages of construction many safety measures needs to be followed, which are listed down below:

H. Tree Felling

- Use hard hats during tree felling
- Ensure safe use and storage of tools such as axes, power chain saw, hand saw of different types, HDPE ropes of approved thickness to drag felled trees and logs.
- Keep the saw blades in proper lubrication and sharpened state for efficient workability.
- Determine proper foot and body position when using the implements for felling, cutting and dragging.
- Wear appropriate foot protection
- Avoid cutting branches overhead.
- Keep first aid kits ready at the site.
- Determine possible hazards in the area, e.g. electrical or telephone or other utility lines, buildings, vehicles and domestic cattle that may create unsafe work situations.
- Prior to felling, determine the safest direction of fall and orient fixing of ropes and
- Cutting positions accordingly.
- Determine the proper hinge size before directing the fall.
- Keep machineries and workers ready for speedy removal of the tree from the main traffic movement area.
- Keep flag men and warning signal signage at either end of felling area to control movement of traffic and warn passers-by.
- Use loud noise signals for warning by-standers and workmen about the impending fall, so as they move away from the direction of fall.

I. Plant Sites, Construction Camp and Quarry Areas

- Install perimeter fencing.
- Ensure good visibility and safe access at site entrances.
- Provide adequate warning signs at the entrance and exit, as necessary.
- Provide adequate space/area for loading and unloading, storage of materials, plant and machinery.
- Display emergency procedure and statutory notices at conspicuous locations.
- Provide areas for collecting garbage and other waste material, and also arrange for their regular/periodic disposal.
- Arrange appropriate storage, transportation and use of fuel, other flammable materials and explosives in line with the license requirements obtained from concerned authorities.
- Provide defined access roads and movement areas within the site.

- Ensure availability of first aid facilities and display notices at various work places showing the location of first aid facilities and emergency contact numbers. Provide and enforce use of PPE at plant and quarry sites.

J. House Keeping Practices

- Provide proper slope in kitchen, canteens, washrooms, toilets and bathrooms for easy and immediate draining of water.
- Keep all walkways and circulation areas clear and unobstructed at all times.
- Ensure that spillages of oil and grease are avoided and in case of accidental spills, these are immediately collected.
- Use metal bins for collection of oily and greasy rags.
- Stack raw materials and finished products out of walkways.
- Do not leave tools on the floor or in any location where they can be easily dislodged.
- Keep windows and light fittings clean.
- Maintain the workplace floors dry and in a non-slippery condition
- Provide and maintain proper drainage system to prevent water logging and unhygienic conditions.
- Ensure that protruding nails in boards or walls are moved or bent over or removed so that they do not constitute a hazard to people.
- Store all flammable materials in appropriate bins, racks or cabinets with proper cover and labels – as required for various products.
- Make sure that hazardous/dangerous chemicals are kept in the goods stores with the appropriate labeling, display of the material-safety-data-sheet (MSDS) and other precautionary measures.
- Display 'no smoking' signs in areas with high risks of fire, (eg. near fuelling areas, diesel/oils/lubricant/paint storage area, hessians, rubber, wood and plastic etc.) in and around working area.

K. Traffic Safety and Roads Works

- Delineate advance warning zones, transition zones and construction zones at both ends of a work front. Use devices such as regulatory signs, delineators, barricades, cones, pavement markings, lanterns and traffic control lights, reflectors and signal men in appropriate manner round the clock.
- No work front should be 'touched' without putting appropriate safety measures in place. SC will be responsible to ensure that the permission for any activity is not given without the required safety plan and practices in place.
- Put signage at appropriate locations as per the road construction activity plan to warn the road users, construction vehicles/equipment operators, pedestrians and local residents about the work in progress, speed controls, hindrances/ blockages, diversions, depressions etc. in lines with contract requirements and IRC guidelines.
- Express a regret signage for the inconvenience caused and alert about the dangers ahead on account of construction activity.

- Signage has to be: (i) simple, easy-to-understand and should convey only one message at a time; (ii) has florescent and reflective properties of the paints; iii) broad, prominent and with appropriate size of letters and figures; (iv) placed at the appropriate 'point/s' as specified in the IRC guidelines to allow proper stoppage/reaction time to approaching vehicles.
- Different sign boards shall have a mix of pictorial signs and messages in local language, Hindi and English.
- While using barricades, ensure that traffic is kept away from work areas and the road user is guided to the safe, alternative movement track.
- Ensure that excavation sites are provided with effective barriers and reflecting signage to prevent any accidental approach by vehicles during the day or night.
- Prevent entry of cattle and wildlife through proper fencing/barricading around the excavation sites.
- Provide proper uniform (light reflecting garments) to flagmen engaged in traffic control at diversions so that they can be singled out from the moving traffic.
- Provide wide red and green flags or red and green lights to flagmen for controlling traffic.
- In high traffic zones and congested areas, use of wireless communication devices with protective headgear and shoes by flagmen has to be ensured to prevent confusion and minimize the risk of accidents.

L. Safety during Excavation

The risk of accidents involving people and vehicles remains high in excavated sites. All pits or excavations shall to be barricaded to warn the road users and residents and to avoid any unauthorized entry of persons, children, domestic cattle or wildlife. For deep excavations and culvert construction sites, painted GI sheets, delineators, lamps (as required) and retro-reflective signage shall be used.

- For excavation in soft loose & slushy soil (above 2.00 m depth where sliding of earth or collapsing of sides may occur)

Excavation more than 1.5 m is to be done in steps of minimum 500 mm offsets with plank and stuttering support, as required under contract clauses.

- For excavation in slippery or water logged area (labour or machinery may slip or get caught in slush)

Try to dewater the area and spread minimum 150 mm thick sand layer to avoid slipping.

- For excavation in rock where chiseling is involved (and hammer or stone pieces may fall and injure the hand, eyes or legs).

Only experienced and skilled labour should be employed. Chisel should be held with a tight fitting grip. Goggles and leg cover should be provided to protect the labour.

- Excavation in rock where blasting is involved (risk of injury to workers and passer-by)

Blasting is to be carried out where absolutely necessary following all explosive handling regulations with mines safety principles including use of hooters, signage, protective gear, safety fuse, detonators, ignition coils and wires, exploder dynamo etc. The danger zone has to be vacated at least 20 minutes before the actual firing. Sufficient warning through positioning of red flags, dander signs, painted drums and sirens for safety of men at work and for any passer-by is to be provided. After a lapse of minimum 15 minutes when a clear signal is given by the site-in-charge through use of whistle or horn or light, the blasting charge should be ignited. After blasting a minimum of 30 minutes gap is to be given for the rocks and earth or blocks of loose boulders to fall of so that safety and security of the staff at the operation zone is ensured. Heavy charges shall not be used in fragile rock systems, where rock disintegrating machinery could be brought to use.

The entire operation shall be conducted under the strict supervision of qualified staff and in the presence of safety officers.

- For excavation for drain or manhole (risk of a passer-by falling into the excavated portion).

The area should be properly barricaded with sign boards and illumination/lamps for night time safety. In congested stretches, watchmen/guards can also be placed for vigil.

- Snake bites or Scorpion Stings during excavation

In areas with vegetation, tall grasses and forest cover, the contractor shall provide the labour with gum boots and gloves. He shall also make snake antidotes available on site. Emergency ve`hicles should also be kept ready to rush the patient to the nearest hospital.

M. Safety during Some Typical Construction Work

- Centering and scaffolding (risk of framework collapse while construction, concreting or just before concreting especially when wooden ballies are used).

Many a times ballies joined together give away due to weak joints. Use of metal scaffolding and centering plates with metal fasteners are the safest and highly recommended materials for use in all road construction works for ensuring safety, stability and casting of structures. All such scaffolding should be placed on a firm and a level base on the ground for ensuring stability. No wooden scaffolding or bamboo scaffolding is to be used for any casting of heavy (RCC) structural construction as the risk to safety of workers is higher.

Railings are to be provided along working platforms and ladders for better safety. Nets shall be hung below the scaffolding or structures where work is on-going to prevent fall of debris, stones, bricks, equipments and other heavy objects and even workmen, which could be fatal.

- Form-work for small/light beams and slabs

The collapse of bottom of the beam that may bring down the slab as well is a risk in such operations, which may injure the labour or supervision staff. Slender ballies without bracing are not be allowed for such works. No concreting should be allowed without bracing at 300 mm above ground and at mid way for normal beams and slabs. The bracings should be for the support of beams as well as the slabs. Direct ballies support from the ground and the practice of tying planks with binding wire to the steel reinforcement shall not be allowed. A temporary railing and properly based working platforms along the periphery of slab reduces risk to the life of labour and supervision staff.

- Dismantling of Scaffoldings

Dismantled materials may fall on passer-by and workers. Workers could also get injured during the removal of such materials. Prior to dismantling of scaffoldings/working platforms, the area of operation should be closed for all outsiders. No one should be allowed within 50 mt. from the place of demolition. Helmets, safety belts and other PPE must be worn by all the workers engaged in such a work. This work requires careful handling by an experienced supervisor/work force and should be executed with utmost caution. Gradual dislodging and use of PPE is required.

- Column Reinforcements

The tendency of bar-benders is to tie the vertical steel with coir rope or 8 mm steel rods as ties on all four sides of the column reinforcements. Reinforcement to columns shall be by welding MS rods with metal scaffolding to keep it in position till the final casting of RCC is done.

- Fall of Objects or Debris from a Height

At bridges construction sites (or in work areas at a height above ground level) thick nylon net or hessian barriers shall be used to prevent any splinter, debris, mortar or concrete from falling onto the passers by or workmen around.

