Rail Infrastructure Development Company (Karnataka) Limited

Draft EIA Report

Preparation of Environmental Impact Assessment Report for Bengaluru Suburban Railway Project

March 2024

2021-22/URBN/OTH/032/EIA&SIA -Rev-04

Submitted by:

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Project Name	Preparation of Environmental Impact Assessment Report and Social Impact Assessment Report for Bengaluru Suburban Railway Project
Document Name	Draft Environmental Impact Assessment (EIA) Report
Document No.	2021-22/URBN/OTH/032/EIA&SIA - Rev-04
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Abbreviations

AAQ	:	Ambient Air Quality
AC	:	Alternating Current
AFC	:	Automatic Fare Collection
AMSL	:	Above Mean Sea Level
AP-HRA	:	Air Pollution Health Risk Assessment
AR	:	Assessment Report
ART	:	Accident Relief Train
ASI	:	Archaeological Survey of India
ASS	:	Auxiliary Sub Station
ATM	:	Automated Teller Machine
BBMP	:	Bruhat Bengaluru Mahanagara Palike
BD	:	Business Development
BDA	:	Bengaluru Development Authority
BEL	:	Bharat Electronics Limited
BEML	:	Bharat Earth Movers Limited
BESCOM	:	Bengaluru Electricity Supply Company
BG	:	Broad Gauge
BIAAPA	:	Bengaluru International Airport Area Planning Authority (BIAAPA)
BMA	:	Bengaluru Metropolitan Area
BMR	:	Bengaluru Metropolitan Region
BMRCL	:	Bengaluru Metro Rail Corporation Limited
BMRDA	:	Bengaluru Metropolitan Region Development Authority
BMTC	:	Bengaluru Metropolitan Transport Corporation
BMTPC	:	Building Materials and Technology Promotion Council
BNC	:	Bengaluru Cantonment
BOD	:	Biochemical Oxygen Demand
BOQ	:	Bill of Quantity
BQL	:	Below Quantifiable Level
BRT	:	Bus Rapid Transit
BS	:	Bharat Stage
BSNL	:	Bharat Sanchar Nigam Limited
BSRP	:	Bengaluru Suburban Railway Project
BT	:	Bio-Technology
BWSSB	:	Bengaluru Water Supply and Sewerage Board
CAIR	:	Centre for Artificial Intelligence & Robotics
CATC	:	Continuous Automatic Train Control
CAMPA	:	Compensatory Afforestation Fund Management & Planning Authority
CBO	:	Community Based Organizations
CBTC	:	Communications Based Train Control
CD	:	Cross Drainage
CDM	:	Clean Development Mechanism
CDR	:	Carbon Dioxide Removal
CER	:	Certified Emission Reductions
CGWB	:	Central Ground Water Board
CII	:	Confederation of Indian Industry

CO	:	Carbon Monoxide
COD	:	Chemical Oxygen Demand
COVID	:	Corona Virus Disease
CPCB	:	Central Pollution Control Board
CPHEEO	:	Central Public Health & Environmental Engineering Organisation
CRS	:	Commuter Rail Services
CSDR	:	Channasandra Station
CW	:	Compound Wall
dB	:	decibel
DBA	:	decibels A
DC	:	Direct Current
DCF	:	Deputy Conservator of Forest
DC&PR	:	Development Controls & Promotion Regulations
DG	:	Diesel Generator
DHL	:	Devanahalli
DIZ	:	Direct Impact Zone
DLRO	:	District Land Revenue Officer
DMA	:	Disaster Management Authority
DMD	:	Disaster Management Division
DMP	:	Disaster Management Plan
DMRC	:	Delhi Metro Rail Corporation
DMU	:	Diesel Multiple Units
DO	:	Dissolved Oxygen
DPR	:	Detailed Project Report
DRDO	:	Defence Research and Development Organisation
DRMAP	:	Disaster Risk Management Action Plan
DTG	:	Distance To Go
DVA	:	Dynamic Vibration Absorber
EA	:	Environmental Assessment
EAC	:	Expert Appraisal Committee
EB	:	Emergency Brake
ECR	:	Environmental Compliance Report
EHS	:	Environmental, Health and Safety
EHSG	:	Environmental, Health and Safety Guidelines
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
EMC	:	Electro Magnetic Compatibility
EMF	:	Environmental Management Framework
EMI	:	Electro Magnetic Interference
EMAP	:	Environmental Management Action Plan
EMoP	:	Environmental Monitoring Plan
EMP	:	Environmental Management Plan
EMPIU	:	Environmental Management Plan Implementation Unit
EMS	:	Environmental Management System
EMU	:	Electric Multiple Unit
ENIECO	:	Esperto Novero Inspection and Engineering Consultancy
ENPV	:	Expected Net Present Value
ESA	:	Environmental and Social Assessment
ESDD	:	Environmental and Social Due Diligence
ESF	:	Environmental Survey Format
ESIA	:	Environmental and Social Impact Assessment

ESS	:	Environmental and Social Standards
ETP	:	Effluent treatment plant
EUR	:	Euro
FAR	:	Floor Area Ratio
F&A	:	Finance and Administration
FGD	:	Focus Group Discussions
FIRR	:	Financial Internal Rate of Return
FHWA	:	Federal Highway Administration
FOB	:	Foot Over Bridge
FTA	:	Federal Transit Administration
FY	:	Financial Year
GC FID	:	Gas Chromatograph-Flame Ionization Detection
GCP	:	Ground Control points
GDP	:	Gross Domestic Product
GHG	:	Green House Gases
GIIP	:	Good International Industry Practice
GoI	:	Government of India
GoK	:	Government of Karnataka
GRC	:	Grievance Redress Committee
GRM	:	Grievance Redressal Mechanism
GRP	:	Glass-Reinforced Plastic
GSDP	:	Gross State Domestic Product
GST	:	Goods and Services Tax
GW	:	Ground Water
HAL	:	Hindustan Aeronautics Limited
HAM	:	Hecto Meter
HC	:	Hydro Carbon
HIV/AIDS	:	Human Immunodeficiency Virus/ Acquired Immuno-Deficiency Syndrome
HMP	:	Hot Mix Plants
HMT	:	Hindustan Machine Tools
HT	:	High Tension
HVAC	:	Heating, Ventilation, and Air Conditioning
ICNIRP	:	International Commission on Non-Ionizing Radiation Protection
ICT	:	Information and Communication Technology
ICTC	:	Information Communication & Technology Centre
IET	:	International Emission Trading
IFC	:	International Finance Corporation
IGBC	:	Indian Green Building Council
IIZ	:	Indirect Impact Zone
ILO	:	International Labour Organization
IMD	:	India Meteorological Department
INR	:	Indian Rupee
IPCC	:	Intergovernmental Panel on Climate Change
IPT	:	Intermediate Public Transport
IR	:	Indian Railways
IRC	:	Indian Road Congress
IRS	:	Indian Railway Standard
ISO	:	International Organization for Standardization
IT	:	Information Technology
IUCN	:	International Union for Conservation of Nature

JPD	:	Joint Project Director
KAMASR	:	Karnataka Ancient Monuments and Archaeological Sites and Remains Act
KfW	:	Kreditanstalt für Wiederaufbau
KIA	:	Kempegowda International Airport
KIADA	:	Karnataka Industrial Areas Development Act
KIADB	:	Karnataka Industrial Areas Development Board
KLD	:	Kilo Litres per Day
Km	:	Kilo Meter
kmph	:	Kilo Meter Per Hour
KPTCL	:	Karnataka Power Transmission Corporation Limited
KPWD	:	Karnataka Public Works Department
K RIDE	:	Rail Infrastructure Development Company (Karnataka) Limited
KSPCB	:	Karnataka State Pollution Control Board
KV	:	Kilo Volt
L&PC	:	Land and Project Coordination
Lday	:	Day Noise Level
Leq	:	Equivalent Continuous Sound Pressure Level
LHS	:	Left Hand Side
LiDAR	:	Light Detection and Ranging
Lnight	:	Night Noise Level
LOQ	:	Limit of Quantification
LS	:	Level Crossing
LS	:	Lump Sum
LULC	:	Land Use Land Cover
MD	:	Managing Director
MENL	:	Maximum Environmental Noise Levels
ml	:	Milli Litre
MoEF&CC	:	Ministry of Environment, Forest & Climate Change
MoHUA	:	Ministry of Housing and Urban Affairs
MPN	:	Most Probable Number
MRTS	:	Mass Rapid Transit System
MSK	:	Medvedev–Sponheuer–Karnik
MSW	:	Municipal Solid Waste
NABL	:	National Accreditation Board for Testing and Calibration Laboratories
NBWL	:	National Board for Wildlife
NDIR	:	Non Dispersive Infra-Red
NDMA	:	National Disaster Management Authority
NDRF	:	National Disaster Response Force
NEC	:	National Executive Committee
NGEF	:	New Government Electrical Factory
NGO	:	Non-Government Organisations
NGEF	:	New Government Electrical Factory
NHAI	:	National Highway Authority of India
NIDM	:	National Institute of Disaster Management
NIHL	:	Noise Induced Hearing Loss
NMT	:	Non-Motorized Transport
NO	:	Nitrous Oxide
NOC	:	No Objection Certificate
NRSC	:	National Remote Sensing Center

NTU	:	Nephelometric Turbidity Unit
OCC	:	Operation Control Centre
ODA	:	Official Development Assistance
OFC	:	Optical Fibre Cables
OHE	:	Overhead Equipment
OHSAS	:	Occupational Health and Safety Assessment Series
PA	:	Protected Areas
PAF	:	Project Affected Family
PAP	:	Project Affected Persons
PF	:	Providend Fund
PHPDT	:	Passengers Per Hour Per Direction
PIA	:	Project Implementation Authority
PIS	:	Passenger Information System
PIU	:	Project Implementation Unit
PM	:	Particulate Matter
POH	:	Periodic Overhaul
PPE	:	Personal Protective Equipment
PPP	:	Public Private Partnership
PPV	:	Peak Particle Velocity
PRS	:	Proposed Railway Station
PS	:	Performance Standards
PSD	:	Platform Screen Doors
PT	:	Public Transport
PUC	:	Pollution Under Control
PVC	:	Polyvinyl Chloride
PWD	:	Public Works Department
RAP	:	Resettlement Action Plan
RDSO	:	Research Design and Standards Organisation
REET	:	Rare Endangered Endemic and Threatened
RFCTLARR	:	Right to Fair Compensation and Transparency in land Acquisition, Rehabilitation and Resettlement
RHS	:	Right Hand Side
RITES	:	Rail India Technical and Economic Service
RMC	:	Ready Mix Concrete
RMS	:	Root Mean Square
RO	:	Reverse Osmosis
ROB	:	Road Over Bridge
RoW	:	Right of Way
RS	:	Railway Station
RUB	:	Road Under Bridge
SAR	:	Sodium Absorption Ratio
SB	:	Safe Brake
SBC	:	Bengaluru City Station
SDG	:	Sustainable Development Goals
SDMA	:	State Disaster Management Authorities
SEAC	:	State Level Expert Appraisal Committee
SEC	:	State Executive Committee
SEIAA	:	State Level Environment Impact Assessment Authority
SEP	:	Stakeholder Engagement Plan
SNCF	:	Société Nationale des Chemins de Fer Français
SO2	:	Sulphur dioxide

SOI	:	Survey of India
SOP	:	Standard Operating Procedure
SP	:	Sectioning and-Paralleling Post
SPCB	:	State Pollution Control Board
SPM	:	Suspended Particulate Matter
SPV	:	Special Purpose Vehicle
SQ	:	Soil Quality
sq.m.	:	Sqaure Meter
SR	:	Schedule of Rates
SSP	:	Sub-Sectioning and Paralleling Post
STD	:	Sexually Transmitted Diseases
STP	:	Sewage Treatment Plant
SW	:	Surface Water
SWR	:	South Western Railway
tCO2e	:	Tonnes of Carbon Dioxide Equivalent
TDS	:	Total Dissolved Solids
TM	:	Traction Motor
TSS	:	Traction Sub Stations
TV	:	Tele Vision
UG	:	Under Ground
UK	:	United Kingdom
ULB	:	Urban Local Body
UNFCCC	:	United Nations Framework Convention on Climate Change
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
UNISDR	:	United Nations International Strategy for Disaster Reduction
USEPA	:	United States Environmental Protection Agency
UPS	:	Uninterruptible Power Supply
VCF	:	Value Capture Finance
VOC	:	Vehicle Operating Costs
WB	:	World Bank
WBESF	:	World Bank Environmental and Social Framework

Abbreviations of Stations

BAND	:	Banaswadi
BAW	:	Chikkabanavara
BNC	:	Bengaluru Cantonment
BNCE	:	Bengaluru East
BWT	:	Bangarpet
BYPL	:	Baiyyappanahalli
CBP	:	Chikkaballapura
CSDR	:	Channasandra
DHL	:	Devanahalli
DMM	:	Dharmavaram
HAS	:	Hassan
HEB	:	Hebbal
HLE	:	Heelalige
HSRA	:	Hosur
JTJ	:	Jolarpettai
KDGH	:	Kodigehalli
KGI	:	Kengeri

KJM	:	Krishnarajapuram
KQZ	:	Kolar
KSR	:	Kranti Veera Sangolli Rayanna
LOGH	:	Lottegollahalli
MWM	:	Malleswaram
NMGA	:	Nelamangala
NYH	:	Nayandanahalli
RNN	:	Rajanukunte
SA	:	Salem
SBC	:	Bengaluru City
TK	:	Tumakuru
WFD	:	Whitefield
YNK	:	Yelahanka
YPR	:	Yeshawantapur

Weights, Measures And Units

dB (A)	:	A-weighted decibel
ha	:	hectare
km	:	Kilometre
Cum	:	Cubic meter
km2	:	square kilometer
KWA	:	kilowatt ampere
Leq	:	equivalent continuous noise level
meq/L	:	milli-equivalents per liter
mg/kg	:	milligram/kilogram
ml	:	Millilitre
NTU	:	Nephelometric Turbidity Unit
ppm	:	parts per million
µg	:	microgram
µs/cm	:	micro siemens per centimeter
m	:	meter
MW	:	megawatt
PM 2.5	:	particulate matter of 2.5-micron size
PM 10	:	particulate matter of 10-micron size

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Chapter 1. Non-Technical Summary

1.1. Introduction

1.1.1. Project Background

Bengaluru population has been growing faster. There has been a phenomenal growth in the population of vehicles as well, especially the two and four wheelers in this period due to rising household incomes. In the absence of adequate public transport system, people are using the personalized modes which is not only leading to congestion on limited road network but also increasing environmental pollution. An average citizen of Bengaluru spends more than 240 hours stuck in traffic every year. Such delays result in loss of productivity, reduced air quality, reduced quality of life, and increased costs for services and goods.

Hence, to overcome the above issue, K RIDE has proposed to implement Bengaluru Suburban Railway Project (BSRP), which is a new Suburban Railway Project envisaging construction of 4 dedicated rail corridors in a period of 6 years. It will link Bengaluru to its satellite townships, suburbs, surrounding areas and provide a mass rail based rapid transit system. K RIDE is a Joint venture of Government of Karnataka and the Ministry of Railways. It has been created to boost "Rail Infrastructure Projects" in the state of Karnataka on the principle of cooperative federalism.

The BSRP corridors are proposed along the existing Indian Railway alignment. BSRP corridors passes through urban agglomerates and also intersect multiple major railway stations. A feasibility study of the project corridors was undertaken by M/s RITES Ltd. to assess the techno-economic feasibility of the project in the year 2019. Total length of the suburban rail is 159.360 Km. Salient features of BSRP Corridors are presented in **Table 1.1**. Key map of the Bengaluru Suburban Railway Project corridors are presented in **Figure 1.1**.

Corridor – 1: KSR Bengaluru City to Devanahalli (47.380Km),

Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara (28.720Km),

Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment) (35.52Km) &

Corridor – 4: Heelalige to Rajanukunte (47.74Km).

Table 1.1. Salient Features of BSRP Corridors

Sl. No.	Item Description	Corridor 1		Corridor 2	Corridor 3		Corridor 4
		KSR Bengaluru City to Devanahalli	Airport Line	Baiyappanahalli Terminal to Chikkabanavara	Kengeri to Cantonment	Cantonment to Whitefield	Heelalige to Rajanukunte
1.	Length of corridor (Km)	41.43	5.95	28.72	18.47	17.05	47.74
2.	Length of elevated section (Km)	18.98	3.55	9.25	10.40	-	9.48

Sl. No.	Item Description	Corridor 1		Corridor 2	Corridor 3		Corridor 4
		KSR Bengaluru City to Devanahalli	Airport Line	Baiyappanahalli Terminal to Chikkabanavara	Kengeri to Cantonment	Cantonment to Whitefield	Heelalige to Rajanukunte
3.	Length of At-Grade section (Km)	22.45	2.40	19.47	8.07	17.05	38.27
4.	Number of stations	15	2	15	9	5	23
5.	No. of Elevated stations	8	2 (cut & cover)	3	3	-	3
6.	No. of At-Grade stations	7		10	5	5	16
7.	No. of future stations	0		2	1	Quadrupling section	4
8.	No. of Interchange stations	3	Nil	2	1		1
9.	No. of Existing ROB on the corridor	10		6	3		6
10.	No. of Existing FOB on the corridor	6		3	5		0
11.	No. of Existing LCs on the corridor	10		11	3		11
12.	No. of LCs' under sanction for RUB/ROB	1		2	1		2
13.	No. of Existing LCs to be eliminated in At-Grade locations	6		7	1		11
14.	No. of LCs where Suburban track is elevated	3		3	1		1
15.	Private Land to be acquired (Vacant / Built-up) Ha	4.9		2.07	8.39	-	16.31
16.	Private land required for Depots (Devanahalli and Soladevenahalli), area in Ha	25.21					

Source: Feasibility Report prepared by RITES Consultant for BSRP Project in 2019 & Design updation as on 04.12.2023.

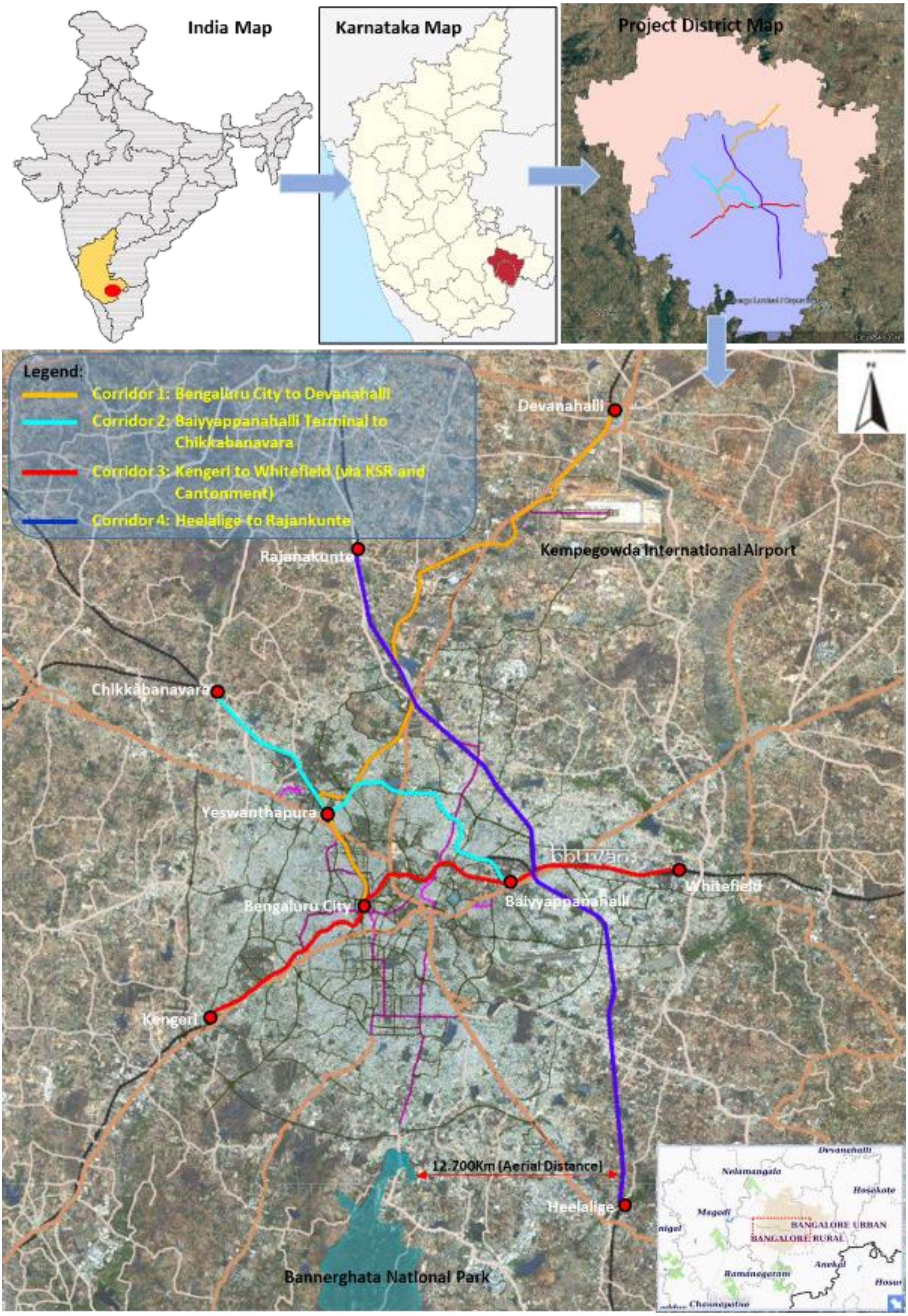

Figure 1.1. Key Map of the Bengaluru Suburban Railway Project Corridors

This Environmental Impact Assessment (EIA) report presents the findings of environmental assessment of the proposed BSRP and the Environmental Management Plan (EMP) to minimise or mitigate the risks and impacts identified. Guidelines formulated by World Bank's Environmental Social Standards, guidance note, General EHS guidelines and Railway specific EHS Guidelines and other relevant Good International Industry Practices (GIIPs) and guidelines stipulated in Environmental Impact Assessment Notification for linear projects by MoEFCC were referred in preparation of EIA. Following are the broad scope of the work for preparation of EIA report;

i. To conduct Environmental Impact Assessment (EIA) and identify potential environmental impacts to be considered in the design of BSRP and recommend specific measures to avoid/mitigate the impacts.
ii. To formulate an implementable Environmental Management Plan (EMP) integrating the measures to avoid the identified impacts and an appropriate monitoring and supervision mechanism to ensure EMP implementation.
iii. To review the proposed alignment and other components and identify possible environmental issues to be addressed during planning, design, construction and operation of the project.
iv. To recommend suitable institutional mechanisms to monitor and supervise effective implementation of EMP.
v. To evaluate appropriate alternative options for alignments, Stations, Depots and Technology
vi. To carryout adequate public interactions/stakeholder consultation to disseminate the project information and to gather opinions/suggestions for environmental aspects
vii. To prepare EIA report including EMP as per the MoEFCC requirements and the formats of external funding agencies like WB, KfW & EIB etc.,

1.2. Environmental Regulatory Framework

A review of the relevant National and State legislations and institutions applicable to this project were undertaken. Also applicability of the environmental policies of external funding agencies were also reviewed for the project.

As per the State and National legislations following are the environmental regulations applicable for the project.

Table 1.2. Environmental Permits / Approvals Required for the BSRP Corridors

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
Pre-Construction Phase						
1.	Forest Clearance under Forest (Conservation) Act	Forest (Conservation) Act, 1980 and amendments	Diversion of forest land for Akkupete Depot	PIA/EMU	8-12 months	Forest Department & MoEFCC
2.	Permission for felling of trees and	The Karnataka Preservation of	Felling of trees along proposed	PIA/EMU	6-8 months	BBMP Forest wing/Forest Department

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
	compensatory Afforestation	Trees Act, 1976 and amendments	BSRP alignment & Stations			
3.	Prior permission to be obtained under The Ancient Monuments and Archaeological Sites and Remains Act	The Ancient Monuments and Archaeological Sites and Remains Act, 1958 and it's Amendment, 2010	Construction of Station and Rail alignment at Devanahalli	PIA/EMU	4-6 months	National Monument Authority
4.	Construction Railway within buffer zone of Lakes	Karnataka Tank Conservation and Development Authority Act, 2018	Crossing/ abutting in buffer zone of Lakes	PIA/EMU	2-3 months	Karnataka Tank Conservation and Development Authority
5.	Consent to Establish & Operate under Air and Water Acts	Water(Prevention and Control of Pollution)Act, 1974 & Air(Prevention and Control of Pollution) Act,1981	Railway Locomotive Workshop	PIA/EMU	2-3 months	Karnataka Pollution Control Board
6.	Building Permissions for Depot, stations and property development	Respective Building bylaws	Before Construction	PIA/EMU	2-3 months	BBMP / Municipal Corporation
7.	Utility/traffic diversion	Respective Acts and Rules	Before Construction	PIA/EMU	2-3 months	Local Offices of respective Authorities such as RTO, BESCOM, BWSSB, Telecom Dept., etc.
8.	Consent to Establish construction yards, labour camps, stations and Depot	Water(Prevention and Control of Pollution)Act, 1974 & Air(Prevention and Control of Pollution) Act,1981	Before Construction	Contractors/PIA /EMU	2-3 months	Karnataka State Pollution Control Board (KSPCB) and Development Authority for

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
	(since non-residential)					land use clearance
9.	Sites to establish labour camps, pre-casting and material yards	Air(Prevention and Control of Pollution) Act,1981	Before Construction	Contractors/PIA /EMU	2-3 months	BBMP / Municipal Corporation
		Land use Master Plan and DC&PR	Before Construction	Contractors/PIA /EMU	2-3 months	
Construction Phase						
10	Consent for Establishment and Operation of Hot Mix Plants (HMP), Crushers, Batching Plants, etc.	Water(Prevention and Control of Pollution)Act, 1974 & Air(Prevention and Control of Pollution) Act,1981	Construction	Contractors	2-3 months	Karnataka State Pollution Control Board (KSPCB)
11.	Consent for Establishment of labour camps		Construction	Contractors	2-3 months	BBMP / Municipal Corporation
12.	Permission for drawl of ground water for construction (not recommended)	Environment (Protection) Act, 1986	Construction	Contractors	2-3 months	Regional Director, Central Ground Water Board and Municipal Corporation
13.	Permission to store and Authorization for Disposal of Hazardous Waste	Hazardous Waste(Management and Handling and trans boundary movement) Rules, 2016	Construction	Contractors	2-3 months	Karnataka State Pollution Control Board (KSPCB)
14.	Consent for disposal of waste water from construction sites and sewage from labour camps	Water (Prevention and Control of Pollution) Act, 1974	Construction	Contractors	2-3 months	Karnataka State Pollution Control Board (KSPCB)

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
15.	PUC certificate for vehicles for construction	Environment (Protection) Act, 1986	Construction	Contractors	1-2 months	Transport Department of Karnataka
16.	Labour employment, safety, health/welfare measures and labour license	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Construction	Contractors	2-3 months	District Labour Commissioner
17.	Permission for management of C&D waste and muck	Construction and Demolition Waste Management Rules, 2016	Construction	Contractors	2-3 months	BBMP/Municipal Corporation and Karnataka State Pollution Control Board (KSPCB)
Operation Phase						
18.	Consent for Operation to Operate Depot	Environment Protection Act, 1986	After construction	PIA /EMU	2-3 months	Karnataka State Pollution Control Board (KSPCB)
19.	Installation and operation of DG sets at stations	Air (Prevention and Control of Pollution) Act, 1981	After construction	PIA /EMU	2-3 months	Karnataka State Pollution Control Board (KSPCB)

The project does not have any risks and impacts on Protected areas, MoEFCC notified Critically Polluted Area, UNESCO's World Heritage sites and Ramsar Wetlands. However, project requires forest land diversion, Archaeological clearance, CFE and CFO from KSPCB and tree felling prior to construction stage. Except Archaeological clearance, the remaining permissions are to be obtained from State agencies. At present, applications for Forest Clearance (for diversion of 18.6Ha of forest land for Akkupete Depot for Corridor 1), Archaeological clearance and Tree felling permission (for Corridor 2) has been submitted.

Forest Clearance: As mentioned above, application for diversion of forest land has been submitted in online web-portal (applicable only for Corridor 1). The application was accepted by Nodal Officer (forest Conservation) for its completion and asked to submitted the hardcopy of the application to Deputy Conservator of Forest, Bengaluru Rural District for field verification and further process. Accordingly, hard copy of the Forest Clearance application was submitted to Deputy Conservator of Forest, where verification of forest land & compensatory afforestation land and enumeration of trees are under progress. Further to obtain Stage-I Forest Clearance requires 6 to 8 months and Stage-II Forest Clearance requires 3-4 months.

Tree Felling Permission: For Corridor 2, Application for felling of 661 trees has been submitted. Out of which, permission for translocation of 58 trees and felling of 268 trees has been issued by the BBMP forest wing. Verification of remaining trees is under progress by the department. Further, tree felling application for 1,430 trees and 764 trees for Corridor 2 has been submitted.