- Water Storage Tanks (for General Use, Curing etc.)

A child of a worker or that of a near-by resident falling into the water tank is also a risk associated with construction sites. The water tanks therefore shall be provided with protective cover/lid with locking arrangement at every site of activity to prevent accidental drowning.

- Site Cleaning

Throwing of waste materials, broken concrete pieces, brick bats, sand etc. straight from the top of a structure onto the ground can injure a worker or a passerby. Such materials should be brought to the ground with the help of lift or the use of rope over pully with a bucket.

N. Operation of Excavators

- Ensure that excavators are operated by authorized persons who have been adequately trained. Prevent any unauthorized use of the excavators.
- Ensure that only experienced and competent persons are engaged in supervising all excavations and leveling activity.
- Check and maintain as per the manufacturer’s manual.
- Issue relevant information, including that related to instructions, training, supervision and safe system of work in writing and provide expert supervision for guidance.
- Ensure that the operation and maintenance manuals, manufacturer's specifications, inspection and maintenance log books are provided for the use of the mechanics,

service engineers or other safety personnel during periodic maintenance, inspection and examination.

- During tipping or running alongside the trenches, excavators must be provided with stop blocks. Avoid operating the machine too close to an overhang, ditch or hole, potential carving in edges, falling rocks and land slides, rough terrain with undulating obstacles.
- Excavators must be rested on firm ground after field operation away from the road
- Locate and identify underground services including telephone cables, OFC cables, sewerage and drainage lines, water supply, electrical cables etc by checking with all concerned underground utility providers.
- When reversing or in cases where the operator's view is restricted, adequate supervision and signaling arrangements shall be provided.
- Ensure that the type and capacity of the excavator are properly chosen for the intended purposes and site conditions. Never use a machine for any purposes other than it is designed for.
- Check and report for excessive wear and any breakage of the bucket, blade, edge, tooth and other working tools of the excavator and ensure replacement/ repair to avoid mishap and break down.
- Check that all linkages/hinges are properly lubricated and ensure that the linkage pins are secured. Never use improper linkage pins.
- Never dismount from or mount on a moving machine.

O. Operation of Trucks and Dumpers

- Ensure that only trained, authorized and licensed drivers operate the vehicles.
- Enlist help of another worker before reversing the vehicle.
- Switch-off the engine when not in use to save fuel, prevent accidents and unnecessary noise and air pollution.
- Lower the tipping bodies when the machine is unattended, but if it is necessary to leave them in the raised position they should be blocked to prevent their fall by fixing a sturdy support below.
- Carryout periodic servicing as per the manufacturer’s requirements. All records of maintenance and repairs should be in writing and available for verification.
- Keep the vehicle tidy and the cabin free from clumsy utilities, which might to obstruct the controls and create hazards.
- Follow safe driving principles including speed limits as per traffic signage.
- Avoid carrying additional passengers in the cabin or on the body of the dumper, while in field operation other than the connected workers.
- Provide stop blocks when the vehicle is tipping into or running alongside excavations or when it is parked.
- Do not overload the vehicle.
- Carry only well secured loads and use proper covers and fasteners.

P. Manual Handling and Lifting

- Avoid manual handling of heavy and hazardous objects and chemicals.
- Pre-assess the actual requirement of manpower in case of emergency situations.
- The hazardous and poisonous materials should not be manually handled without proper equipments/gears and prior declaration of the risks needs to be made to the involved workers.
- All concerned persons shall be trained in proper methods of lifting and carrying.
- In all manual operations where groups of workers are involved, a team leader with necessary training to handle the entire work force in unison has to be provided for.
- Watch and ward to control/supervise/guide movement of equipments and machineries, loading and unloading operations, stability of the stockpiled materials and irregularly shaped objects have to be provided for safety and security of workers.
- Carriageway used by the workers must be free from objects, which are dangerous.
- Loading and unloading from vehicles shall be under strict supervision.

Q. Electrical Hazards in Construction Areas

- Statutory warning leaflets/posters are to be distributed/displayed by the Contractor in the vicinity of work sites for the benefit of all workers, officers and supervisors as well as the public, indicating the do's and don'ts and warning related to electrical hazards associated with operations to be executed/in progress.
- All wires shall be treated as live wires.
- Report about dangling wires to the site-in-charge and do not touch them.
- Only a qualified electrician should attempt electrical repairs.
- Train all workers about electrical safety.
- Shut down the equipment that is sparking or getting over heated or emitting smoke at the time of operation, if it is not the normal way of working of such machines.
- Inform technical person/s for required maintenance.
- Never used damaged wires for electrical connection.
- Demolition, tree felling and removal of overhead transmission lines shall be undertaken with strong, efficient and closely monitored arrangements to avoid accidents.

R. Use and Storage of Gas (LPG)

- Store filled gas/LPG cylinder in a secure area – mark this as a no smoking area.
- Transport, store, use and secure cylinders in upright position.
- Ensure proper ventilation at the ground level in locations where LPG is in use.
- Avoid physical damage to the cylinders.
- Never weld near the cylinder.
- Store empty cylinders secured and upright.
- Make sure that the cylinder is closed immediately after use.
- Investigate immediately if there is the smell of LPG or gas.

- Never use destenched gas/LPG on site.
- Make sure that there is no other unrelated fire in the vicinity of the cylinder.

S. Gas Welding

- The welders and welding units should follow all the basic principles of welding for safety and security.
- Use face shield to protect the eyes.
- Use goggles, particularly when chipping slag and cutting strips.
- Use gloves long enough to protect wrists and forearms against heat, sparks, molten metal and radiation hazards.
- Use high-top boots/gum boots to prevent sparks, splinters, sharp edges of metal and hot welded strips, welding rods, electric cables etc. from injuring the legs.
- Avoid inhaling the noxious fumes and gasses from burning electrodes by using gas masks and screen of the work area to prevent the glair moving outside it.
- Keep the key hung from the regulator control for split seconds operations to stop the valve in case of any accidental damage or leakage to supply pipeline that may catch fire and cause accidents in case acetylene or LPG cylinder.
- The welding area should have sufficient openings with fixed exhaust ventilators or adequate air flow openings to remove poisonous fumes and gases.
- Take precautions of wearing hard hats or fiber helmets to prevent injury due to fall of any object and accidental injury from projections while welding.
- Welders operating above ground should have adequate safety belt secured to stable platform to prevent accidental fall or injury from the scaffold. All electrical and gas connection lines up to the welder should be sufficiently insulated and protected from sharp edges and sharp objects. These shall not come into contact with hot metal.
- Do not use gas cylinders for supporting work or as rollers.
- While using LPG or CNG cylinders for welding, follow all safety precautions as has been prescribed by the supplier company.
- Avoid fire hazards and accidents by posting safety supervisors to oversee the activities of workers.
- Do not store explosives, high inflammable materials, loose hanging overhead objects, hot welded strips etc. near gas cylinders.
- Close all valves, switches and circuits while leaving the work place under proper lock and key. In case of mobile units, proper carriage procedures have to be followed for safety and security of men and materials.

T. Fire Safety Practices

- Before fire breaks out
- Designate fire officers.
- Store flammable material in proper areas having adequate fire protection systems.
- Display sufficient warning signs.
- Install fire alarm wherever required and test regularly.

- Inspect fire extinguishers regularly and replace as necessary.
- Train selected personal on use of fire extinguishers
- Fire escape route should be kept clear at all times and clearly indicated
- Display escape route maps prominently on each side.
- Provide sufficient exit signs at prominent locations for directing people to the escape staircases and routes.
- Train workers about the escape route and assembly point/s.
- Carryout fire drill periodically.

When fire breaks out

- Alert all persons through fire alarms or other methods.
- Put off the fire with appropriate fire extinguishers only when you are sure that you are safe to do so.
- Escape if you are in danger through the fire escape route to assembly point.
- Call-up Fire Service.
- Fire officers to carryout head count at the assembly point.

U. Noise Hazards and its Control

- Plan camp lay-out in a manner that ensures barriers/buffers between residential/ office units and high noise generating zones.
- Use sound meters to measure the level of noise and if it exceeds 75 dB(A), then ensure preventive measures.
- Make personnel aware of noisy areas by using suitable warning signs and insist on use of ear protectors/ear plugs to prevent excess noise affecting the workmen.
- Reduce noise at source by: use of improved equipments; regular and proper maintenance of the machinery as per the manufacturer's manual; by replacing rickety and noisy equipments and machineries. Screening locations with noise absorbing material; making changes in the process/equipment; controlling machine speeds; ensuring that two noise-generating machines are not running at the same time close to each other at same location; using cutting oils and hydraulic noise breakers; providing vibration and noise absorbing platform and firm embedding of equipments with fasteners.
- Appoint a competent person to: carryout a detailed noise assessment of the site; designate ear protection zone/s; give training/instructions on the necessary precautionary measures to be observed by site personnel including using suitable type of ear protection equipments.

V. Personal Protective Equipment

General

- Provision of personal protective equipment has to be made over and above all measures taken for removing or controlling safety hazards on a work site.
- Ensure that sufficient personal protective equipments are provided and that they are readily available for every person who may need to use them.

- The Contractor's Project Manager shall ensure that all persons make full and proper use of the personal protective equipment provided.
- Provide instruction/s and training for the proper use and care of personal protective equipment.
- Ensure that the personal protective equipments are in good condition.
- Train workers to report unintentional damages for replacement and to always keep the personal protective equipment clean.
- PPE includes, but may not be limited to, hard hats, goggles, ear plugs, gloves, air filters/masks, boots, ropes etc.