Application for tree felling permission for remaining corridors will be submitted as and when the executive agency was appointed by K RIDE.

Archaeological clearance: An dully filled application form has been submitted to Archaeological department for obtaining clearance for ASI monuments located near Devanahalli Station on Corridor 1. A joint site visit has been completed and obtaining clearance is under progress.

Status on Permissions/approvals obtained by Contractor for Corridor 2: Status of clearances obtained by the Contractor prior to contruction is presented in Section 3.6.8.

Further , project will have potential risks & impacts on air, noise, vegetation, cultural heritage and health and safety issues to labours and community establishment during construction phase. Considering the above, project is categorised as “A Category - High Environmental and Social Risks” under KfW’s environmental and social safeguard policy. As per EIB’s Environmental and Social Standards, the project is categorized as “High Risk”. Hence, project requires detailed Environmental and Social Assessment.

1.3. Baseline Environmental Profile

Field inspections/investigations were conducted to collect sensitive receptors details, collection of secondary information, designing baseline environmental monitoring networks and to disseminate project information and to gather public opinion. This helps in developing the baseline environmental profile for the project. The environmental investigation were conducted with i) direct impact zone and ii) indirect impact zone. As part of the study, baseline environmental monitoring was conducted for environmental attributes such as air, noise, vibration, water (surface & ground water) and soil. Baseline environmental monitoring was conducted through NABL accredited land M/s Enviro Solutions & Labs, Coimbatore in the month of March & April 2022. Ambient vibration study was conducted through M/s. Esperto Novero Inspection and Engineering Consultance (ENIECO) Pvt. Ltd. between 23rd March, 2022 to 5th April, 2022. Collected data were collated and analyzed to derive the baseline environmental condition of the project. The proposed BSRP alignment falls in Bengaluru Urban and Bengaluru Rural Districts.

Baseline environmental profile of the project was studied for six environmental components such as i) land environment, ii) water environment, iii) air environment, iv) noise environment, v) biological environment and vi) socio-economic environment to understand the environmental sensitivity of the project.

Land Environment: All the project corridors are passing through plain to undulating terrain. As the project corridor is proposed adjacent to existing Indian Railway alignment, topographic corrections (cutting & filling) will be carried out to maintain the gradient as per Indian railway guidelines. Granite and gneiss rock formations are predominantly covered in the project districts. Land use of the proposed suburban railway alignment is predominantly passes through built-up area followed by agriculture, water bodies, barren land etc., BSRP stations are proposed to integrate with existing Indian railway stations, wherever feasible. Further, five new stations are proposed within Indian Railway land ie,. Srirampura, Kaverinagar, Jalahalli, RV college, a station between Airport KIADB Station and Devanahalli Station, a station between Mathikere and Doddanakundi Station and

Bommasandra. Two depots are proposed at Soladevanahalli (private land) and Akkupete village near Devanahalli (forest land).

Soil quality monitoring was undertaken in the project facilities to establish the baseline condition. Soil samples were collected in four locations for Corridor 1, three locations in Corridor 2, four locations in Corridor 3 and five locations in Corridor 4. Criteria for collection of soil samples are landuse, potential polluted areas, etc., Results of the soil quality monitoring reveals that, there are no contamination of soil either from present landuse activities or from the existing Indian railway operation.

Water Environment: The BSRP corridor are proposed along the existing Indian Railway alignment. Hence, the proposed BSRP alignment is not passing through the water bodies. There are no perennial rivers crossing in the project alignment. Corridor 1 railway alignments abuts three lakes along its path, whereas Corridor 4 abuts four lakes. However, necessary care has been taken in designing the railway alignment to keep away from the lake bunds. The BSRP corridors crosses Rajakaluves/storm water drains at 89 locations. The BSRP corridors are mainly passes through Bengaluru Urban areas, where these water bodies are highly contaminated with sewage water. This is evident from field verifications and baseline water quality monitoring. Appropriate measures will be taken during construction phase to avoid further deterioration of these water bodies.

As part of baseline environmental monitoring, surface and ground water quality monitoring were undertaken by engaging NABL accredited Laboratory for BSRP corridors. The surface water samples were collected and analysed as per the procedures specified in Class C of IS: 2296 specifications. Surface water quality monitoring was carried out at 37 locations, out of which seven locations in Corridor 1, eight locations in Corridor 2, ten locations in Corridor 3 and twelve locations in Corridor 4. Samples were collected from lakes and Rajakaluves/storm water drains abuts/crosses along the BSRP corridors. The outcome of the surface water quality are reveals as follows;

For Corridor 1, all the surface water quality parameters falls within permissible limits of IS: 2296 Standards except for Biological Oxygen Demand and Total Coliform.

For Corridor 2, TDS, Nitrate, Biological Oxygen Demand and Total Coliform values exceed the permissible limits of IS: 2296 Standards in all the monitoring locations. However, the remaining parameters for all the monitoring locations are falling within the permissible limits of IS: 2296 Standards.

For Corridor 3, TDS values exceeds permissible limits of IS: 2296 Standards in Drain at Chikkadabasandra (SW8) and Nitrate values are exceeding in the locations from Drain at Dubasipalya (SW1), Drain at Chikkadabasandra (SW8), Drain near Ayyappanagar (SW9) and Drain near Whitefield (SW10). Further, Biological Oxygen Demand and Total Coliform values exceeds the permissible limits of IS: 2296 Standards in all the monitoring locations. However, the remaining parameters for all the monitoring locations are falling within the permissible limits of IS: 2296 Standards.

For Corridor 4, TDS values exceeds permissible limits of IS: 2296 Standards in Gottamaranahalli Lake (SW1) and a canal near Panathur (SW5). Chloride value exceeds in Gottamaranahalli lake (SW1) and Nitrate values are exceeding in the locations from Gottamaranahalli lake (SW1), a canal near Panathur (SW5) and Canal near Geddalahalli (SW9). Further, Biological Oxygen Demand and Total Coliform values exceeds the permissible limits of IS: 2296 Standards in all the monitoring locations. However, the remaining parameters for all the monitoring locations are falling within the permissible limits of

IS: 2296 Standards. Overall the water in the monitored sites is not suitable for drinking without proper treatment and disinfection process.

Ground water quality monitoring was carried out at 23 locations, out of which five locations in Corridor 1, three locations in Corridor 2, six locations in Corridor 3 and nine locations in Corridor 4. Samples were collected from open and bore wells near the BSRP corridors. The ground water samples were collected and analysed as per the procedures specified in IS: 10500 Drinking Water specifications.

For Corridor 1, Ground water is neutral in nature in samples collected in Corridor 1. Nitrates value in bore well in KSR Bengaluru (GW1) and bore well in Yelahanka (GW3) is exceeding the Permissible limits of IS:10500 Standards and Total Nitrogen is exceeding the permissible limits of IS:10500 Standards in bore well in KSR Bengaluru (GW1). Ground water parameters of remaining locations are falling within the permissible limits of IS: 10500 standards.

For Corridor 2, Ground water is neutral in nature in samples collected in Corridor 2. Nitrates and Total Nitrogen are found slightly on higher side in bore well in Shettyhalli (GW3) which is exceeding the permissible limits of IS:10500 Standards. Ground water parameters of remaining locations are falling within the permissible limits of IS: 10500 Standards.

For Corridor 3, Ground water is slightly alkaline in samples collected in Corridor 3. Colour, Turbidity, Nitrates and Total Nitrogen are exceeding the permissible limits of IS:10500 Standards. Nitrates and Total Nitrogen is exceeding the permissible limits of IS:10500 Standards in bore well in Sarvangnya Nagar (GW4). Ground water parameters of remaining locations are falling within the permissible limits of IS: 10500 Standards.

For Corridor 4, Ground water is slightly alkaline in samples collected in Corridor 4. Nitrates value is exceeding the permissible limit of IS:10500 in bore well in Heelalige (GW1), Open Well at Gattahalli (GW2), bore well in Marathahalli (GW4) and bore well in Hennur (GW6) and Total Nitrogen is exceeding the permissible limits of IS:10500 Standards in bore well in Heelalige (GW1), Open Well at Gattahalli (GW2), bore well in Marathahalli (GW4) and bore well in Hennur (GW6) and bore well in Naganahalli (GW8). Ground water parameters of remaining locations are falling within the permissible limits of IS: 10500 Standards.

Air Environment: The major source of air pollution in the project region are transportation, industries, domestic and construction activities. Ambient Air quality monitoring was conducted along the BSRP Corridors as part of baseline environmental monitoring. The major pollutants of significance to railways air quality are Fine Particulate Matter (PM2.5), Respirable Particulate Matter (PM10), Sulphur dioxide (SO2), Nitrogen oxides (NOx), Carbon monoxide (CO) and Hydrocarbon (HC). Ambient Air Quality monitoring was conducted at all the pre-identified environmental receptor locations, by engaging NABL approved laboratory. Ambient air quality monitoring was carried out at 47 locations, out of which twelve locations in Corridor 1, eight locations in Corridor 2, twelve locations in Corridor 3 and fifteen locations in Corridor 4.The criteria used for ambient air quality monitoring are density and type of land use, type and nature of vulnerable groups, meteorological parameters etc. The results are compared with the standards prescribed by Central Pollution Control Board (CPCB) for "Industrial, Residential, Rural and Other areas". The overall concentrations of PM_{10}, $PM_{2.5}$, SO_2, NOx, CO and HC were observed to be well within the standards prescribed by Central Pollution Control Board (CPCB) for Industrial, Rural, Residential and Other area for all the BSRP Corridors.

Meteorology & Climate: Meteorological data for the project was collected from India Meteorological Department. Both Bengaluru Urban and Rural districts experience semi-arid tropical climate wherein four distinct seasons viz., South west monsoon (June – Sep.), North East monsoon (Oct – Dec.), winter season (Jan. – Feb.) and summer season (April – May). Maximum temperature recorded in the months from March-May and minimum temperature recorded in the months from November to February at both Bengaluru Urban and Rural Districts. The monthly mean temperature varies from 20.82 to 27.68 degrees at Bengaluru Urban, whereas the monthly mean temperature varies between 20.9 to 27.4 degrees at Bengaluru Rural. South west monsoon is predominant in the districts, On assessing the annual rainfall for the year 2018, Bengaluru North taluk is the highest with 1030 mm and lowest for Bengaluru South taluk with 781 mm. The Bengaluru Urban and Rural district records relative humidity due to its presence in high altitude. The highest humidity recorded in Bengaluru Urban district is in the month of August which is 75.4% and the lowest humidity recorded in the month of March, which is 44.6%. The highest humidity recorded in Bengaluru Rural district is in the month of August (~ 78.72%) and the lowest in the month of March (~ 48.47 %).

Noise and Vibration Environment:

Ambient Noise Level: As part of baseline environmental study, Noise level monitoring was carried out continuously for 24 hours with one hour interval at each location during the study period. Ambient Noise level monitoring was conducted at all the pre-identified environmental receptor locations, by engaging NABL approved laboratory. Noise monitoring locations were selected as per CPCB guidelines and Guidelines on Noise & Vibration study for Metro Rail Transit system by RDSO. Ambient Noise level monitoring was carried out at 72 locations, out of which 20 locations in Corridor 1, 12 locations in Corridor 2, 16 locations in Corridor 3 and 24 locations in Corridor 4. The results are compared with the standards prescribed by Central Pollution Control Board (CPCB) for Noise "Industrial, commercial, Residential and Silent Zones" for day and night time.

In Corridor 1, the ambient noise level exceeds the permissible level of CPCB standards in Govt. School, Benniganahalli (NQ1), Mother Mary English School (NQ2), Manipal Hospital (NQ6), Nitte Meenakshi Institute of Technology (NQ7), Cluny convent high school (NQ8), Bishop Sargent Secondary school, Devinagar (NQ12), and Yelahanka Gnanabarathi School (NQ17) for both day time and night time. In remaining locations, noise standards are within permissible limits of CPCB standards for day and night time.

In Corridor 2, the ambient noise level exceeds the permissible level of CPCB standards in all the locations during day time. Whereas it exceeds the standards during night time at Govt. School, Benniganahalli (NQ1), Mother Mary English School (NQ2), Eunice English school , Lingarajapuram (NQ3), Public Library MK Nagar (NQ5), P.R Public School, MK Nagar (NQ8), National Public School, Shettyhalli (NQ11) and Residential House, and Chikkabanavara (NQ12) for night time. In remaining locations, noise standards are within permissible limits of CPCB standards for day and night time.

In Corridor 3, the ambient noise level exceeds the permissible level of CPCB standards in Bengaluru Institute of Management Studies (NQ2), Holy Gopsee Prayer House (NQ7), Karnataka Welfare Association for the Blind, Sheshadripuram (NQ8), Mount Carmel College Palace Road (NQ10), Anugraha AG church Jeevanahalli (NQ12), City Hospital, Pulikeshi Nagar (NQ13) and Central Library, Jeevanahalli (NQ14) for both day time and night time. In remaining locations, noise standards are within permissible limits of CPCB standards for day and night time.

In Corridor 4, the ambient noise level exceeds the permissible level of CPCB standards in Banglore College of Engineering, Heelalige (NQ1), Norwich High School, Electronic City Phase II (NQ2), Kies mansion School, Chinnappanahalli (NQ6) and Govt. PU College, Yelahanka (NQ13) for both day time and night time. In remaining locations, noise standards are within permissible limits of CPCB standards for day and night time.

Ambient Vibration Level: Baseline of vibration level is done after collecting multiple data sets on all the 12 monitored locations with tri-axial sensors under normal operating conditions. The monitoring periods ranged was continues 24 hours for each location. Vibration study has been undertaken by Esperto Novero Inspection and Engineering Consultancy (ENIECO) Pvt. Ltd. from 23rd March 2022 to 6th April 2022. Vibration impacts for this project are based on the criteria as defined in the FTA guidance manual Transit Noise and Vibration Impact Assessment (FTA Report FTA-VA-90-1003-06, May 2006) and Research Designs & Standards Organisation (RDSO) guidelines. The criteria for acceptable ground-borne vibration are expressed in terms of rms velocity levels in decibels and the criteria for acceptable ground-borne noise are expressed in terms of A-weighted sound levels. The vibration monitoring locations are classified into three landuse categories. 1) Vibration Category 1 – High Sensitivity (vibration-sensitive research and manufacturing, hospitals with vibration-sensitive equipment, and university research operations), 2) Vibration Category 2 – Residential: (residential land uses and any buildings where people sleep, such as hotels and hospitals) and 3) Vibration Category 3 – Institutional: (schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment). The vibration monitoring was conducted at three locations for each of the BSRP Corridors. As far as possible all the vibration categories land uses are covered during the monitoring.