Eye Protection

- Road construction work sites, quarries and crushers are full of dust particles, sand, splinter, harmful gases, bright light and welding arc lights, which are injurious for the eyes. Therefore, eye protection and adequate lighting in work areas is required. All workers, supervisors and inspection officers and dignitaries coming over for study of works should be compelled to wear eye protecting glasses/goggles properly fitting the eye sockets to prevent damage due to dust, gases and other particles.
- Head Protection
- Hard hats are compulsory for all workers, supervisors and managers/officials while working and/or inspecting a work sites.
- Hard hat areas shall be demarcated clearly.
- Hearing Protection
- Provide ear plugs or ear muffs to the workers and to those who need to get in and out of a high noise area frequently. Use re-usable earplugs when the reduction required (15-25 dBA) is not excessive. Use earmuffs where a large attenuation of upto 40 dBA is demanded.
- Do not use dry cotton wool for hearing protection because it doesn't provide any such protection.
- Provide disposable ear plugs for infrequent visitors and ensure that these are never re-used.
- Replenish ear plugs from time to time for those who need to work continuously for a long period in a high noise area/s.
- Use ear muffs with replaceable ear cushions because they deteriorate with age or may be damaged in use.
- Avoid wearing spectacles with ear muffs.
- Use soap and water or the recommended solvent for cleaning ear muffs.
- Respiratory (Protective) Equipment
- Wear suitable maks for protection when there is a potential for small particles entering the lungs, e.g. emptying of cement bags, working at crusher sites etc.
- Provide training to all persons using the masks/respirators for their correct fitting, use, limitations and symptoms of exposure.
- Clean and inspect all respirators before and after use.

- Store respirators properly when not in use.
- Safety Footwear
- Wear suitable footwear for work
- Use safety footwear on site or in other dangerous areas.
- Wear suitable safety shoes or ankle boots when working anywhere where there is high risk of foot injuries from slippery or uneven ground, sharp objects, falling objects etc.
- All safety footwear, including safety shoes, ankle boots and rubber boots, should be fitted with steel toecaps.
- Avoid wearing flip flops, high heeled shoes, slippers, light sport shoes in situations where there is a risk of foot injury.
- Keep shoelace knots tight.
- Hand Protection
- Wear suitable gloves for selected activities such as welding, cutting and manual handling of materials and equipment.
- Do not wear gloves where there is a risk of them becoming entangled in moving parts of machinery.
- Wash hands properly with disinfectant soap and clean water before drinking or eating.
- Wash hands immediately after each operation on site when the situation warrants.

W. First Aid

- Provide first aid boxes at every work site in a cool and shaded place.
- Ensure that training on the use of the first aid box is provided to at least every supervisor on the site.
- Display the list of persons along with their contact numbers who are trained on providing first aid.
- Ensure that every first aid box is marked "First Aid" in English and in local language.
- Check for expiry dates and replace the contents, as necessary.
- Maintain a register on health records including injuries/accidents.

X. Accident Investigations

- Carryout the investigation/s as quickly as possible.
- Investigation should be carried out both internally as well as through third party.
- Conduct interviews with as many witnesses as necessary including the affected persons and supervising officials.
- Do not rely on any one/limited source of evidence.
- Check all the log books, stock registers, issue registers, movement registers on site
- Safety regulations, traffic signals and signal men activities, signage, as well as other field positions and keep a record of all investigations through audio-visual and electronic medium for presenting an evaluation of the incident/s.

- After completion of the investigation/enquiry, a summary of the facts recorded, sequence of happenings, persons-in-charge, persons examined, equipments and machineries tested, follow-up of action as per legal requirements, copy of station diary entry, hospital entry, safety regulations etc. to be prepared with a comparative analysis for proper assessment.

Annexure 28: Guidelines for Preparation of Traffic Management Plan

The Contractor shall at all times carry out work on the road in manner creating least interference to the flow of traffic with the satisfactory execution. For all works involving improvements to the existing state highway, the Contractor shall, in accordance with the directives of the CSC, provide and maintain, during execution of the work, a passage for traffic either along a part of the existing carriageway under improvement, or along a temporary diversion constructed close to the state highway. The Contractor shall take prior approval of the CSC regarding traffic arrangements during construction.

Ensuring Traffic Safety And Control

Where subject to the approval of the Engineer the execution of the works requires temporary closure of road traffic use, the Contractor shall provide and maintain temporary traffic diversions. The diversions shall generally consist of 200 mm thickness of gravel 4.5 meters wide laid directly upon natural ground and where any additional earthworks are required for this purpose that will be provided under the appropriate payment items.

Where the execution of the works requires single-lane operation on public road, the Contractor shall provide and maintain all necessary barriers, warning signs and traffic control signals to the approval of the Engineer.

With the exception of temporary traffic arrangements or diversions required within the first 4 weeks of the Contract, the Contractor shall submit details of his proposals to the Engineer for approval no less than 4 weeks prior to the temporary arrangement or diversion being required. Details of temporary arrangements or diversions for approval as soon possible after the date of the Letter of Acceptance.

The colour, configuration, size and location of all traffic signs shall be in accordance with the code of practice for road sign. In the absence of any detail or for any missing details, the signs shall be provided as directed by the Engineer (CSC).

The Contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, marking, flags, lights and flagmen as may be required by the Engineer for the formation and protection of traffic approaching or passing through the section of the road under improvement. Before taking up any construction, an agreed phased programme for the diversion of traffic or closer of traffic on the road shall be drawn up in consultation with the SE.

At the points where traffic is to deviate form its normal path (whether on temporary diversion or part width of the Carriageway) the lane width path for traffic shall be clearly marked with the aid of pavement markings, painted drums or a similar device to the directions of the SE. At night, the passage shall be delineated with lanterns or other suitable light source.

One-way traffic operation shall be established whenever the traffic is to be passed over part of the carriageway inadequate for four-lane traffic. This shall be done with the help of temporary traffic signals or flagmen kept positioned on opposite sides during all hours. For regulation of traffic, the flagmen shall be equipped with red and green flags and lanterns/lights.

On both sides, suitable regulatory / warnings signs as approved by the SE shall be installed for the guidance of road users. On each approach, at least two signs shall be put up, one close to the point where transition of carriageway begins and the other 120 m away. The signs shall be of design and of reflectory type, if so directed by SE.

Upon completion of the works for which the temporary traffic arrangements or diversions have been made, the Contractor shall remove all temporary installations and signs and reinstate all affected roads and other structures or installations to the conditions that existed before the work started, as directed by the Engineer.

Maintenance of Diversions And Traffic Control Devices

Signs, lights, barriers and other traffic control devices, as well as the riding surface of diversion shall be maintained in a satisfactory condition till such time they are required as directed by the SE. The temporary traveled way shall be kept free of dust by frequent applications of water, if necessary.

List of Traffic safety Signs/Equipment (Guideline)

Sl. No.	Signs	Length of work zone considered		Minimum quantity to be procured	
		No. of Signs	Length in (m)	No. of Signs	Length in (m)
1	Barricading	130	500	2600	10000
2	Men at work	5	500	100	10000
3	Keep Left	11	500	220	10000
4	Go slow	8	500	160	10000
5	Flag men	3	500	10	10000
6	Narrow signs	4	500	80	10000
7	Lantern(Amber Blinker)	4	500	80	10000
8	Traffic control Lights	2 Sets			10000
9	Cones	15	500	300	10000

Note:
Safety jackets and helmets should be provided to all the workers/ Engineers working on the road.
Fixed mobile solid barricades must be placed between the workmen and traffic or pedestrian and traffic.
All the safety signs should be according to IRC: 67 and IRC: SP: 55: 2001