Based on the summary of the baseline vibration monitoring performed, except for Corridor 1 V3 location – NITTE Global Institute, Yalahanka where the Peak Particle Velocity (PPV) is 0.128 mm/s which is less than threshold trigger level (05 mm/s). In rest of the locations, the PPV is higher than the threshold trigger level. The maximum PPV recorded was at Corridor 3 V-3 location, Karnataka Welfare Association for the Blind, Sheshadripuram which showed a PPV of 8.636 mm/s. The second highest was recorded at Corridor 3 V-1 location, Suhasini Hospital Kengeri, which recorded a PPV of 6.171 mm/s. These two areas fall under the Corridor 3 and proper action has to be taken to reduce the baseline vibration levels. Corridor 1 V-1 location recorded a PPV of 1.107 mm/s and Corridor 4 V-2 location recorded a PPV of 1.313 mm/s, which is the third highest value and proper remedial actions has to be taken to bring down the vibration level below the threshold trigger level.

All other locations have recorded less than 1.00 mm/s but higher than 0.5mm/s, which is the threshold trigger level. Hence, the construction team must give priority and take proper corrective and preventive actions to mitigate and reduce the vibration level.

Biological Environment:

Forests: Bengaluru Urban forest division is situated on the southern portion of Karnataka. The division has about 6712.94 Ha of forest area. It has two sub-divisions, namely, Bengaluru North sub-division and Bengaluru South sub-division, and consists of five ranges, namely, Anekal, Bengaluru, Krishna Raja Puram, Kaggalipura and Yelahanka. . The forests of Bengaluru Urban division are of dry deciduous scrub type, and consist of species such as Chigare, Pachali, Bekke, Kakke, Kagali, Lantana, Bandarike, Jalari, etc. Due to its urban agglomerates there are no major faunal species found in the forests of the division.

The geographical area of the Bangalore rural forest division is 2266 sq. km or 226600 Ha out of which 18642.92 Ha are forest lands. Forests therefore constitute about 8.25% of the geographical area of the division. The forests are of tropical dry deciduous type mostly containing Acacia, Albizia, Wrightia tinctoria, Zizyphus, Dendrocalamus strictus, Anogeissus latifolia etc. Common fauna found in forest area of the Bengaluru Rural Forest Division are Slot bear, panther, Block buck, Chital, Spotted deer, large verity of retails, Hares, Porcupine , Jackal, Fox, Peacocks etc.

The BSRP alignments are proposed along the existing Indian Railway alignment for the entire length. The nearest forest land as per the above table is TurahalliGudda Protected Forest, which is located at 2.1Km from the proposed Corridor 3 railway alignment. There are no impacts on any forest flora or fauna considering the its proximity and urban growth. However, a depot is proposed in reserved forest land in Akkupete village near Devanahalli, which requires diversion of 18.6 ha of forest land. As per the information received from Forest Dept., this forest land was taken up for compensatory afforestation for 25 Ha in the year 2001. *Eucalyptus fibrosa* and *Acacia mangium* tree species are predominantly planted in this forest land as part of Compensatory Afforestation scheme. As per WB's ESS 6 & EIB's ESS 4, the project doesn't fall is Natural and Critical Habitats. However, project alignment passess through modified forest (agricultural land and pantation forest), which are highly influenced by human interventions.

Protected Areas: The proposed BSRP corridors are not passing through or abutting any protected areas such as National Park, Wildlife Sanctuary and Conservation reserves. The BSRP alignments are proposed along the existing Indian Railway alignment for the entire length. However, there are two protected areas such as Puttenahalli Lake Birds Conservation Reserve and Bannerghatta National Park present in the Bengaluru Urban District. There are no protected area present within indirect impact zone in Bengaluru Rural district.

The nearest protected area present is Puttenahalli Lake Birds Conservation which is 850m (aerial distance) from the Corridor 4 - Heelalige to Rajanukunte railway corridor and 970m from the Corridor 1 - – Bengaluru City (KSR) to Devanahalli. Puttenahalli Lake birds conservation reserve is located near Vinayaka Bhadavane on Doddabalapura road. Apart from this, Bannerghatta National Park located at 12.7 Km (aerial distance) from the Corridor 4 - Heelalige to Rajanukunte. There is unlikely any impact on these protected areas either on the land or its flora and fauna from the project because of its distance and presence of urban settlements around it.

Flora: Vegetative cover in the proposed BSRP Corridors are ornamental and indigenous tree species. Common tree species that are affected due to project is Rain tree (*Samanea saman*), Peepal tree (*Ficus religiosa*), Indian Cork tree (*Millingtonia hortensis*), Gulmohar (*Delonix regia),* Jamun tree (*Syzygium cumini*), Copper pod tree (*Peltophorum pterocarpum Becker*), Tulip tree (*Liriodendron*), Black siris tree (*Albizia odoratissima*), Pongamia tree (*Pongamia Pinneta*) etc..

Tree enumeration activity was carried out to identify the type of flora present in the project corridors, also to know the number of trees affected due to proposed project. As per the tree making and enumeration survey, total trees affected in BSRP Corridors are 32572 trees (Corridor-1 is 7198, Corridor-2 is 3469, Corridor- 3 is 2072, Corridor-4 is 2306, Akkupete Depot – 17505 and Soladevanahalli Depot - 22). Majority of these trees falls within Indian Railway land. In addition to Railway land, trees present in private land, BBMP land and other government land are also affected due to project. To understand the vulnerability, threatened and endangered characteristics of flora, affected tree species due to the project was compared with IUCN red list. As per the IUCN red list for Flora, there are few tree species ie., *Leucadendron argenteum, Saraca asoca, Jacaranda mimosifolia* and *Senegalia ferruginea* falls under vulnerable category and *Aegle marmelos* tree species falls under near threatened category. Mitigation measures have been proposed to preserve these tree species while removing/translocation activity, so that it can be planted during compensatory afforestation.

Fauna: Faunal distribution along the proposed corridor alignment is limited to common species since being located well within the extensively developed areas of Bengaluru Urban limit. Faunal species observed during site investigation and consultations are Amphibia - Indian Green Frog, Indian bullfrog, Black-spectacled Toad, Reptilia - Green Lizard, Garden Lizard, Monitor lizard, Snakes - Indian Cobra, Rat Snake, Birds - Common Koel, House Sparrow, Common Mynah, Spotted Dove, etc., Mammalia - House Shrew, Indian Flying Fox, Palm Squirrel, etc., and Fishes – Catla, Tilapia, Rohu, Snake head fishes, etc., As per the IUCN red lists, there are no vulnerable, threatened or endangered species of fauna present along the project corridors. As per the environmental investigation, there are no invasive alien flora and fauna species present along the project corridors. As per the reconnaissance, it is revealed that the plants and animals found along the project corridors are indigenous to the region and in IUCN category also.

Socio-Economic Environment: Bengaluru is the sixth largest city of India and one of the fastest growing cities of Asia. It has acquired the name of 'Silicon City", due to its progressive trend in Information technology. According to the Oxford Economic's Annual Global Cities Report, Bengaluru city will see an annual GDP growth rate of about 8.5% between 2019- 2035. Bengaluru's per capita income is highest in the state for the year 2018-19. As per the 2011 census, total population of the Bengaluru urban district is 95,88,910 with population density of 4,378 persons per sq.km compared to 2,985 persons per sq.km in the year 2001. The population of Bengaluru rural district as per 2011 census was 9,87,257 persons comprising 5,07,486 males and 4,79,743 females.

Major crops grown Bengaluru urban district are paddy, ragi, maize, horse gram and oilseeds along with horticultural crops like banana, grapes, papaya, mango sapota, pomegranate and plantation crops like coconut and rose. The main crops grown in the Bengaluru rural district are Paddy, jowar, Bajara, Maize, Wheat pulses oilseeds like groundnut, sunflower vegetables fruits and cash crop like sugarcane and others. Also project districts are well known for Horticulture, floriculture and poultry industries.

Archaeological sites: The Corridor 1 alignment is falling within Regulated zone (i.e., 300 m from the proposed alignment to Protected monument boundary) of two Archaeological Survey of India protected monuments 1) Tippu Sulthan's Birth place (13°14'57.35"N & 77°42'34.88"E) (aerial distance - 271m) and Fort in Devanahalli (13°14'46.49"N & 77°42'25.90"E) (aerial distance -228m) near Devanahalli town. There is ten lane national highway road (NH 48) is passing in between proposed BSRP and the Monument. Exiting railway line is also present on right hand side of the proposed BSRP alignment. Appropriate protection measures and chance find measures are suggested during construction activities.

Cultural/ Religious Structures: There are about 132 cultural/religious structures and eight burial ground present along the BSRP Corridors. These cultural/religious structures includes temple, shrine, tree shrine, church, mosques, etc., Out of these, 127 cultural religious structures, 28 structures are in Corridor-1, 30 structures in Corridor-2, 57 structures in Corridor- 3 and 12 structures in Corridor-4. None of these structures are notified as cultural heritage by the urban local body. As per social impact assessment there are 21 religious structures (Corridor 1 – one structure, in Corridor 2 – 14 structures, Corridor 3 – four structures and Corridor 4 – two structures) are directly affected due to proposed BSRP. Most of these structures such as tree shrines, shrines, few minor temples are encroachments falling within Indian Railway RoW. The affected structures shall be translocated to nearby locations in consultation with local community and Urban Local Body. However, there are no impacts on burial ground or its access roads due to proposed project corridors.

Environmental Sensitive Receptors: Sensitive receptors includes educational institutes, hospitals, Clinics, etc. All these features are environmentally and socially very sensitive and needs critical care in preserving them during implementation of Suburban rail project. There are about 67 environmental sensitive receptors present along the BSRP Corridors. Out of 67 receptors, Corridor 1 is having eight receptors, Corridor 2 – 24 receptors, Corridor 3 – 23 receptors and Corridor 4 – 12 receptors. As per the Resettlement Action Plan, suitable compensation shall be paid to the affected party.

1.4. Stakeholder Consultation

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 and local self-government bodies and officials of various Government departments. To ensure that stakeholder 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.

As part of the project, design stage stakeholder consultation was conducted along the BSRP corridors to gather the environmentally sensitive site which needs to be taken care during designing of the rail alignment and issues identified as the regulatory requirements of the GoI, GoK and World Bank's ESS. In design phase, Stakeholder consultation was conducted in two phase 1) Focus Group Discussions/public interactions and 2) Institution Level Consultations.

Focus Group discussions/public interactions were conducted at 30 locations in Corridor 1, 46 Locations in Corridor 2, 20 locations in Corridor 3 and 39 locations in Corridor 4. Various categories of people, from housewives to Auto drivers to govt. officers were interacted to disseminate the project information and to understand the environmental conditions of the region and to obtain the views/suggestions/opinion on the project for the betterment of the environment. In general, public present along the proposed Suburban Railway track were asked about the Air Quality, Noise level, social & cultural issues and water logging issues.

Out of 135 public interactions/FGDs, in 81 FGDs i.e., 60% informed that, introduction of Suburban Railway will enhance the overall environmental condition of the region, however remaining 54 FGDs i.e., 40% told that, Suburban Railway project will not make any difference to the environment and public transportation system. Following are the key demands/ suggestions/ opinion received from Public during the interaction;

- Requested for appropriate noise control measures also suggested to not to honk within the city limit.
- Suggested to provide adequate drainage system along the BSRP corridors to avoid inundation/ water logging during rainy seasons and proper maintenance of the same.
- Demanded for adequate underpasses to cross railway from one side to another side.

- Requested for proper fencing at road junctions to avoid dumping of construction waste and garbage along the alignment.
- Demanded to minimise the tree felling and undertake tree plantation and landscaping along the railway track to enhance the green cover and to improve aesthetics of the region.
- Suggested to complete the construction of Suburban Railway project quickly within a given timeframe.
- Proposed improvement should be limited and to have minimum impact on their land and their property.
- Demanded for appropriate compensation for loss of land property and livelihood.

Stakeholders have made various suggestions during implementation of the project. These suggestions are being considered by the K RIDE during the project implementation duly considering local regulations, legal requirements and safety measures to the extent practicable and feasible.

Institutional Level Consultations: Institutional level stakeholder consultation was conducted to disseminate the project information to the authorities and to collect their opinion/suggestion on environmental sensitivity, measures and regulatory obligations to the project. It also helped in gathering secondary data such as forest details, application forms for clearance, etc., Institutional consultations were conducted with South Western Railway Dept., Forest dept., Archaeological Survey of India and Pollution Control Board, Lake Authority and BBMP Forest wing departments. Summary of outcome of institutional level consultation for project is presented in **Table 1.3**.

Table 1.3. Summary of Institutional Level Consultations for the BSRP Corridors

Sl No	Name of the Person*	Date	Position	Opinion/suggestion/data sought
1		22.12.2021	Deputy Conservator of Forest, Bengaluru Forest Division – [redacted]	Requested for Forest map for Bengaluru Urban Forest Division, and understood forest clearance and tree felling permission (non-forest) process.
2		05.03.2022	First Division Clerk, Bengaluru Rural Forest	Discussed about status of Akkupete Forest Land and clarified Forest clearance process.
3		12.04.2022	Range Forest Officer, ICTC Cell, Forest Head Office, Bengaluru – Ph:	Discussed on forest spread along project corridors and requested to provide the digitised forest map for Bengaluru urban and rural Districts.
4		22.12.2021	First Division Clerk, Bengaluru Urban Forest – Ph: [redacted]	Discussed on forest spread along project corridors

Sl No	Name of the Person*	Date	Position	Opinion/suggestion/data sought
5		22.12.2021	First Division Clerk, Bengaluru Urban Forest– Ph: [redacted]	Discussed on forest spread along project corridors and requested to provide the forest map for Bengaluru Urban District.
6.		21.03.2022	Divisional Safety Officer, South Western Railways – Ph:	Discussed on safety aspects with respect to Indian Rail alignment and at Stations in project area. Further, clarified any contaminated area/harzard area identified along the project railway alignment to undertake extra-care during the baseline study. However, it was confirmed that, no such areas were present along the project corridors.
7.		20.04.2022	Assistant Superintending Archaeologist, Regional Office, Archaeological Survey of India, Bengaluru – Ph: 080-[redacted]	Information disseminated on project corridors and presense of ASI monuments in Devanahalli near Corridor 1. Information gathered on ASI clearance process.
8.		20.04.2022	Senior Environmental Officer, Bengaluru City Zone, KSPCB, Bengaluru – Ph: 080 [redacted]	Discussed on improvement proposal of project corridors. Requested for data on contaminated area/harzard areas/waterbodies identified along the project railway alignment to undertake extra-care during the baseline study. However, it was confirmed that, no such area was located along the project corridors. Also applicability of Air & Water Acts to the project were discussed.
9.		27.04.2022	Engineer (Civil), Ground floor, Karnataka Seed Bhavan, Bellary Road, Near Hebbal, Bengaluru – Mob-.	Discussed on improvement proposal of project corridors. And informed that, corridor 1 & 4 are abutting few lakes and crosses stormwater drains. It was adviced to undertake

Sl No	Name of the Person*	Date	Position	Opinion/suggestion/data sought
				necessary mitigation measures to avoid any pollution or affecting the carrying capacity of the lakes/stormwater drains. Further, It was told by concerned Engineer that, legal obligation of Karnataka Tank Conservation and Development Act is applicable for the projects and explined that necessary permission required to obtain from this Authority prior to intiating the site activity.
10.		27.04.2022	Manager, BBMP Forest Wing, Annex Building, BBMP, Corporation Circle, Bengaluru. Ph. – 080 [redacted]	Information disseminated on project corridors. Details of gaint trees and historical trees present within the limit. It was informed that, no such trees present align the railway alignment. Requested on procedure involved in tree felling permission (within BBMP limit) process. It was informed to submit the tree felling application with tree details such as tree species, girth, height, tree coordinates and photos for obtaining permission for the project.