Examples of some good practice in traffic control safety during construction

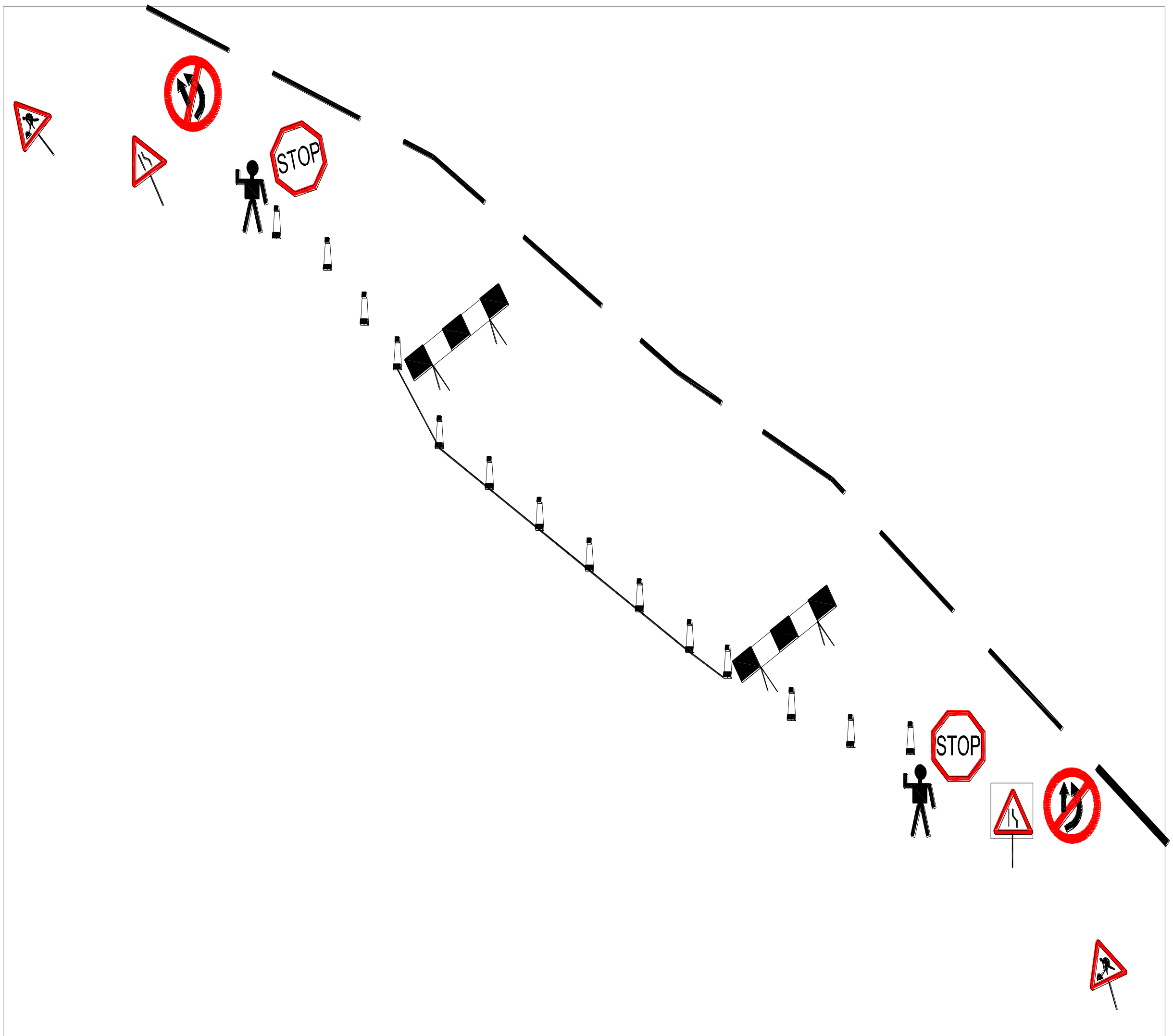


Figure-1 : Diversion of Traffic on Half of the Road Width (Say Left)

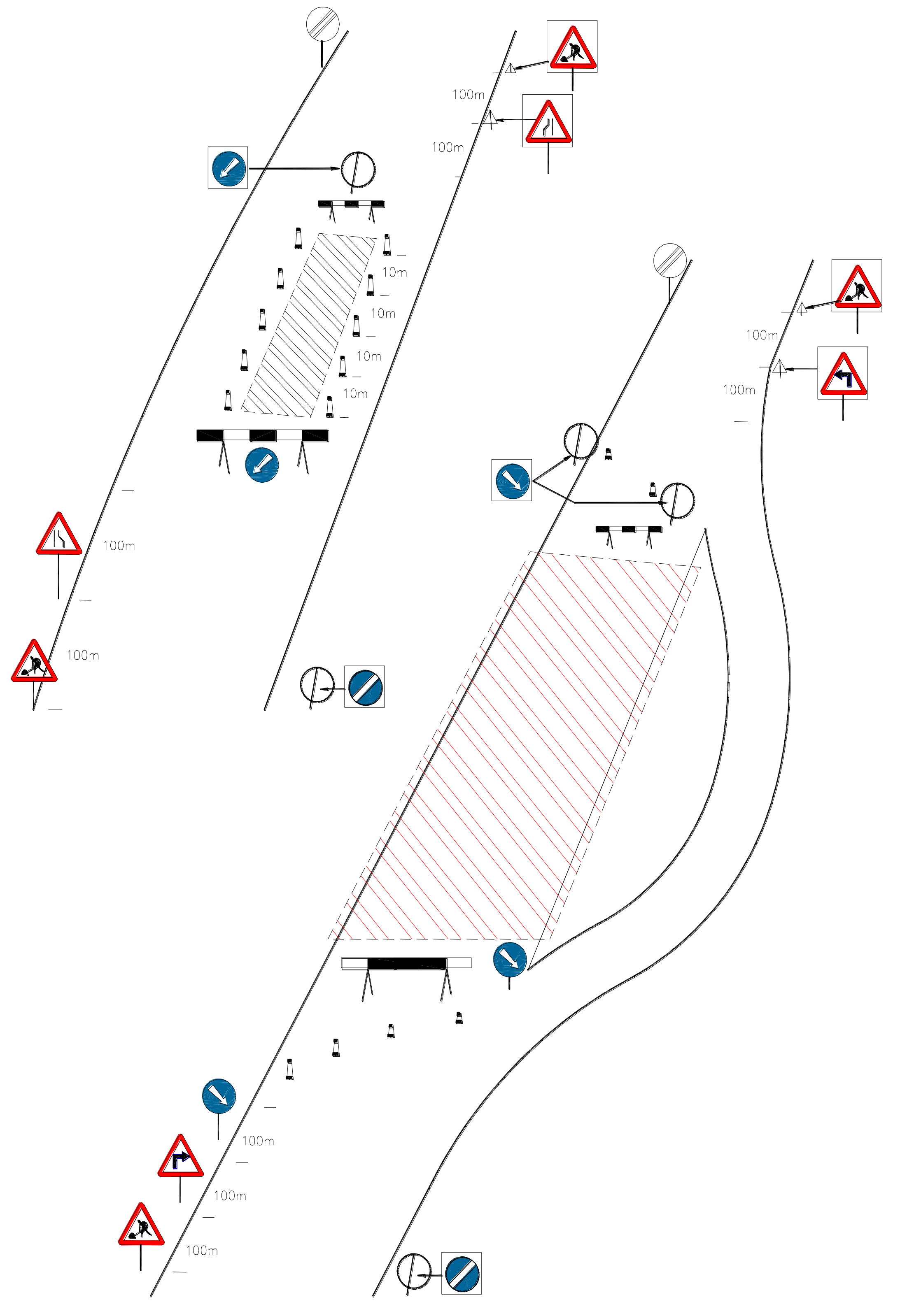


Figure : 2

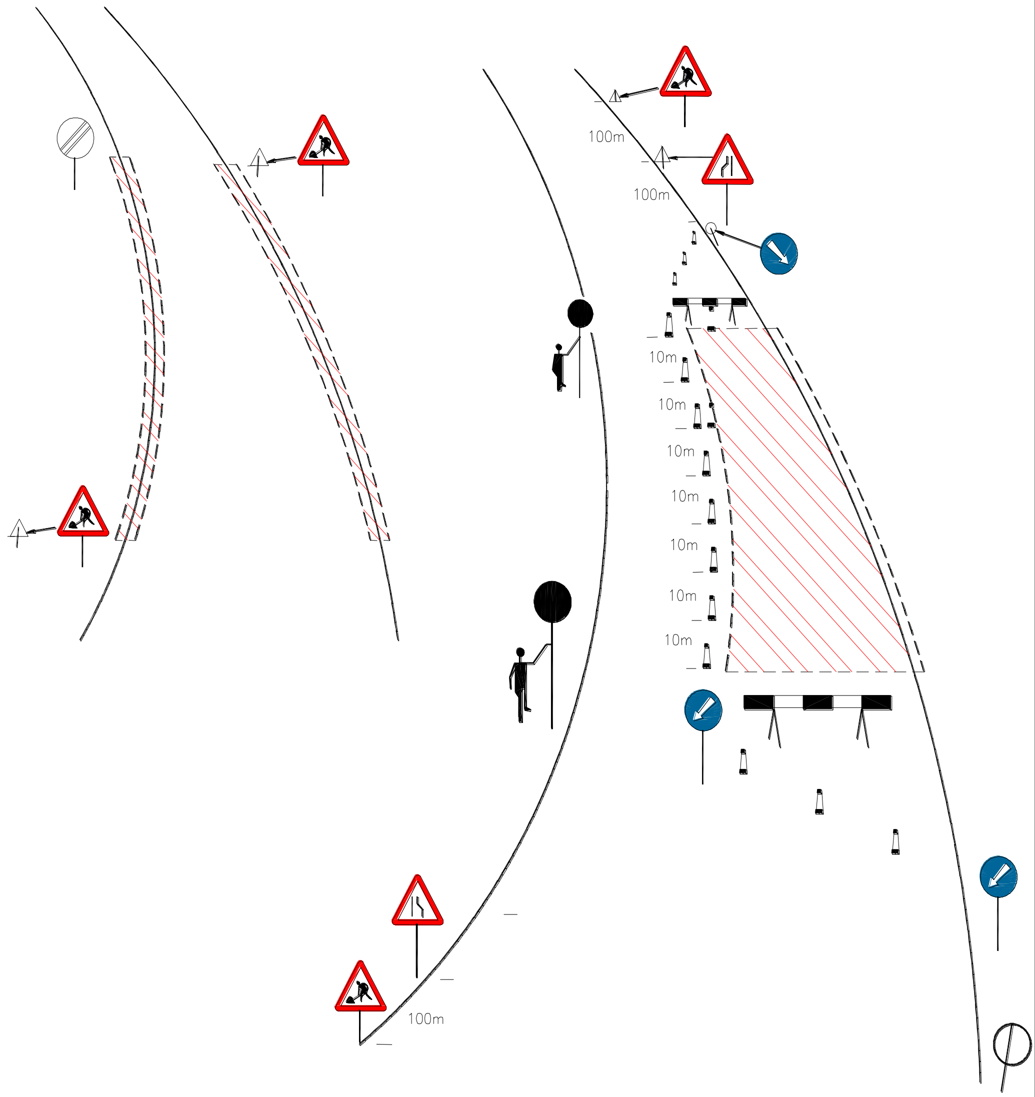


Figure : 3

SIGN LAYOUT FOR LANE CLOSURE

(Drawn for Driving on Left)