**The name and contact details (Mobile No. & email ID) of the Institutional Stakeholder consultation participants are available in K RIDE records, but due to its sensitivity, the same is not disclosed.*

Opinion/suggestions and data gathered with respect to legal implications of the project and mitigation measures are suitably considered in the preparation of EIA report. Also, guidelines and application forms collected from these statutory bodies are being utilized for obtaining NOC/permissions.

As part of Stakeholder consultation, about ten public interactions/FGDs were condcuted at cultural heritage sites ie., ASI protected monuments 1) Fort, Devenahalli and 2) Tippu Sulthan's Birth Place, Devanahalli. Total five consultations were conducted for each ASI monuments. Details of FGDs conducted are presented in **Annexure 6.1**. As per the interactions, the public residing near the monuments didn't anticipates any threat to the monuments due to the project. Instead they opined that, due to introduction of suburban rail, there will be arrival of more visitors to these ASI monuments resulting economic development of the region. Some of the specific suggestion/opinions expressed by the public are as follows;

- They demanded for a rest area/toilet facility near these monuments for the visitors.
- Requested to provide proper storm water drainage situated along northern part of the fort to avoid flooding during rainy season.
- Suggested to develop Sihineerina Kere /Lake (adjacent to Fort) under CSR to attract more tourists.

1.5. Analysis of Alternatives

It is customary to include a 'No Action alternative' in order to confirm that the BSRP project is a requirement of the people of Bengaluru Urban and rural districts and hence need to be implemented. The BSRP project is very crucial for Bengaluru urban district to minimise the traffic congestion and to provide smooth, hassle free, efficient way of transportation to commuters. The 'no action alternative' will not allow any of these improvements therefore cannot be acceptable to the local people.

The 'no action alternative' will not resolve this issue; on the other hand, it will result in an increase in accidents, deterioration of air and noise quality and pose challenge to pedestrian safety. The present traffic demand will increase primarily due to growth in activities earmarked for developments besides socio-economic growth of the influencing areas.

Action Alternatives will contribute to ease the existing traffic congestion, enhance economic efficiency and growth potential of the area, and improve the well-being and livelihood of those within the potentially affected area of the project region.

In addition to no action alternative and action alternative, alternative options for structures, alignments, stations, Depots and Technology are explored.

Since, 90% of the BSRP alignment is proposed within Indian railway land, there were no alternative options were studied for the project alignment. Further, Stations are integrated with existing station or developed next to existing stations. Hence, no alternative options warranted for the same. Two depots are proposed at Soladevanahalli (Corridor 2) and Akkupete village (Corridor 1). Total extent of land area required for Soladevanahalli Depot and Akkupete Depots are 9.3 Ha and 18.6 Ha respectively. The depots are strategically selected by considering accessibility to BSRP Railway alignment and availability of large extent of land. Considering land scarcity the Akkupete depot land is selected in forest land for the BSRP.

BSRP will be developed utilizing Electric Multiple Unit (EMU) train, which consist of self-propelled carriages that uses electricity as the motive power. EMUs are popular on commuter and suburban rail networks around the world due to their fast acceleration and pollution-free operation. Being quieter than Diesel Multiple Units (DMU) and locomotive-drawn trains, EMUs can operate later at night and more frequently without disturbing nearby residents.

1.6. Environmental Impact and its Mitigation Measures

1.6.1. Impacts during Design/Preconstruction Phase and Mitigation Measures

The environmental and social impacts associated with the pre-construction stage mainly includes impacts due to design and location of the project as well as site preparation for construction. The main issues that are involved in the preconstruction stage are tree felling, diversion of forest land, relocation of public utilities etc. Most of the impacts of preconstruction stage are permanent in nature. The anticipated impacts associated with the preconstruction stage and their mitigation measures are tabulated below:

Table 1.4. Anticipated Impacts Associated with the Preconstruction Stage and Their Mitigation Measures

S.No.	Environmental Component	Impacts Anticipated	Mitigation Measures
1	Tree Felling	32572 number of trees shall be felled (excluding trees forest land)	1:10 compensatory afforestation
2	Forest Land Diversion	Diversion of 18.6 ha of Reserve Forest	Obtaining forest clearance and undertaking compensatory afforestation through forest dept.
3	Establishment of Labour Camp	Negotiations with the local residents for land lease	Land Lease agreement and closure of camp with restoring the land to original state.
4	Disaster Management	Slope failure, Fall of boulders, formation of gullies in the slope due to heavy runoff.	Stability structures were proposed to curb the anticipated disasters.

1.6.2. Impact during Construction and Operation Phase and Mitigation Measures

During construction period the major environmental issues will be related to dust generation, emission of gaseous emissions, pollution due to operation of plants and equipment, contamination of land and soil, contamination of water bodies and public as well as community and workers health and safety, demography, employment, social infrastructure. These anticipated impacts will be mainly temporary and localised in nature and are likely to persist for short duration till the construction activities are over in a particular area. However, there are some long term adverse impacts due to construction. The likely impacts due to construction activities and operation of the project are briefed below along with the mitigation measures and institutional responsibility of implementation of environmental safeguards measures, further, these are detailed in **Chapter 8.**

Table 1.5. Impact during Construction and Operation Phase and Mitigation Measures

Environmental Issue/Attributes	Mitigation Measures
Loss of Top Soil	Excavation will be done only to the pegged area for constructing the suburban railway.
	Agricultural areas will be avoided for borrowing of materials, unless requested by the land owner for lowering of land to increase its water holding capacity.
	The topsoil from all areas of cutting and all areas to be permanently covered will 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 maintain the soil physico- chemical and biological Characteristics.

Environmental Issue/Attributes	Mitigation Measures
Compaction of Soil	Construction vehicles, machinery and equipment will move, or be stationed in the designated area, to avoid compaction of soil.
	If operating from temporarily hired land, it will be ensured that the topsoil for agriculture remains preserved & not destroyed by storage, material handling or any other construction related activities.
Soil Contamination from Fuel and lubricants	Impervious platform and oil and grease trap for collection of spillage from constructions and petroleum storage areas, equipment vehicle maintenance platform will be appropriately provided at construction camp, servicing area and liquid fuel as well as lubes at storage areas.
Soil Contamination from Construction waste and spoils	All spoils will be disposed of as desired and the site will be fully cleaned before handing over.
Community water Source	Any community water source as wells, tube-wells, etc., lost incidentally will be replaced immediately
Drainage and run off	Earth, stones, wastes and spoils would be properly disposed off, to avoid blockage of any drainage channel.
	All necessary precautions will be taken to construct temporary or permanent devices to prevent inundation or ponding.
Contamination of water from construction and allied activities	All necessary precautions will be taken to construct temporary or permanent devices to prevent water pollution due to increased siltation and turbidity.
	All wastes arising from the project will be disposed of, as per SPCB norms, so as not to block the flow of water.
	Wastes must be collected, stored and taken to approve disposal site.
Sanitation and waste disposal in construction camps	Garbage collection and disposal as well as sanitation facilities will be provided at camps
	The construction camps will be located away from water sources.
	Sanitary and sewage disposal facilities at camp to avoid epidemics
	The workplace will have proper medical approval by local medical, health or municipal authorities.
Use of water for construction	The Contractor will make arrangements for water required for construction in such a way that the water availability and supply to nearby communities remain unaffected.
	If a new tube-well is to be bored, prior sanction and approval by the Ground Water Board/Authority will be obtained
	Wastage of water during construction will be minimized.
Emissions from Vehicles and Equipment	All vehicles, equipment and machinery used for construction will regularly maintained to ensure that the pollution emission levels conform to the statutory norms.
	The batching plants will be sited at least 0.5 km in the downwind direction from the nearest human settlement and forest area
Dust Generation	The batching plants will be sited at least 0.5 km downwind from the nearest habitation. The hot mix plant will be fitted with dust suppression system.

Environmental Issue/Attributes	Mitigation Measures
	Water will be sprayed in the lime/cement and earth mixing sites, constructions sites, batching plant site, loading and unloading areas and temporary service and access roads.
	After compacting, water will be sprayed on the earthwork regularly to prevent dust.
	Material transportation will be carried out in covered vehicles
	Vehicles and machinery will be regularly checked to conform to the CPCB Standards for emission
	Concrete mixing, batch mix plant, will be well sealed. equipped with dust suppression system
	Workers at mixing sites will wear nasal masks to reduce the chances of exposure to fine dusts (PM_{10}& $PM_{2.5}$)
	Regular monitoring of PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO and /HC will be carried out as mentioned in the Environmental Monitoring Plan
Noise Pollution from Construction vehicles and Machinery	The plants and equipment used for construction will strictly conform to CPCB noise standards.
	Vehicles and equipment used will be fitted with silencer and maintain accordingly.
	Noise standards of industrial enterprises will be strictly enforced to protect construction workers from severe noise impacts.
	Noise levels to be monitored (for 24 hrs.) as per monitoring plan
Loss or Damage to Vegetation	Apart from trees earmarked for felling, no additional tree clearing within the RoW will be carried out.
	Area of tree plantation cleared will be replaced according to compensatory Afforestation Policy under Forest Conservation Act-1980.
Compaction of Vegetation	Construction vehicles, machinery and equipment will move or be stationed in the designated area only to prevent compaction of vegetation outside the RoW.
	While operating on temporarily acquired land for traffic detours, storage, material handling or any other construction related or Incidental activities, it will be ensured that the trampling of soil and damage to naturally occurring herbs and grasses is avoided.
Occupational Health &Safety	The Contractor will comply with the requirements of the Environmental, Health, and Safety (EHS), Guidelines of the World Bank Group, April 2007[1] and the statutory norms of safety during Construction. The relevant ones are general guidelines available on the internet.
	Adequate drainage, sanitation and waste disposal will be provided at workplaces.
	Proper drainage will be maintained around sites to avoid water logging leading to various diseases.
	Adequate sanitation and waste disposal facilities will be provided at construction camps by means of septic tanks, soakage pits etc.
	A health care system will be maintained at construction camp for routine check-up of workers and avoidance of spread of any communicable disease

Environmental Issue/Attributes	Mitigation Measures
	Safety of workers undertaking various operations during construction will be ensured by providing appropriate Personnel Protective Equipment (PPEs) such as helmets, masks, safety goggles, safety belts, ear plugs etc. Contractor will also provide safety plans for working at height and electrical safety.
	The electrical equipment will be checked regularly
	At every work place, a readily available first aid unit including an adequate supply of dressing materials, a mode of transport (Ambulance), nursing staff and an attending doctor will be provided.
	Strict enforcement of labour laws to discourage child labour and forced labour
	The Contractor will organize awareness program on HIV aids and sexually transmitted diseases (STDs) for workers on periodic basis.
Infection of Covid Virus	The Contractor will prepare SOPs for work site, camp, facility areas, allied sites prior to start of works by following the guidelines issued by the Government of India from time to time, the WHO Guideline for Workplace, ILO's Guide note on COVID-19. The Contractor will periodically organise awareness camps on prevention and control of COVID-19 spread. The Contractor will strictly follow the government instructions on COVID-19 The Contractor will follow the Guidance framework provided in EMP in preparation of their SOP for various sites of activities including Work zone, Camp site, Stockyards, Plant Sites, canteen, etc.
Community Health and Safety	The Contractor will comply with the requirements of the WB's general Environmental, Health, and Safety (EHS), IFC's specific guidelines on Health and Safety and the statutory norms of safety during construction
	To ensure safe construction in the temporary accesses during Construction, lighting devices and safety signal devices will be install.
	Traffic rules and regulations will be strictly adhered to.
	Railway & road safety education will be imparted to drivers running construction vehicles.
	Adequate signage, barriers and persons with flags during construction to control the traffic will be provided.
	Temporary makeshift pathways and wooden planks will be provided for public and nearby property owners to access their property.
	Proper barricading will be provided at all the work sites, near habitation areas and camp sites will be
	At all-time safe access for public movement near habitation area will be ensured
Archaeology and religious and cultural heairtage	Interpretation panels/signage must be provided for the monument.
	Drainage system should be checked so that the corridor level should not be higher than the monument and water should not enter inside the monument complex.
	Prior intimation should be given to ASI authority to monitor the site and also to check the impact on monument during /post digging (excavation) process

Environmental Issue/Attributes	Mitigation Measures
	Prior permission must be obtained from the Competent Authority for any construction or increase in height.
	In case of chance find, the contractor shall immediately stop working and intimated to Envi. Specialist of GC and concerned Archaeological officials. Work will be resumed on getting the permissions from concerned Archaeological officials.
	Affected religious/ cultural structures shall be suitably relocated in consultation with local community and urban local bodies.
Clean-up Operations, Restoration and Rehabilitation	Contractor will prepare site restoration plans, which will be approved by the Engineer. The clean-up and restoration operations are to be implemented by the Contractor prior to demobilization.
	The contractor will clear all the debris material at site, temporary structures; dispose all garbage, night soils and POL waste as per Comprehensive Waste Management Plan and as approved by the Engineer (GC). All disposal pits or trenches will be filled in and effectively sealed off. Residual topsoil, if any will be distributed on adjoining/ proximate barren land or areas identified by the GC in a layer of thickness of 75 mm-150 mm. All construction zones including lakes-beds, culverts, road-side areas, camps, 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 the Engineer (GC).
Operation Phase	
Monitoring of Operation Performance	The K RIDE will monitor the operational performance of the various mitigation/enhancement measures carried out as a part of the project. The indicators selected for monitoring include the survival rate of trees; utility of enhancement provision for relocated utilities, hand pumps and other relocated structures if any; status of rehabilitation of borrow areas etc.
Maintenance of Drainage	K RIDE will ensure that all drains (side drains, cross drains etc.) are periodically cleared especially before monsoon season to facilitate the quick passage of rainwater and avoid flooding..
Pollution Monitoring	K RIDE will undertake periodic monitoring of the ambient air quality, noise level, vibration, water (both ground and surface water) quality, soil pollution/contamination in the selected locations as suggested in environmental monitoring plan. K RIDE will appoint MOEFCC/NABL/ approved pollution monitoring agency/Laboratory for this purpose.
Noise Pollution	Noise pollution will be monitored as per monitoring plan at different zones. Noise control programs are to be enforced strictly. Monitoring the effectiveness of the pollution attenuation barriers, if there is any, will be taken up.

1.6.3. Climate Change & Risk Assessment

Climate Change Risks was assessed by using matrix method to identify the magnitude of impacts and predicting risks for various climate change conditions on vulnerable rail assets/infrastructure such as bridges, railway tracks, culverts, operating speed, etc.,

- Due to tree felling, increase in Carbon Emission during Pre-construction phase is 710 Tonnes/Year and reduction in Oxygen is 1596 Tonnes/Year.
- Due to introduction of BSRP, reduction in CO2 is estimated to 19,66,166 Tonnes/year and reduction in Green House Gas emission ie., PM -742 Tonnes/year, NOx – 13447 Tonnes/year, HC- 3348 Tonnes/year and CO- 17042 Tonnes/year for the year 2025.
- Due to compensatory afforestation (included trees felled along alignment and for Depots), about 7100 Tonnes/year Carbon will be reduced for the year 2025 and 7254 Tons/year of Oxygen will generated after 5 years of plantation.

Adaptation measures during unprecedented climate change events during project life cycle were proposed as part of mitigation measures.

1.6.3.1. Climate Change Risks and Vulnerability Assessment for the Project

The potential impacts of climate change on BSR infrastructures/assets are compiled and briefly outlined under Section 8.3.6 of EIA Report. These potential impacts call for careful consideration of rail design, construction, and maintenance to achieve lasting benefits. World Bank (WB ESS 3 – 'A' Management of air Pollution under Resource Efficiency and Pollution Prevention and Management) and EIB Guidelines (EIB ESS 5 – Climate Change) have been followed for Climate Change Risks Vulnerability Assessment (CRVA).

Weather-related hazards are already among the factors most frequently causing disturbances for railways. Temperature, rainfall along with Flooding, storm and humidity are the major climate parameters that could impact the suburban railway infrastructure in Bengaluru, whereas snow, permafrost, storms and sea-level rise factors are not applicable to BSRP as the city is far away from Sea and snow falling regions. Based on the Overall Climate Change Risk Assessment Results the Climate Risks of BSRP are categorised as Medium Risks.

The consequences of these failures can lead to risks such as inconvenience, economic losses due to disruptions, and an increase in carbon emissions due to additional transportation effects to reach the destination; also including serious consequences such as train derailments, damage to the railway infrastructure, and danger to human life.

Climate Adaptation /Mitigation Plan and Budget

Key Adaptation Measures towards Climate Risks to be considered to protect railway assets against specific weather events are discussed under Section 8.3.6 of the EIA Report. Climate Adaptation Plan for BSRP includes Adaptation measures as follows:

- implementation of thermally treated Head-hardened 1080 grade steel rails, 60 UIC (at Design Stage itself) to overcome high temperature risks,
- Elevated Rails avoid the impact of Floods on Rail network assets,

- Utilization of Concrete mix materials increased durability, high strength and resistance to overcome flood and erosion impacts.
- Installation of Rainwater harvesting systems at all stations in the viaduct sections of Corridors to overcome high rainfall run-offs and flood
- Construction of Central Water Board approved recharge pits along the median at each pier location to facilitate percolation of runoff into the ground
- Installation of Standby diesel generator sets in case of emergencies, including flooding in BSRP stations
- Application of Emergency Early Warning System with Signaling and integrated tele-communication system to manage Risk Hazards
- Provision for Support equipment and plant necessary for maintenance to carry out preventive, restorative, and adaptive maintenance
- Construction of at-grade and elevated medium capacity rail lines in BSRP with implementation of Specific Environmental Management Action Plan (EMAP) to mitigate impact of pollutants on Climate

Along with the applicable adaptation measures Asset infrastructures, such as drainage systems, catenary systems, and vegetation management shall be maintained by K RIDE, to reduce their impact due to climate change. Further, K RIDE will follow the guidelines and Preventive measures as per Indian Railway Manual to handle Monsoon Preparedness, Flood events, regular checking of Retaining walls, Rail affecting Tanks, drain cleaning and slope stability in BSRP.

As per estimate, the Cost of Rainwater harvesting/Construction of Recharge Pits is ₹ 312.9 Lakhs. Other costs are included under civil works cost. The main mitigation activity includes Construction of at-grade and elevated medium capacity rail lines in BSRP along with implementation of mitigation measures to reduce CO2 emission during construction stage of the BSRP. Estimated Savings in GHG Emissions of the project is 7,104.52 tCO2e/year and overall estimated mitigation cost is $ 19,450.52 million.

1.7. Project Benefits

The proposed project also yields beneficial or positive impacts on natural and social environment along with the negative impacts on Environment. The Suburban railway system after construction and commissioning will certainly reduce the pollution level and add convenience to the public, but such project may grossly aggravate the pollution problem during construction stage, especially in respect of noise and air pollution which are generally at their peak. To compound the issues further, suburban railway alignment generally passes through densely populated areas and high vehicular traffic zones, at certain areas where there is already high pollution level. Higher the compression of implementation period higher is the pollution level due to intense construction activity increasing pollution levels. The Project will have numerous direct and indirect positive impacts on socio-economic and environmental aspect, out of which key identified positive impacts are listed below;

- Employment Opportunities
- Benefits to Economy
- Direct benefits to passengers
- Safety

- Traffic Noise Reduction
- Reduction of plying vehicles and Traffic congestion on Road
- Saving in Road Infrastructure
- Low energy Consumption
- Reduced Air pollution and
- Carbon-Di-Oxide reduction.

1.8. Environmental Management Plan

Environment Management Unit (EMU) is intended to facilitate implementation, tracking and reporting on Environment Management Plan and Environment Monitoring Plan proposed for the project. The Environmental Management Plan / Action Plan (EMP/EMAP) is the synthesis of all proposed mitigation and monitoring actions, set to a time-frame with specific responsibility assigned and follow-up actions defined. It contains all the information for the proponent, the contractor and the regulatory agencies to implement the project within a specified timeframe.

Table 1.6. Summary of Environmental Management Action Plan (EMAP)