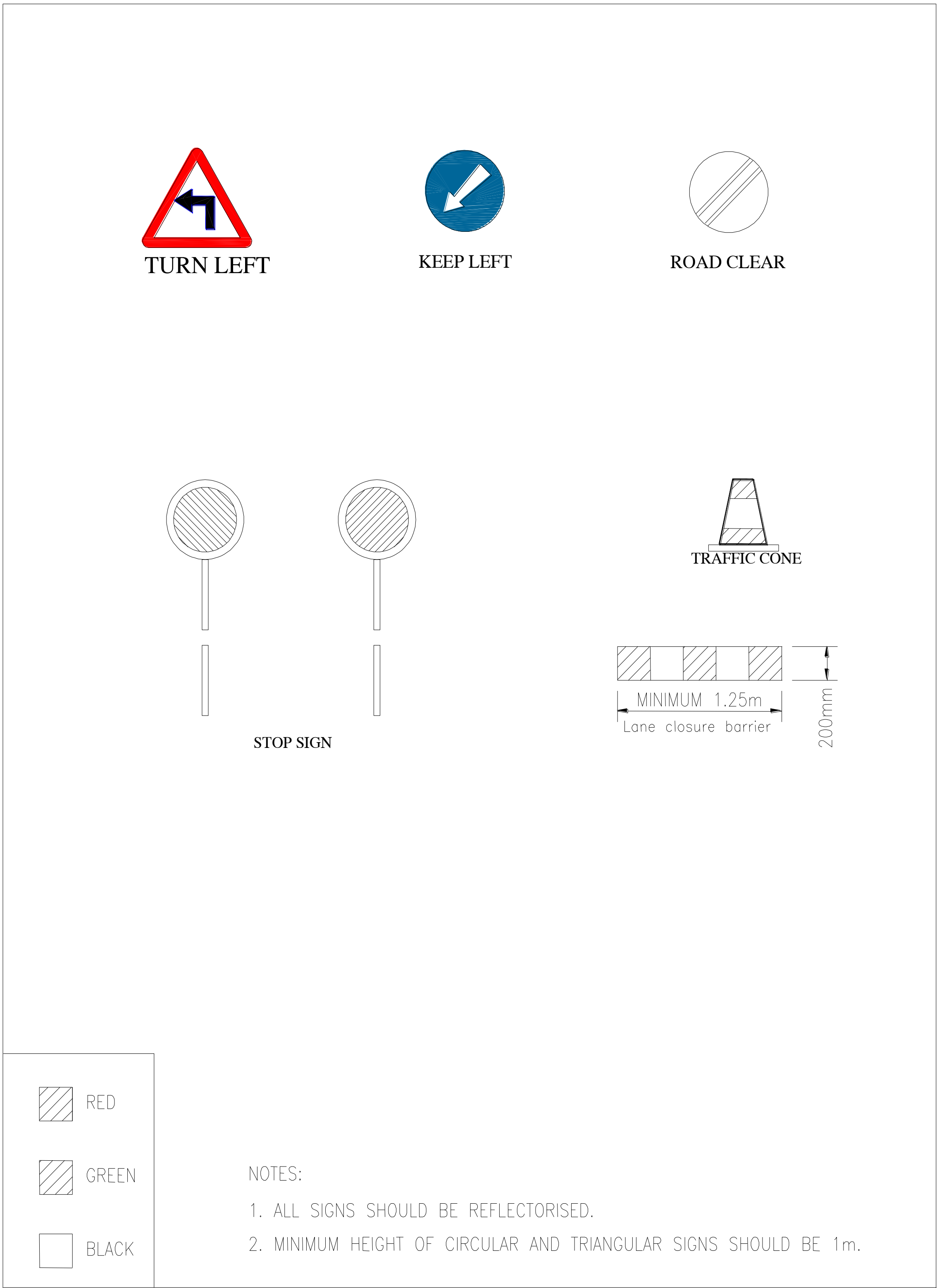

TURN LEFT
KEEP LEFT
ROAD CLEAR
TRAFFIC CONE
MINIMUM 1.25m
Lane closure barrier
200mm
STOP SIGN
RED
GREEN
BLACK
NOTES:
1. ALL SIGNS SHOULD BE REFLECTORISED.
2. MINIMUM HEIGHT OF CIRCULAR AND TRIANGULAR SIGNS SHOULD BE 1m.

Figure : 4

Annexure 29: Storage, Handling, Use and Emergency Response for Hazardous Substances

Handling Hazardous Substances (including Chemicals)

- As far as practicable the hazardous materials will be stockpiled under proper mechanical loading, unloading and stacking aided by manual labour where necessary.
- Exercise great care in the storage and use of chemicals because they may be explosive, poisonous, corrosive or combustible.
- Separate different chemicals physically and store accordingly after proper labeling.
- Stock taking of all hazardous will be mandatory together with enforcement of manufacturer's or supplier's safety standard/s and drill exercises.
- New and less known chemicals and building materials, for which toxicological studies are wanted, need to be properly evaluated prior to their inclusion in the materials list.
- All containers should be clearly labeled to indicate contents.
- Maintain the Material Safety Data Sheet of all chemicals for reference on safety precautions to be taken and the use of suitable PPE.
- Ensure use of correct personal protective equipment before allowing workers to handle chemicals.
- When opening containers, ensure holding of a rag over the cap/lid or use of safety gloves, as some volatile liquids tend to spurt up when released.
- Eye fountain, emergency shower and breathing apparatus should be available near the workplace.
- Ensure immediate medical attention in case of spill/splash of a chemical.
- Safety instructions for handling emergency situations shall be displayed prominently at both the storage and use locations.

Transportation, Refueling and Maintenance Procedure

- Truck or suitable containers will bring in all fuel and fluids.
- There will be no storage of fuel, oil or fluids within 200m of a water line.
- Prior to re-fueling or maintenance, drip pans and containment pans will be placed under the equipment.
- Absorbent blankets may also be required to be placed under the equipment and hoses where there is a possibility of spillage to occur.
- All used oils or fluids will be properly contained and transported to appropriately licensed (authorized) disposal facilities.
- Following re-fueling and maintenance, the absorbent blankets (if any) and spill pans will be picked up and the fuel truck or container moved outside of the 100m (or 50m) wide area.

Emergency Spill Procedure

- Should a spill occur, either through accidental spillage or equipment failure, the applicable emergency spill procedure as outlined in sections below and/or as directed by the manufacturer/supplier shall be followed:
- Spill Procedure (Inside a Stream)
- In the case of a spill, overflow or release of fluid into the stream waterway (whether water is flowing during the spill or not), do what is practical and safely possible to control the situation, while sending SOS for help from the technical wings and fire brigade or any other govt. agency.
- Stop the flow
- Stop the release into the waterway
- Shut down the equipments
- Close valves and pumps.
- Plug leaking of damage hosepipes or containers with suitable sealants or temporary plugs at the holes.
- Remove Ignition Sources
- Cut off the supply sources and shut down the sources of power supply.
- Cordon up the area and salvage the spilled materials for recycling or disposal as would be suggested by the technical experts or as per the manufacturer’s guidelines for the product. In case of inflammable materials, mobile phones, electrical switches and heat generating machines, sparking electrodes etc. shall not be operated.
- Portable fire extinguishers need to be kept handy in such vehicles for immediate use as a damage control measure.
- Clean-up and Disposal
- Emergency Services shall be engaged for the containment, clean-up and disposal of contaminants released into the environment.
- Reporting
- The Contractor's Environmental Officer will document the event and submit the reports to the Engineer, the Client and appropriate regulatory agencies like the Pollution Control Board.
- Procedure Review
- The Engineer will review the report, determine if changes are required to be incorporated in the plan of activity under the revised guidelines and recommendation/s that have been suggested by the technicians/manufacturer/ supplier /fire brigade /SPCB /environment officer of the PIU, as the case may be.
- Spill Procedure (On Land)
- All types of spills are hazardous - whether liquid or amorphous or solid and accordingly the spill has to be dealt with. For liquids, sealing the leakage or emptying the container into another empty vessel may be considered. For solid or semi-solid or viscous products, special salvage equipments are to be used. For fine particles and water soluble chemicals, neutralizing or scraping the affected soil from

the area has to be resorted to with mechanical removal and depositing at a safe site as would be recommended by experts.

- Notification
- All legal authorities such as civil administration including the district Collector, the sub- divisional officer, Tehsildar, the local SHO of the police station, the SP, Divisional Forest Officer, the Inspector of Factories and Boiler, the SPCB authority monitoring the pollution in the area, site engineer/supervision consultant and environmental officer of OWD/PIU, local gram panchayat and people’s representatives have to be informed about the incident, the probable damage, current and after effects, precautionary measures to be taken and already taken and restrictions imposed on movement of men, material, live stock etc in an around the site of spill.
- Cleanup and Disposal
- The Engineer's Environmental Officer will ensure that a proper cleanup and disposal method is determined. Absorbent pads will soak up the spilled material. The pads will be contained and removed from site for disposal at a licensed (authorized) facility.
- Reporting
- The Contractor's Environmental Officer will document the event and submit reports to the Engineer, the Client and appropriate regulatory agencies like the Pollution Control Board(s).
- Procedure Review
- The Engineer will review the report; determine, if changes are required to procedures and; recommend implementation of all required changes.

Annexure 30: Identification of Construction Camp Site

(Report to be prepared by the concessionaire)

Name of Project Stretch:___________________

Construction Stage Report: Date______________Month___________Year___________

(Layout plan of Construction camp with allied facilities to be attached with format)

Format to be submitted before target date of establishing camps

Sl. No:	Item	Details	Remarks by CMU if any
1	Name of the Village and taluk		
2	Chainage (km), Side (LHS/RHS)		
3	Size of Camp		
4	Current land use		
5	Ownership of the land (owned/leased)		
6	Distance from nearest settlement		
7	Distance from the nearest water source		
8	Distance from ecologically sensitive areas		
9	No of trees with girth > 0.3m		
10	Is top soil conservation required (Yes/ No)		

Remarks

	Submitted (Concessionaire)	Checked (EO)	Approved (CSC)
Signature			
Name			
Designation			

Annexure 31: Identification of Labour Camp Site

(Report to be prepared by the Concessionaire)

Name of Project Stretch:___________________

Construction Stage Report: Date______________Month___________Year___________

(Layout Plan of labour camp and working drawings of dwelling units with allied facilities to be attached with format)

Format to be submitted before target date of establishing camps

Sl. No:	Item	Details	Remarks by CMU if any
1	Name of the Village and taluk		
2	Chainage (km), Side (LHS/RHS)		
	Details of Camp		
3	Size of Camp		
4	Current land use		
5	Ownership of the land (owned/leased)		
6	Distance from nearest settlement		
7	Distance from the nearest water source		
8	Distance from ecologically sensitive areas		
9	No of trees with girth > 0.3m		
10	Is top soil conservation required (Yes/ No)		

Remarks

	Submitted (Concessionaire)	**Checked (EO)**	**Approved (CSC)**
Signature			
Name			
Designation			

Annexure 32: Identification of Quarry and Crusher Site

(Report to be prepared by the Concessionaire)

Name of Project Stretch:___________________

Construction Stage Report: Date______________Month________________________ ________________Year___________

Sl. No:	Item	Details	Remarks by CMU if any
1	Name of the Village and taluk		
2	Chainage (km), Side (LHS/RHS)		
3	Size of Camp		
4	Haul Road Length		
5	Current land use		
6	Ownership of the land (owned/leased)		
7	Distance from nearest settlement		
8	Distance from the nearest water source		
9	Distance from bridge		
10	Distance from water supply schemes		
11	Distance from railway line		
12	Distance from reservoir, canal etc.		
13	Distance from nearest main road		
14	Distance from NH, SH		
15	Distance of stone crusher from adjacent unit		
16	Distance from ecologically sensitive areas		
17	No of trees with girth > 0.3m		
18	Is top soil conservation required (Yes/ No)		

Remarks

	Submitted (Concessionaire)	Checked (EO)	Approved (CSC)
Signature			
Name			
Designation			

Annexure 33: Identification of Borrow Site

(Report to be prepared by the Concessionaire)

Name of Corridor___________________

Construction Stage Report: Date______________Month___________Year___________

Sl.No:	Item	Details	Remarks by CMU if any
1	Name of the Village		
2	Chainage (km)		
3	Side (LHS/RHS)		
4	Haul Road Length		
5	Quantity of Available Material		
6	Type of Material		
7	Ownership of Land (whether it is lease or not)		
8	Present land use		
9	Distance from Nearest Settlement		
10	Distance from schools, playgrounds etc.		
11	Distance from the nearest Water source		
12	Distance from NH, SH and other roads		
13	Distance from toe of embankment if any		
14	Distance from toe of the bank along the river side		
15	Distance from toe of irrigation tank bund		
16	No of trees to be cut down		

Remarks

	Submitted (Concessionaire)	**Checked (EO)**	**Approved (CSC)**
Signature			
Name			
Designation			

Annexure 34: Identification of Debris / Muck Disposal Site

(Report to be prepared by the Concessionaire)

Name of Corridor___________________

Construction Stage Report: Date______________Month___________Year___________

Sl.No:	Item	Details	Remarks by CMU if any
1	Name of the Village		
2	Chainage (km)		
3	Side (LHS/RHS)		
4	Haul Road Length		
5	Quantity of debris generating		
6	Nature of Debris		
7	Present land use		
8	Specify whether the land is lease or not.		
9	Distance from Nearest Settlement		
10	Distance from the nearest Water source		
11	No of trees to be cut down		

Remarks

	Submitted (Concessionaire)	Checked (EO)	Approved (CSC)
Signature			
Name			
Designation			

Annexure 35: Register of Sites Opened and Closed

Date	Location				Type of Site (Q/C/B/ CC/LC)	Opening Date	Closing Date
	Ownership	Place Name	Chainage	Distance from the project road			

(Q- Quarry, C – Crusher, B – Borrow Area, CC- Construction Camp, LC – Labour Camp)

Annexure 36: Identification of Source of Water for Construction

Name of Corridor___________________

Link No.__________________________

Construction Stage: Monthly Report – Date: Month___________Year___________

Sl. No.	Source (Name)	Location /Ch.	Distance from Road	Permission Required	Remarks

Remarks

Submitted	**Checked**	**Approved**
Signature	Signature	Signature
Name	Name	Name
Designation		
Contractor	Environmental Engineer.	Executive Engineer (CMU)
Construction Supervision Consultant		

Annexure 37: Setting-up Construction Camp

(To be filled by the Contractor)

Name of Corridor ____________________

Link No. ___________________________

Construction Stage Report: Date_______________

Month____________

Year____________

(Site Layout of Construction camp and working drawings of dwelling units with allied facilities to be attached with format)

Format to be submitted before target date of establishing camps

Sl.No:	Item	Unit	Details	Remarks by CMU if any
1.	Detail of item camp			
a	Size of Camp	m x m		
b	Area of Camp	Sq.m		
c	Distance from Nearest Settlement			
d	Distance from the nearest Water source	Type/Size/Capacity/Present Use/Ownership		
e	Date of camp being operational dd / mm / yy			
f	Present land use			
g	No of trees with girth > 0.3m.			
h	Details of Storage area (Availability of impervious surface)	m x m		
i	Availability of separate waste disposal	Cum		
2	Details of topsoil stacking			
a	Quantity of top soil removed	Sq.m		
b	Detail of storage of topsoil	Describe stacking arrangement		
3	Details of workforce			
a	Total No of Laborers	Nos		
b	Total no of Male Workers	Nos		
c	No of Male Workers below 18 years of age	Nos		
d	Total No of Female Workers	Nos		
e	No of Female workers below 18 years of age	Nos		
f	No of children	Nos		
4	Details of dwelling units			
a	No of dwellings/huts			
b	Minimum Size of Dwelling	m x m		

Sl.No:	Item	Unit	Details	Remarks by CMU if any
c	No. of openings per dwelling	Nos		
d	Minimum size of opening	m x m		
e	Walls	Specifications		
f	Roofing	Specifications		
g	Flooring	Specifications		
h	Drinking Water Tank	Specifications		
	Capacity of Drinking Water Tank	Cum		
i	Size of Drinking Water Tank	m x m		
j	Total no of WC	Nos		
k	No of Wcs for female workers	Nos		
l	Minimum Size of WC	m x m		
m	Total No of Bathrooms for female workers	Nos		
n	Size of septic tank for WC/Baths	m x m		
o	Capacity of Water Tank for WCs			
p	/Bathrooms and general purpose			
g	Fencing around camp	Y/N		
5	Details of facilities			
a	Availability of security guard 24 hrs a day	Yes/No		
b	Details of First Aid Facility	Yes/No		
c	Availability of Dav Care Centre	Yes/No		
d	Availability of dust bins (capacity 60ltr)	Nos		

Remark

Annexure 38: Establishment of WMM Plant / Batch Mix Plant

(To be submitted by Contractor for taking permission from CMU)

Name of Corridor____________________

Link No.___________________________

Sl No	Locations				Area (m^2)	Distance from Nearest Water Course (m)	Distance from nearest settlement	Existing land use	Prevalent wind direction	Weather in down wind direction (Y/N)	Approved by EO (Y/N)	Remarks
	Name of Village	Chainage (km)	Side (LHS/RHS)	Haul Road Length (m)								

Remarks

Submitted

Signature

Name

Designation
Contractor

Construction Supervision Consultant

Checked
Approved

Signature
Signature

Name
Name

Environmental Engineer.
Executive Engineer CMU

Annexure 39: Establishment of Borrow Areas

(To be submitted by Contractor for taking consent for opening of Borrow area)

Name of Corridor

Link No:

Sl No	Locations				Area (m^2)	Quantity of Available Material	Type of Material	Distance from Nearest Water Course (m)	Distance from the nearest settlement	Land Use		No of trees to be affected	Approved by EO (Y/N)	Remarks
	Name of Village	Chainage (km)	Side (LHS/RHS)	Haul Road Length (m)						Before	After			

Attach Photograph of proposed site, location map, agreement etc.

Rehabilitation plan measures **Location I:** **Location 2:**

Remarks

Submitted	**Checked**	**Approved**
Signature	Signature	Signature
Name	Name	Name

Designation………………..

Contractor Environmental Engineer. Executive Engineer PWD

Construction Supervision Consultant

Annexure 40: Details of Earthwork

(To be filled by the Contractor)

Name of Corridor___________________

Link No.__________________________

Monthly Report for Each Borrow Area under use

Month………………………

Reporting

Date of Submission…………………………..