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
Design Phase			
D1	Land acquisition, Displacement of people and private property acquisition and related impact on environmentally sensitive areas	Alignments are designed to utilise Government and Indian Railway lands to the maximum and to avoid or minimize impacts on private land or properties, in accordance with Land Acquisition Act, 1894 and Rehabilitation and Resettlement Act, 2013 and WB ESS 5 and EIB Standard 6. Accordingly, RAP is prepared including (i) the analysis of number, status, eligibility of PAPs and related mitigation measures following lenders standards, (ii) consultation activities with community members, including discussion of corrective and remedial actions with the PAPs (iii) GRM's availability.	Design Consultant/GC & K RIDE
D2	Change in Land Use and Impact on land	The compensation for land is detailed in Social Impact Assessment Study Report. Impact on Private land comprises of residential land, commercial land and vacant land. As per RAP notice shall be given in advance to the encroachers (and squatters, if any) present in the Corridor of Impact, who need to be relocated. All R and R activities shall be undertaken as per the relevant acts and also comply with WB's ESS 5. Entitlements as per K RIDE entitlement framework shall be completed before the commencement of construction.	Design Consultant/GC & K RIDE
D3	Diversion of Forest Land	Shall be diverted in compliance with the Forest (Conservation) Act, 1980 and in compliance with WB ESS 6.	Design Consultant/GC & K RIDE
D4	Impact on Flora and Aquatic Bodies causing loss of trees and water bodies	Transplantation of trees shall be carried out by the BBMP Forest Wing and Forest Authority in consultation with K RIDE. Tree removal shall be carried out in accordance with the Karnataka Forest Act, 1963 (Karnataka Act 5 of 1964) amended with Karnataka Forest Rules, 1969, The Karnataka Preservation of Trees Act, 1976 and The Karnataka Preservation of Trees (amendment) Act, 2014, Forest Conservation Act 1980 and ESS 6 of World Bank and ESS 4 of EIB. Compensatory afforestation and its maintenance for loss of trees will be undertaken by Bengaluru Rural Forest division as per these above Acts/guidelines.	Design Consultant/GC & K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
		The Forest Department will be responsible for the Afforestation Programme and Tree Maintenance during project implementation.	
D5	Project Design	Project design should incorporate green building measures such as energy efficient design and optimisation of resources, conservation of water, greening of building, etc., to make the project environmentally sustainable with minimum carbon footprint during its operation. Measures such as using of fly ash bricks and manufactured sand & wood, using locally availably natural materials, solar lighting system, lightings with sensors, design with proper ventilation and natural lighting system, reuse of treated water, rainwater harvesting, appropriate waste management components, increasing greening options inside and outside the Station buildings etc.	Design Consultant/GC & K RIDE
D6	Impact on Archaeological Monuments	Corridor 1: Impact on legally protected Archaeological Monuments - Devanahalli Fort and Tippu Sultan's Birth Place at Devanahalli, due to proposed alignments. Measures shall be implemented in accordance with ESS 8 of World Bank, EIB ESS 10 and The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI). There are no ASI monuments/cultural heritage sites present in Corridor 2, 3, & 4.	Design Consultant/GC & K RIDE
Pre-Construction Activity			
P1	Land & Private Property Acquisition and Displacement	The acquisition of land and private properties shall be carried out in accordance with the R & R Plan /RAP and entitlement framework of the Project in accordance with ESS 5, Karnataka Industrial Areas Development Act, 1966 (KIADA) and Government of Karnataka Revenue Department resolutions. As per RAP notice shall be given in advance to the encroachers (and squatters, if any) present in the Corridor of Impact, who need to be relocated. All R and R activities shall be undertaken as per the relevant acts and also comply with WB’s ESS 5 and EIB ESS 6. Entitlements as per K RIDE entitlement framework shall be completed before construction starts. It is ensured that no private property will be acquired and no PAPs will be displaced prior to RAP approval.	Contractor/GC & K RIDE
P2	Impact on Flora - Tree Removal - Loss of trees	All efforts shall be made to preserve/save trees. Specific attention shall be given for protecting giant trees, green tunnels and locally important trees (religiously important etc.). Details of the trees affected due to the proposed project corridors are given in (Section 4.9.2 of EIA Report) Tree cutting shall be proceeded only after all the legal requirements including attaining of In-principle and Formal Clearances from the Forest	Contractor/GC & K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
		Dept. are completed and subsequently a written order is issued to the Implementing Agency. Tree preservation will be line with Karnataka Preservation of Trees Act, 1976, Forest Conservation Act 1980 and ESS 6 of World Bank and EIB's ESS 4. Compensatory afforestation for the tree cut and translocated trees shall be carried out by BBMP forest Wing/ Forest Dept. as per the statutory guidelines of Forest Conservation Act, 1980 and Karnataka Preservation of Trees Act, 1976, Tree Management Plan, EIB's ESS 4 and ESS 6 of World Bank.	
P3	Relocation of Community Utilities and Common Property Resources	All community utilities and properties i.e. hand pumps, open wells, water supply lines, sewer lines, telephone cables, buildings and health centers shall be relocated before only when construction of corridor activities commence. This will be in line with ESS 10 of World Bank and EIB's ESS 1.	Contractor/GC & K RIDE
P4	Relocation of affected Cultural and Religious Properties	All religious property resources such as shrines, temples and mosques within the project corridor shall be relocated. Total number of cultural properties affected in BSRP corridors is given in the Section 8.3.8. of EIA Report. A list of Common property resources affected due to project corridors are presented as **Table 8.11**. If there is any relocation of the religious structures may happen then it shall be identified in accordance with the choice of the community. K RIDE in consultation with local people shall finalize those. The relocation shall be completed before the construction starts in these sites. This will be in line with ESS 1 & 5 of World Bank and EIB's ESS 1 & 6.	Contractor/GC & K RIDE
P5	Construction materials	Construction materials shall be procured from approved agencies as far as possible. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring	Contractor/GC & K RIDE
P6	Project Associated facilities (construction camp, disposal sites, batching mix plant, etc.,)	Siting of the project associated facilities shall be as per the guidelines and details of layout to be approved by GC Resident Engineer and Environment Specialist, shall comply with Occupational Safety and Health Standards, Part 1910.142 and in line with ESS 1, 3 & 6 of World Bank.	Contractor/GC & K RIDE
P7	Labour Procurement	Labour procurement shall be in accordance with labour laws and Contract Document - The Factories Act, 1948, The Building and Other Constructions Workers (Regulation of Employment and Conditions of Service) Act, 1996 (BOCW Act, 1996), The Industrial Relations Code 2020, The Code on Social Security 2020, The Occupational Safety, Health and Working Conditions Code, 2020 and The Code on Wages 2019. The	Contractor/GC & K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
		Contractor shall preferably use unskilled labour drawn from local communities to give maximum benefits to the local community. This will be in line with ESS 2 of World Bank and EIB's ESS 1.	
P8	Orientation Training for Implementing Agencies and Contractors	The K RIDE shall organize Orientation Sessions and regular training sessions at all stages of the project. This shall include on-site training (general as well as in the specific context of a sub-project). These sessions shall involve all staff of K RIDE involved in the implementation of EMP, Environmental Specialists of GC and Contractors. The training shall be conducted as per EMP and other training plan/s developed by Environmental Specialists of GC/K RIDE.	Contractor/GC & K RIDE
	Construction Camp Locations – Selection, Design and Layout	Siting of the construction camps shall be as per the guidelines and details of layout to be approved by GC Resident Engineer and Environment Specialist, shall comply with Occupational Safety and Health Standards, Part 1910.142 and in line with ESS 1, 3 & 6 of World Bank and EIB ESS 1, 3 & 4.	Contractor/GC & K RIDE
Construction Phase			
C1	Clearing, Grubbing and tree felling	Only ground cover/shrubs that impinge directly on the permanent works or necessary temporary works shall be removed with prior approval from the Sr. Environmental Specialist of GC. The Contractor, under any circumstances shall not cut or damage trees and forest reserves. Trees identified under the project shall be cut only after receiving clearance from the BBMP Forest Wing/Forest Dept./DoEF/MoEFCC (as applicable) and after the receipt of K RIDE's written permission in this regard. This will be in line with ESS 1 & 6 of World Bank and EIB ESS 1 & 4.	Contractor/GC & K RIDE
C2	Disposal of Construction Wastes and Debris from dismantling structures and work zones	Waste Management Plan shall be prepared by the Contractor for disposal of debris and municipal wastes in consultation and with approval of Environmental Specialist of CSC. Waste generated in the project shall be handles as per the Solid Waste Management Rules, 2016, amended in 2018, Construction and Demolition Waste Management rules 2016 and other guidelines of PCB and ESS 1 & 3 of World Bank and EIB ESS 1 & 3. Reusable and recyclable materials shall be stored and sold to PCB approved vendors.	Contractor/GC & K RIDE
C3	Soil erosion and fugitive dust generation	The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of temporary berms, temporary mulches, seeding or other methods as necessary to control erosion shall be implemented. Careful planning, timing of cut and fill operations and re-vegetation shall reduce the Soil Erosion and dust generation. Suitable measures and construction methods shall be implemented as per EHS Plan and in line with WB ESS 3 and EIB ESS 1 & 3.	Contractor/GC & K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
C4	Stripping, stocking and preservation of top soil	The preservation of Top soil shall be in accordance with EPA 1986 and ESS 1 & 6 of World Bank and EIB ESS 1 & 3. The topsoil from all areas of cutting and all areas to be permanently covered shall be stripped off to a specified depth of 150 mm and stored in stockpiles. A portion of the temporarily acquired area and/or Right of Way shall be earmarked for storing topsoil. The locations for stock piling shall be pre-identified in consultation and with approval of Environmental Specialist of GC.	Contractor/GC & K RIDE
C5	Traffic Management Planning for traffic diversions and detours	Temporary diversions shall be taken care in line with WB ESS 4 & EIB ESS 9 and with the approval of the Resident Engineer and Environmental Specialist of GC. Detailed Traffic Control Plans shall be prepared by the Contractor and approved by Environmental Specialist and Resident Engineer of GC seven days prior to commencement of works on any section of road. The Traffic Control Plans shall contain details of temporary diversions, traffic safety arrangements for construction under traffic, details of traffic arrangement after cessation of work each day, safety measures for night time traffic and precaution for transportation of hazardous materials and arrangement of flagmen.	Contractor/GC & K RIDE
C6	Construction Water	Procurement of Construction Water shall be carried out by the Contractor in compliance with Environmental Protection Act, 1986, The Water (Prevention and Control of Pollution) Act, 1974 and WB ESS 1 & 4 and EIB's ESS 1, 3, & 9. The quantity required for construction with other details shall be planned properly, linked to the contractor's work plan and the same shall be submitted to the CSC.	Contractor/GC & K RIDE
C7	Drainage and flood control	Contractor shall ensure that no construction materials like earth, stone, or appendage disposed-off in a manner that block the flow of water of any water course and cross drainage channels in compliance with WB ESS 1 & 3 and EIB ESS 1 &3.	Contractor/GC & K RIDE
C8	Water Pollution Control	The Contractor shall take all precautionary measures to prevent entering of wastewater, oil & grease into streams, water bodies or the irrigation system during construction. Reuse of water used for curing and for other uses shall be planned. The proposed measures shall be implemented in compliance with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 1& 3 of World Bank and EIB's ESS 1& 3. Water quality monitoring shall be undertaken periodically at construction site and labour camps as per Environmental Monitoring plan.	Contractor/GC & K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
C9	Air Pollution Control	The Contractor shall use cover for materials of dust generating like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free-board to reduce spills and avoid fugitive dust. The Contractor shall sprinkle water at construction sites to suppress dust, during handling of excavation soil or debris or during demolition. Contractor shall ensure that all vehicles, equipment and machinery used for construction are regularly maintained and confirm that pollution emission standards and comply with the relevant statutory requirements of CPCB such as The Air (prevention and control of pollution) Act, 1981 and EPA, 1986 and/Motor Vehicles Rules 2000 with amendments and WB ESS 1& 3 and EIB's ESS 1 & 3. Stack height of equipment/ Plants and D. G. sets at plant site should conform to KSPCB Standards. Air quality monitoring shall be undertaken periodically at construction site, sensitive receptors and labour camps as per Environmental Monitoring plan.	Contractor/GC & K RIDE
C10	Noise Pollution Control	All Vehicles and equipment used in construction shall be fitted with exhaust silencers. Construction of permanent and temporary noise barriers; and natural and artificial barriers could be considered for use as shielding against construction noise. In Loading and un-loading areas with machinery noise muffles, etc. and personal protective gear shall be provided to workers. All construction equipment & machineries will have to comply with Noise Pollution (Regulation and Control) Rules, 2000 & amendments and ESS 3 of World Bank and ESS 1 & 3 of EIB. Noise barriers should be constructed at sensitive receptor location as budgeted in EMP. Noise level monitoring shall be undertaken periodically at construction site, sensitive receptors and labour camps as per Environmental Monitoring plan.	Contractor/GC & K RIDE
C11	Vibration Control	As part of vibration control measures, routing heavily-loaded trucks away from residential and sensitive areas. Operation of earth-moving equipment on the construction site as far away from vibration - sensitive sites as possible. Phase demolition, earth-moving and ground-impacting operations so as not to occur in the same time period. Avoidance of night time construction activities near residential and sensitive areas. Vibration Monitoring shall be carried out at the locations specified in monitoring plan by the K RIDE and the Engineer through the approved monitoring agency. Building condition surveys at sensitive structures shall be carried out as per regulations and Guidelines; and in line with WB ESS 1& 3 and EIB's ESS 1& 3.	Contractor/GC & K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
C12	Soil pollution Control	The measures proposed to prevent ingress of toxic / heavy metals shall be implemented. Contractor shall take all necessary precautions such that construction material, diesel, grease, waste oil, chemicals etc. does not spill on ground. Soil quality monitoring shall be undertaken periodically at construction site, sensitive receptors and labour camps as per Environmental Monitoring plan.	Contractor/GC & K RIDE
C13	Solid waste disposal from construction activities	The contractor shall prepare the comprehensive waste management plan in line with the provisions of Hazardous and other wastes (management and trans boundary movement) rules 2016 and its amendments and ESS 1&3 of World Bank, EIB's ESS 1&3 and submit to the Project Authority for concurrence.	Contractor/GC & K RIDE
C14	Personal Safety Measures for Workers	Labors should be provided with Protective footwear, protective goggles and nose masks to the workers employed in asphalt works, concrete works, crusher etc. The Contractor shall comply with all regulations regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress. The Contractor shall comply with all the precautions as required for ensuring the safety of the workmen as per the International Labour Organization (ILO) Convention No. 62 as far as those are applicable to this contract. The Contractor shall not employ any Child Labor (person below the age of 18 years as per ILO's standards for hazardous work) for any work and no woman shall be employed on the work of painting with products containing lead in any form. The Contractor shall make sure that during the construction work all relevant provisions of WB ESS 1& 4 and EIB's ESS 1, 8 & 9 and Building and other Construction Workers (regulation of Employment and Conditions of Services) Act, 1996 are adhered to.	Contractor/GC & K RIDE
C15	Community Health and Safety	Temporary ramps, makeshift pathways, temporary mobile foot over bridges, etc., should be provided to facilitate easy access to adjacent buildings and shops. Special consideration shall be given in the local traffic management to the safety of pedestrians. Traffic Management and Engineering measures like traffic segregation, one-way movements, traffic diversions, acquisition of service lanes, etc. shall be implemented in compliance with the Traffic Management Plan and Indian Standards and WB ESS 2 and 4 guidelines for the safety of pedestrians and other road users. The Contractor shall ensure that all signs, retro-reflectors, barricades, pavement markings are provided to caution local public and pedestrians. All necessary fencing and lights shall be provided to protect the public in construction zones. The Contractor shall provide Fire Extinguishers at Plant sites and Construction Camps. The Contractor shall organize Training and Mock Drill for Workers, Technical and Non-technical persons involved in the project. Contractor shall provide	Contractor/GC & K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
		community safety which shall be included in Traffic and Safety Management Plan prepared in compliance with EHS guidelines and WB ESS 1 & 4 and EIB ESS 1 & 9.	
C16	Incident/Accident/Risk/ Disaster Management	Incident Management Plan shall be prepared and reported as per reporting formats. Emergency Response Plans shall be implemented. Preventive measures shall be adopted to avoid reoccurrence of the incident. Readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules. Suitable transport at all times to take injured to the nearest hospital. This is in line with WB ESS 2 & 4 and EIB ESS 8 & 9.	Contractor/GC & K RIDE
C17	Construction/Labour Camp Management	Contractor shall follow all relevant provisions of the Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act, 1996 and Factories Act, 1948 and amended in 1987, International Labour Standards (ILO) and WB ESS 2 and EIB's ESS 8 for construction and maintenance of labour camp. At every workplace, shelter shall be provided free of cost, separately for use of men and women labourers. The height of shelter shall not be less than 3m from floor level to lowest part of the roof. Shelters shall be with adequate illumination and ventilation and the space provided shall be on the basis of at least 0.5m2 per head. Sufficient number of mosquito nets shall be provided. Housekeeping and hygiene are monitored by the Contractor. Proper drinking water facility and canteen facility to be provided by the contractor. Free and adequate transport facilities shall be provided for all workers employed by the Contractor and residing at base camp to construction sites and Back. The Sewage system for the camp shall be designed, built and operated in such a manner that no health hazards occurs and no pollution to the air, ground water or adjacent water courses take place. Separate and adequate toilets/urinals and wash room Facilities shall be provided at Base Camp for Workers, separate for men and women (marked in vernacular). Wastewater shall be discharged to the existing sewage network or will be disposed-off in septic tank and soak pit. Solid waste generated from labour camps shall be segregated and collected in separate. Colour coded garbage bins for wet and dry wastes (for non-biodegradable and biodegradable waste) will be provided and regularly emptied. Solid waste generated in camp should be handed over to BBMP authority. Periodical health check-up for construction workers and their family and for the sick persons. Occupational Health Centre, Ambulance van and clinical room to test HIV/ AIDS/COVID prevention and control with all requirements.	Contractor/GC & K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
C18	Flora and Fauna: Plantation/Preservation/ Conservation Measures	The Contractor shall take reasonable precaution to prevent his workmen or any other persons from removing and damaging any flora (plant/vegetation) and fauna (animal) including fishing in any water body and hunting of any animal. If any wild animal is found in the vicinity of construction sites by chance, at any point of time, the contractor shall immediately upon discovery thereof acquaint in the Environmental Specialist of GC and carry out his instructions for dealing with the same. The compensatory plantation shall be carried out by the State Forest Department/BBMP forest wing. The Environmental Specialist of GC shall inspect regularly the survival rate of the trees planted. The tree protection/preservation, cutting and disposal shall be planned in line with The Karnataka Tree Preservation Act, 1976 & amendment Rule 2008, Forest Conservation Act 1980 and ESS 6 of World Bank and EIB's ESS 4.	Contractor/GC & K RIDE
C19	Preservation of fossils, archaeological remains, etc.	All fossils, coins, articles of value of antiquity, structures and other remains of archaeological interest discovered on the site shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation and WB ESS 8 & EIB's ESS 10. The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He shall, immediately upon discovery thereof and before removal acquaint the Environmental Specialist of GC. The GC shall seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work in the site.	Contractor/GC & K RIDE
C20	Contractor's Closure Activities before Demobilization	Clean-up Operations, Restoration and Rehabilitation activities shall be implemented during project closure by the Contractor in line with WB's ESS 3, 4 & 6 and EIB's ESS 3, 9 & 4. Contractor shall prepare site restoration plans, which shall be approved by the Environmental Specialist of GC. The clean-up and restoration operations are to be implemented by the Contractor prior to demobilization. The Contractor shall clear all temporary structures; dispose all garbage, night soils and POL (Petroleum, Oil and Lubricants) wastes as per Comprehensive Waste Management Plan and as approved by GC. All disposal pits or trenches shall be filled in and effectively sealed off. All construction zones and facilities including culverts, project corridor side areas, camps, batching plant sites and any other area used/affected due to the project	Contractor/GC & K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
		operations shall be left clean and tidy, at the Contractor's expense, to the entire satisfaction to the Environmental Specialist of GC.	
Operation Phase			
O1	Environmental Enhancement Measures - Tree Plantation	Compensatory Afforestation - Community Plantation shall be carried out by Forest Authority/BBMP in consultation with K RIDE. Local Trees shall be selected for plantation. Survival rate of the planted trees should be ensured by engaging tree expert.	PIA, K RIDE
O2	Monitoring of Operation Performance Indicators	The K RIDE shall monitor the operational performance of the various mitigation/enhancement measures carried out as a part of the project in line with WB's ESS 3, 4 & 6 and EIB's ESS 3, 9 & 4. The indicators selected for monitoring include the survival rate of trees; utility of enhancement provision made under the project; ETP & bio-digesters operations; and effectiveness of noise barriers. This will comply with WB's ESS 3, 4 & 6 and EIB's ESS 3, 9 & 4.	PIA, K RIDE
O3	Pollution Monitoring	The periodic monitoring of the ambient air quality, noise level, vibration, water (both ground and surface water) quality, soil quality in the selected locations as suggested in Environmental Monitoring Plan through the KSPCB or its approved monitoring agency and shall be in compliance with Environmental Protection Act, 1986, The Air (Prevention and Control) Act, 1981, The Water (Prevention and Control) Act, 1976 and The noise pollution (regulation and control) rules, 2000; and with all with Amendments and WB ESS 3 and EIB's ESS 3. A separate study should be conducted on the benefits of Suburban railway project in reduction of Carbon emission, pollution reductions, reduction in traffic congestion, decrease in road accidents, economic benefits due to better connectivity, etc.,	PIA, K RIDE
O4	Water supply	The source of water supply at Depots is municipal water supply. This will be supplemented by re-use of treated water of effluent treatment plant.	PIA, K RIDE
O5	Liquid waste - sewage & Effluent disposal at stations and Depots	Measures including treatment and reuse of waste water by installing Bio-digesters at Stations and Effluent treatment plant for Depots. Treated water shall be reused for flushing, washing and gardening purpose.	PIA, K RIDE

Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
O6	Solid waste disposal at stations and Depots	Organic waste shall be segregated and treated by in-site bio composter technique. Based on the situations, the municipal solid waste shall be handed over to the BBMP Authority for proper treatment and disposal.	PIA, K RIDE
O7	Incident Management	Proper maintenance of Incident Records shall be taken care. Required preventive measures shall be under taken to avoid repetition of risks/hazards. Incident Management Plan shall be in accordance with EHS guidelines and Emergency Response Plan.	PIA, K RIDE
O8	Community Health - Public awareness on Noise levels and Health Affects	Emergency-response planning and monitoring for prevention and control of pollution or other risk incidents during operation shall be established. **Corporate Social Responsibility**: Public shall be advised to construct the noise barriers such as walls, double glazed windows and tree plantation between the roads and their property.	PIA, K RIDE
O9	Monitoring and Grievances	Grievance mechanism shall be in line to monitor progress of implementation of the EMP/EMoP measures and results achieved. Project-level grievance redressal Mechanism shall be implemented.	PIA, K RIDE

1.8.1. Environmental Monitoring Plan

Monitoring of environmental quality during construction and operation stages reflects the success of implementation of the mitigation measures. Also it provides a chance to review the suggested measure and improve upon the measures. To ensure the effective implementation of the Environmental Management Plan (EMP), it is essential that an effective monitoring plan be designed and carried out. The environmental monitoring plan covering various performance indicators including periodic monitoring of environmental quality in terms of air, water, noise, vibration and soil quality, ecology, community and workers health and safety frequency and institutional arrangements for the project in the construction and operation stages has been formulated for the project. Environmental Monitoring of performance indicators will be conducted by the project authority. The monitoring plan has been suggested with performance indicators to be monitored, locations, frequency and timeframe of monitoring. Periodical monitoring of air, water and noise quality and survival rate of plantations also has been suggested. An independent environmental auditor will be appointed to evalute the implementation of EMP during construction and operation phase. Following figure indicate the institutional organisation for EMP implementation.