1.Location of Borrow Area under use

Sl No	Name of Village	Chainage (km)	Side (LHS / RHS)	Haul road length (m)
I				
II				

2. Details of Borrow Areas

2.1	Capacity of the Borrow Area	
2.2	Percentage of the capacity exhausted	
2.3	Total quality of the Earth Excavated (in cum)	
2.4	Quantity of Top Soil removed from the Borrow Areas	
2.5	Location of Top Soil stored removed	
2.6	Quantity of Top Soil stored at the beginning of the month	
2.7	Quantity of Top Soil utilized at the end of the month	
2.8	Location (s) where Top Soil has been utilized (Specify on a location plan)	
2.9	Quantity of earthwork excavation from existing road	
2.10	Total quantity of earthwork reused in cum. (5%)	
2.11	Location disposal (if other than sites) (Specify clearly on a location plan)	
2.12	Quantity of earthwork re-used in fill operation	
2.13	Location of borrow areas in disuse / exhausted	
2.14	Outline a rehabilitation plan for each of the exhausted borrow areas with special reference to Erosion Protection Measures. Also, submit at separate detailed rehabilitation plan for exhausted borrow areas for approval supported adequately with layouts, plans and drawings.	

Submitted	**Checked**	**Approved**
Signature	Signature	Signature
Name	Name	Name
Designation………………..		
Contractor	Environmental Engineer	Executive Engineer (CMU)
	Construction Supervision Consultant	

Annexure 41: Details of WMM Plant

Details of WMM Plant

(To be filled by the Contractor)

Name of Corridor___________________, Link No.__________________________

Monthly Report for Each WMM Plant

Reporting Month…………………………, Date of Submission………………………

1. Environment Features of the surrounding area

1.1	Name and location of WMM Plant (w.r.t. PWD km ch.)	
1.2	Wind direction	
1.3	Name (s), distance population and type of settlements in a 1.5 km radius of site.	

2. Draw Sketch Plan of WMMP clearly indicating distance and approach roads.

3. Details of WMMP and Mitigation Measures taken

3.1	Installed Capacity	
3.2	Average Utilization	
3.3	Make	
3.4	Model	
3.5	Last Serviced	

4. Explain Air Pollution Control Measures taken at the WMMP site

5. Explain Noise Pollution Control Measures taken at the WMMP site

Remark

Submitted	**Checked**	**Approved**
Signature	Signature	Signature
Name	Name	Name
Designation		
Contractor (CMU)	Environmental Engineer	Executive Engineer

Construction Supervision Consultant

Annexure 42: Details of Machinery in Operation

(To be filled by the Contractor)

Name of Corridor____________________

Link No.___________________________

Monthly Report for Each Contract Package

Reporting Month…………………………

Date of Submission………………………

(Attach copy of PPCB emission control certificate every 3 months)

1. Details of Machinery Operation

1.1	Total machinery in operation	
1.2	Number of pavers	
1.3	Number of rollers	
1.4	Number of excavators	
1.5	Number of graders	Nos
1.6	Number of dumpers	Nos
1.7	No. of workshops with repairs facility (furnish location and type of facility provided)	Workshop on Facility Location Provided
1.8	Number of vehicles in repair at each location	
1.9	Umber of oil interceptor provided in each repair / fuelling site	
1.10	Total quantity of oil and wastes recovered in each interceptor during last month.	Oil waste Liters, kg.
1.11	Details of waste disposal. (Whether Sold / Disposed)	

Remarks

Submitted	**Checked**	**Approved**
Signature	Signature	Signature
Name Designation	Name	Name
Contractor (CMU)	Environmental Engineer. Construction Supervision Consultant	Executive Engineer

Construction Supervision Consultant

Annexure 43: Safety Check List

(To be filled by the Contractor)

1 Contract No.

2 Name of Contractor

3 Representations

4 Name of Safety Officer

5 Date of Inspection

Location 1…………………………Location 2…………………………Location 3 ………………………

Adequate at time of Inspection Needs Improvement. Needs Immediate Attention	Location 1			Location 2			Location.3			Remarks
	A	B	C	A	B	C	A	B	C	
General										
House Keeping										
Stacking of Material										
Passageway										
Lighting										
Ventilation										
Others										
Electrical										
Switches										
Wirings										
Fixed Installation										
Portable Lighting										
Portable Tool										
Welding Machine										
Others										
Fire Prevention										
Fire Fighting Appliance										
Dangerous Goods Store										
Gas Welding Cylinders										
Others										

Adequate at time of Inspection Needs Improvement. Needs Immediate Attention	**Location 1**			**Location 2**			**Location.3**			**Remarks**
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	
Others										
Dust Control										
Noise Control										
First Aid Equipment										
Washing Facility										
Latrine										
Canteen										
Provision of Personal Protective										
Helmet										
Eye Protector										
Ear Protector										
Respirator										
Safety Shoes										
Safety Belts										
Others										

Annexure 44: Accident Report

(To be completed on Occurrence of Injury by the Safety Officer)

Type of Accident

D01( )	Fall of person from a height		D11 ( )	Explosion
D02( )	Slip, trip or fall on same level		D12 ( )	Fire
D03( )	Struck against fixed objects		D13 ( )	Contact with hot or corrosive substance
D04( )	Struck by flying or falling objects		D14 ( )	Contact with poisonous gas or toxic substances.
D05( )	Struck by moving objects		D15 ( )	Contact with poisonous gas or toxic substances
D06( )	Struck / caught by cable		D16 ( )	Hand tool accident
D07( )	Stepping on hail etc.		D17 ( )	Vehicle / Mobile plant accident
D08( )	Handling without machinery		D18 ( )	Machinery operation accident
D09( )	Crushing / burying		D19 ( )	Other (please specify)
D10( )	Drowning or asphyxiation			

Agent Involved in Accident

E01 ( )	Machinery		E11 ( )	Excavation / underground working
E02 ( )	Portable power appliance		E12 ( )	
E03 ( )	Vehicle or associated equipment / machinery		E13 ( )	Ladder
E04 ( )	Material being handled, used or stored		E14 ( )	Scaffolding /gondola
E05 ( )	Gas, vapor, dust, fume or oxygen		E15 ( )	Construction formwork, shuttering and false work.
E06 ( )	Hand tools		E16 ( )	Electricity supply cable, wiring switchboard and associated equipment
E07 ( )	Floor edge		E17 ( )	Nail, sllnter or chipping
E08 ( )	Floor opening		E18 ( )	Other (Please specify)
E09 ( )	Left shaft		E19 ( )	
E10 ( )	Stair edge			

Unsafe Action Relevant to the Accident

F01 ( )	Operating without authority		F11 ( )	Failure to use eye protector
F02 ( )	Failure to secure objects		F12 ( )	Failure to use respirator
F03 ( )	Making safety devices inoperative		F13 ( )	Failure to use proper clothing
F04 ( )	Working on moving or dangerous equipment		F14 ( )	Failure to use warn others or given proper signals

F05 ( )	Using un-safety equipment		F15 ( )	Horseplay
F06 ( )	Adopting unsafe position or posture		F16 ( )	No unsafe action
F07 ( )	Operating or working at unsafe speed		F17 ( )	Others (please specify)
F08 ( )	Unsafe loading, Placing, mixing et		F18 ( )	
F09 ( )	Failure to use helmet		F19 ( )	
F10 ( )	Failure to use proper footwear			

G01( )	No protective gear		G08 ( )	Unsafe layout of job, traffic etc.
G02( )	Defective protective gear		G09 ( )	Unsafe process of job methods
G03( )	Improper dress / footwear		G10 ( )	Poor housekeeping
G04( )	Improper guarding		G11 ( )	Lack of warning system
G05( )	Improper ventilation		G12 ( )	Defective tool, machinery or materials
G06( )	Improper illumination		G13 ( )	No unsafe condition
G07( )	Improper procedure		G14 ( )	Others (please specify)

Annexure 45: Road Safety Reporting Formats

Name of Corridor___________________

Link No.__________________________

One time reporting before commencement of construction I the Construction Zone

Sketch of construction zone showing all sub zones and location of signs, etc. to be attached with format

(Reporting by Contractor to CMU)

Format on Acquisition of Temporary diversions to be attached with format

Construction stage: Monthly Report- Date…………………Month………………….Year………………….

DIVERSION NO._____location (km_____)

Sl.No	Item	Unit	Compliance	Remarks
Details of Construction Zone				
1	Length of Construction Zone			
2	Distance between this and next construction zone			
3	Length of transition sub zone (should be min 50 for a sped of 50 km/ hr)			
4	Length of work sub zone in urban stretch (should be <2 km)			
5	Length of work sub zone in rural stretch (5-10 km)			
6	Distance between two work sub zones			
Signage's in Construction Zones				
1	Sign saying 'Men at Work' 1 km ahead of transition sub zone			
2	Supplementary sign saying diversion 1 km provided			
3	Sign saying 'Road Closed ahead' provided			
4	Compulsory Right Turn /Left sign provided			
5	Detour sign placed			
6	Sharp deviation sign placed at end of advance warning sub zone			
Signage in Transition Sub Work Zone				
1	Signage saying 'Keep Right /Left' provided			
2	Delineators placed along length of transition			

Sl.No	Item	Unit	Compliance	Remarks
Signage in work sub zone				
1	Hazard Marker placed where railing for CD structure on diversion starts			
2	Barricade on either side of work sub zone			
Signage in Termination sub zone				
1	Sign for indication of end of work zone 120 m from end of termination sub zone			
Road Delineator				
1	Roadway indicators provided			
2	Hazard Makers provided			
3	Object Makers Provided			

Submitted **Checked** **Approved**

Signature Signature Signature

Name Name Name

Designation………………..

Contractor Environmental Engineer. Executive Engineer CMU

Construction Supervision Consultant

Annexure 46: Redevelopment of Borrow Areas

(To be filled by the Contractor)

Name of Corridor____

Link No.____

Construction stage: Monthly Report-Date_______________Month______________Year

Drawing for Redevelopment to be attached for each Borrow Area (photographs of sites before use & after rehabilitation to be attached)

Sl. No	Borrow Area Location					Borrow Area No	Land use	Rehabilitation Measures	Date of approval of Rehabilitation	Date of Handing Over to Owner	Remarks
	Name of Village	Chainage (km)	Side (LHS/ RHS)	Area (M2)	Haul road length (m)						

Remarks

Submitted | **Checked** | **Approved**

Signature | Signature | Signature

Name | Name | Name

Designation………………..

Contractor | Environmental Engineer. Construction Supervision Consultant | Executive Engineer CMU

Annexure 47: List of PAP due to tunnel and Approach Roads

LIST PAP IN THE SOUTHERN SIDE (KOZHIKODE)			
Sl no	Name and address	To be acquired	Remarks
1	Priya Joseph,)Binu JP(jose nivas, Civil station, Kozhikode, 9544672402	Three vacant buildings and land	She possesses land and buildings in the opening of the tunnel area at Maripuzha. Land and buildings be acquired
2	Prabha Joseph, Palayoor house,Eraneloor PO,Trichur, 9496165119	Land	She possesses land in the opening of the tunnel area at Maripuzha. Land be acquired
3	Sebastian Joseph, Palayoor,Thrissur Mob: 9496165119	Land	His land, house, and other immovable property comes within the alignment. His daughter has also land there.
4	Aneta Jacob, Pichappillil,7907430054	Land	She possesses land in the opening of the tunnel area at Maripuzha. Land be acquired
5	7/523,Jose, Anikudiyil house,Kundanthode,Nellippoil,9605224847	Residential building	His house, toilet, goat shed, cattle shed and around 3acres of land be acquired at Kundanthode
6	Joy Mazhuvanchery, Marippuzha,Anakkampoil	Land	He possesses land in the opening of the tunnel area at Maripuzha. Land be acquired
7	Mani Chemparathi, Marippuzha,Anakkampoil	Land	He possesses land in the opening of the tunnel area at Maripuzha. Land be acquired
8	7/525, Shiju, kuttiyanikkal house, Muthappanpuzha post,PIN-673603,Mob: 701239553	Agricultural land	He possesses land in the opening of the tunnel area. Land be acquired at Kundanthode
9	Sunny joseph,Anakkalunkal house,Marippuzha,Muthappanpuzha post,Mob:9846559008	Agricultural land	He possesses land in the opening of the tunnel area. Land be acquired at Kundanthode
10	Jose,neelur,Marippuzha,Anakkampoil	Land	He possesses land in the opening of the tunnel area at Maripuzha. Land be acquired
LIST PAP IN THE NORTHERN SIDE (WAYANAD)			
Sl no	Name and address	Property to be acquired	Remarks
1	Mustafa,Vellathur house,Meenakshippalam,Meppadi post	Yassin Hotel, and restaurant	Kiosk, be acquired
2	Abdurahiman K T,,Meenakshippalam,	Abdurahman's Tea Shop	Kiosk, be acquired

	Meppadi post,Mob:9526952132	&stationary	
3	Nasil,Peroor house, Konarkad,Meppadi	Grilax Hotel & Restaurant	Portion of land may be acquired
4	Hameed .N, Naduthodi, Thanjilod,meppadi	Tea shop	kiosk
5	Nithinchandran,Southern Adventures,9744447044	Southern Adventure,	Zip line, Must be acquired
6	Akshay,puthankottupalliyel house,Meenakshi,Meppadi post,mobile:8590187535	Sasiyettante chayakkada and parking place	8/670-671,Must be acquired
7	Asraf,Pulikkalakath, Meenakshippalam , Meppadi,7034872474	House and land	8/462,Residential building must be acquired
8	Abubaker,Kulamban,Thanjilod , Meppadi,9074782706	House and land	8/459, Residential building may be acquired. Very close to the road
9	Hussain, Thanjilod ,Meppadi,6282405848	House and land	8/665, Residential building may be acquired
10	Hamsakkutti,Thajilod,Meenakshippalam , Meppadi,8848200531	House and land	8/461, Residential building may be acquired
11	Seithalavi, Kankalath, house,Meenakshippalam, Meppadi, 6238409159	House and land	8/460, Residential building may be acquired
12	8/K S Jagannath, Jagu nivas,Puthan vayal,kalppetta,mobile:9744927826	Absentee landlord	Agricultural land, Land acquisition required
13	8/Meenakshivilas estae,Chooralmala road,Meppadi post,mobile:9745328092	Estate	Portion of land may be acquired
14	KalladiMakham,Meenakshipalam, Meppady	Prayer hall	Must be acquired
15	Padmakumar,Amritha,Chelavoor,kozhikkode 9447025087	Absentee landlord	His land comes within the alignment. Will lose
16	Raveendran Nair,kalliyoor,Chelavur,9447025087	Absentee landlord	His land comes within the alignment. Will lose

17	Moothorakkutty,Malayil,Chelannur, 9447025087	Absentee landlord	His land comes within the alignment.Will lose

Annexure 48: List of PAP due to tunnel and Approach Roads

Sl no	Name of settlement	Area of settlement (in ha)	No of tribal families possessing land	No of landless tribal families	No of non-tribal families possessing land in settlement	No of families possessing record of right
1	Kuppachi Colony	10.53	33	0	0	0
2	Kalladi Colony	2.43	7	0	0	6
3	Mammikkunnu Colony	2.43	7	0	9	5
4	Athichodu Colony	0.08	2	0	0	0
5	Chooralmala Colony	0.40	4	0	0	0
6	Punchirimattom colony	0.20	0	0	0	0
7	Attamalakkuzhi Colony	0.20	3	0	0	0
8	Parappanpara Colony	0.00	0	7	0	0
9	Nellimala Colony	1.26	14	1	0	14
10	Kadasikkunnu Colony	1.54	10	3	0	0
11	Clubmattam colony	0.11	12	0	0	0
12	Vattakundu Colony	12.15	46	0	0	0
13	Aranamala Adivasi colony	61.62	43	0	0	23
14	Olakkunnu Naika Colony	4.86	9	0	0	0
15	Anappara Naika Colony	8.10	13	0	0	0
16	AnakkaduAdivasiColony	4.86	29	2	0	0
17	Kottathara Wayal Paniyar Colony	0.51	6	0	0	0
18	Idinjakkolli Adivasi Colony	24.29	36	4	0	33
19	Vellakkettu Adivasi Colony	7.69	20	1	0	17
20	Vengachola AdivasiColony	32.39	46	4	0	40
21	Govindappara Adivasi Colony	10.93	33	0	0	30
22	Jaihind Colony	25.07	97	7	0	22
23	Kallumala Colony	12.15	82	0	38	120
24	Kariyatthanpara	1.75	7	2	0	0
25	Kolppara	6.82	25	0	0	0
26	Rattakkolli	1.70	13	7	0	0
27	Ambukuthi	1.91	6	3	0	0
28	Arambukuthi	0.27	16	3	0	0
29	Chullimoola	0.16	5	15	0	0
30	Kuttamangalam	1.42	3	3	0	0
31	Ambalakkunnu	1.21	8	0	0	0
32	Valiyammoola Colony	16.19	2	3	0	0

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The Biological Survey Team and Contributors

Dr Shaji P K Approved Expert of Ecology and Biodiversity with nearly 30 years of experience.

Mr. Arjun K. - Botanist with nearly 6 years of research experience.

Aranyakam Nature Foundation Team

Dr. P. S. Easa: Scientist with about forty-seven years of experience in wildlife research and management

Dr. Sandeep Das: Scientist with about 13 years of experience especially on herpetofauna and birds

Dr. Manju C. Nair: Scientist with about 25 years of experience in Bryophyte plants

Dr. K. P. Rajesh: Scientist with about 25 years of experience in Pteridophyte plants

Shri S. Dhruv Raj: A Naturalist with expertise in birds and herpetofauna

Dr. K. P. Rajkumar: Scientist with about10 years of experience in herpetofauna and birds

Dr. B. Mufeed: An expert on bryophyte plants with about seven years of experience

Ms. C. Karthika: An expert on birds currently pursuing her Ph D work on birds.

Dr. Dhaneesh Bhaskar: An expert on Grass Hoppers and animal ecology with about 12 years of experience.

Shri Nithin Divakar: An expert on Bats currently doing his Ph D on bats.

Shri K. A. Ahammed Javad: A Naturalist with good experience in Reptiles.

Shri C. P. Nidheesh: A Naturalist with expertise on amphibians

Shri Fidal R. Babu: A Herpetofauna student with considerable exposure to field surveys.

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Shri Hari Lal (Forest Range Officer), Shri K. Mani (Section Forest Officer) Shri K. C. Sivaraman (Section Forest Officer), Shri Jomish K. Johny (Beat Forest Officer), Shri Nithin (Beat Forest Officer), Ms. Ancy Pathrose (Beat Forest Officer), Smt. K. K. Sajini (Beat Forest Officer) and Shri Akbar Ali (Forest Watcher) of Meppadi Range.