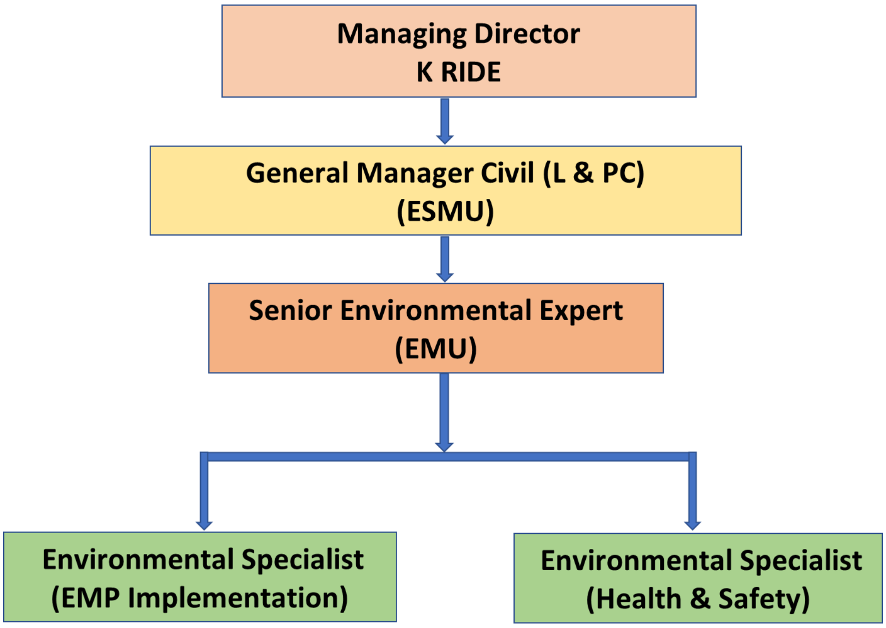

Figure.1.2. Organization Structure of PIA's Environmental Management Unit

1.9. Conclusion and Recommendations

The Environmental Impact Assessment Report for the proposed BSRP Corridors ie., Corridor 1 - Corridor 1 - KSR Bengaluru City to Devanahalli, Corridor 2 - Baiyyappanahalli Terminal to Chikkabanavara, Corridor 3 - Kengeri to Whitefield and Corridor 4 - Heelalige to Rajanukunte provides the detailed information of baseline environmental condition, project improvement details and positive and negative environmental and social impacts of the project. After detailed assessment following conclusions and recommendations are made for implementation of the project.

- Considering the Environmental and Social vulnerability of the project, the project is categorized as "A Category - High Environmental and Social Risks" under KfW's environmental and social safeguard policy. As per EIB's Environmental and Social Standards, the project is categorized as "High Risk". Hence, project requires detailed Environmental and Social Assessment.

- Development of Akkupete Depot requires diversion of 18.6Ha reserved forest land. Hence, the project requires forest clearance from the Regional Office of MoEF&CC through Karnataka State Forest Department. Further Compensatory Afforestation is to be carried out as per Forest (Conservation) Act, 1980.
- Since two archeologically protected monuments by ASI ie., 1) Fort, Devanahalli (aerial distance - 228m) and 2) Tippu Sulthan's Birth Place, Devanahalli (aerial distance - 271m) are situated within Regulated Area ie., 300m from the rail alignment as well as Devanahalli Station in Corridor 1 - KSR Bengaluru City to Devanahalli, requires prior permission from the National Monument Authority, New Delhi under Ancient Monuments and Archaeological Sites and Remains Act, 1958 and it's Amendment, 2010.
- Proposed development of BSRP corridors requires cutting of 32572 trees (Corridor-1 is 7198, Corridor-2 is 3469, Corridor- 3 is 2072, Corridor-4 is 2306, Akkupete Depot – 17505 and Soladevanahalli Depot - 22). It is hence, recommended to translocate the small trees wherever possible and plant at least ten trees for each tree cut for the project. Tree Cutting Permission is required under Forest Conservation Act, 1980 and Karnataka Preservation of Trees Act, 1976 from Karnataka State Forest Department. Compensatory afforestation will be undertaken by BBMP forest wing/Forest dept. as per the statutory guidelines of Karnataka Preservation of Trees Act, 1976.
- The project is not passing through or affecting MoEFCC notified protected areas, CPCB identified critically polluted areas and Ramsar's international importance wetlands, UNESCO designated world heritage sites.
- However, there are two protected areas such as Puttenahalli Lake Birds Conservation Reserve and Bannerghatta National Park present in the project study area.
- The nearest protected area present is Puttenahalli Lake Birds Conservation which is 850m (aerial distance) from the Corridor 4 - Heelalige to Rajanukunte railway corridor and 970m from the Corridor 1 - – Bengaluru City (KSR) to Devanahalli. Puttenahalli Lake birds conservation reserve is located near Vinayaka Bhadavane on Doddabalapura road. Apart from this, Bannerghatta National Park located at 12.7 Km (aerial distance) from the Corridor 4 - Heelalige to Rajanukunte. There is unlikely any impact on these protected areas either on the land or its flora and fauna from the project because of its distance and presence of urban settlements around it.
- Out of 127 religious/cultural structures, 18 religious structures (Corridor 1 – 1 structure, in Corridor 2 – 11 structures, Corridor 3 – 4 structures and Corridor 4 – 2 structures) are affected due to proposed BSRP.
- Out of 67 receptors, only one environmental sensitive receptor ie., Vinay Nursing Home at existing chainage 4/733 in Corridor 2 is affected due to project.
- Since there are 7 lakes and 89 storm water drains present along the project corridors, proper care should be taken during construction stage to avoid the deterioration of the water quality. However, none of the lakes directly affected due to project proposals.

- Climate Change Risks was assessed by using matrix method to identify the magnitude of impacts and predicting risks for various climate change conditions on vulnerable rail assets/infrastructure such as bridges, railway tracks, culverts, operating speed, etc., Adaptation measures during unprecedented climate change events during project life cycle were proposed as part of mitigation measures.
- Temporary risks & impacts are anticipated on air quality, water quality and noise level along the project corridors during the construction stage. The project will also pose risks and impacts on workers' health and safety during construction phase. Further, an increase in the ambient noise level is anticipated along the project corridors during the operation stage of the project.
- By implementing appropriate measures as detailed in the EMP and proper monitoring of the construction activities, the potential negative impacts can be regulated or minimised.
- As part of EMP implementation and enhancement measures about ₹ 7227.54 Lakhs (Corridor 1 – 4486.64 lakhs, Corridor 2 – 1098.23 lakhs, Corridor 3 – 807.79 lakhs and Corridor 4 – 834.87 lakhs) has been budgeted to carryout compensatory afforestation for tree felling, erecting concrete noise barriers at sensitive receptors (educational institutes & health centers), rainwater harvesting pits, provisions for environmental monitoring during construction and operation phase, awareness and training, etc., are considered.

The proposed project will enhance rural-urban connectivity, ease traffic congestion, and provide a cleaner mobility solution to lakhs of daily commuters. It will play a key role to boost economic progress of the state. The project will enhance the air quality in Bengaluru city due to introduction of Suburban Railway as there will be drastic reduction in vehicular traffic resulting in the reduction in greenhouse gas emissions. It was also revealed in the public interactions that, the proposed project will help in resolving the traffic congestion of Bengaluru and enhance the overall environmental condition of the region.

To mitigate the risks & impacts during construction and operation stages of the project, a comprehensive environmental management and monitoring plan has been prepared using WB's ESS, EIB's ESS, General EHS guidelines, Railway specific EHS Guidelines and other relevant Good International Industry Practices (GIIPs) and guidelines stipulated in Environmental Impact Assessment Notification for linear projects by MoEFCC. With this, the proposed project is unlikely to cause any significant adverse effects on the surrounding environment. To make the project environmentally sound and sustainable, the EMP will be made part of the contractual/bid document and will be ensured that, the implementation of EMP measures are contractors responsibility under the supervision and guidance of GC and K RIDE.

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Chapter 2. Introduction

2.1. Project Background

Bengaluru population has been growing faster. There has been a phenomenal growth in the population of vehicles as well, especially the two and four wheelers in this period due to rising household incomes. In the absence of adequate public transport system, people are using the personalized modes which is not only leading to congestion on limited road network but also increasing environmental pollution. An average citizen of Bengaluru spends more than 240 hours stuck in traffic every year. Such delays result in loss of productivity, reduced air quality, reduced quality of life, and increased costs for services and goods.

Hence, to overcome the above issue, K RIDE has proposed to implement Bengaluru Suburban Railway Project (BSRP), which is a new Suburban Railway Project envisaging construction of 4 dedicated rail corridors in a period of 6 years. It will link Bengaluru to its satellite townships, suburbs, surrounding areas and provide a mass rail based rapid transit system.

2.2. Project Proponent

K RIDE is a Joint venture of Government of Karnataka and the Ministry of Railways. It has been created to boost “Rail Infrastructure Projects” in the state of Karnataka on the principle of cooperative federalism. Currently, the joint venture has been mandated with the critical responsibility of executing the flagship Bengaluru Suburban Rail Project (BSRP) and two large doubling projects. Headquartered in Bengaluru, K RIDE aims to become a benchmark in executing Rail based infrastructure projects in an agile, innovative and qualitative manner. K RIDE has taken up the project of developing four dedicated suburban rail corridors in Bengaluru City, planned to be constructed within a time period of six years.

2.3. Brief Profile of the Project Region

Bengaluru, a multifunctional Metropolitan and the capital city of Karnataka, is the fifth largest metropolis in India and is one of the fastest growing cities in Asia. The city is branded as “Garden City” in early 90’s and now well-known as “Silicon Valley of India” for spearheading the growth of Information and Communication Technology (ICT) based industries. Bengaluru has become a cosmopolitan city attracting people and business alike, within India and internationally and has become a symbol of India’s integration with global economy.

The city has grown rapidly in the past few decades from pensioner’s paradise to the IT capital of India. Due to the presence of IT, BT and large public sector industries such as HAL, BEL, BEML & HMT etc., and major industries in automation, garments, etc., leading to rapid in-migration into the city. Recently, the city has emerged as a global start-up hub and bringing innovation and contribution to GDP, diversity of economy and adding to employment opportunities.

Bengaluru with its strong economic base, contributes about 1.9% of India’s GDP (2013-14) and 34% to Karnataka’s GSDP (2013-14). The Metropolis houses about 40% of urban population of Karnataka and has witnessed 42% population growth during the decade 2001-2011, thus playing the role of primate city in the state. In this context, population in the city of Bengaluru accounts for nearly 14.6% of the state’s population concentrated in only about 0.64% of land area1. As per the recent studies, Bengaluru has ranked number one and expected to achieve 8.5% annual growth forecast by 20352. Due to its high quality talent pool, the city has become a breeding ground for tech startups.

2.4. Overview of the Project

Project corridors fall within the limits of Bengaluru urban district which mainly traverse busy major business districts of Bengaluru city. A small portion of the Corridor-1 Rail alignment is falling in Bengaluru Rural District. About 76.435Km (excluding railway legnth in doubling project) of the dedicated rail corridor length is designed to fall within the existing RoW along the south-western railway network in the city to avoid the social impacts due to fresh land acquisition.

Bengaluru is an important and a major junction on the South-Western railway network. There are three major railway stations in Bengaluru - City Railway Station, Cantonment Railway Station and Yeshwantpur Railway Station. Bengaluru is served by 5 radial rail corridors.

- B.G. line from Chennai on east
- B.G. line from Mumbai-Pune on north-west
- B.G. line from Guntakal on the north
- B.G. line from Salem / Thiruvananthapuram from east
- B.G. line from Mysuru from south-west

BSRP corridors passes through majority of these corridors and also intersect multiple major railway stations mentioned above. A feasibility study of the project corridors was undertaken by M/s RITES Ltd. to assess the techno-economic feasibility of the project in the year 2019. Total length of the suburban rail is 159.360 Km. Salient features of BSRP Corridors are presented in **Table 2.1**. BSRP corridors details with its proposed length are presented below;

Corridor – 1: KSR Bengaluru City to Devanahalli (47.380Km),

Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara (28.720Km),

Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment) (35.52Km) &

Corridor – 4: Heelalige to Rajanukunte (47.74Km).

Table 2.1. Salient Features of BSRP Corridors

Sl. No.	Item Description	Corridor 1		Corridor 2	Corridor 3		Corridor 4
		KSR Bengaluru City to Devanahalli	Airport Line	Baiyappanahalli Terminal to Chikkabanavara	Kengeri to Cantonment	Cantonment to Whitefield	Heelalige to Rajanukunte
1	Length of corridor (Km)	41.43	5.95	28.72	18.47	17.05	47.74

1 Bengaluru Revised Master Plan 2031, Vision Document

2 World Economic Forum – Cities in 2035

Sl. No.	Item Description	Corridor 1		Corridor 2	Corridor 3		Corridor 4
		KSR Bengaluru City to Devanahalli	Airport Line	Baiyappanahalli Terminal to Chikkabanavara	Kengeri to Cantonment	Cantonment to Whitefield	Heelalige to Rajanukunte
2.	Length of elevated section (Km)	18.98	3.55	9.25	10.40	-	9.48
3.	Length of At-Grade section (Km)	22.45	2.40	19.47	8.07	17.05	38.27
4.	Number of stations	15	2	15	9	5	23
5.	No. of Elevated stations	8	2 (cut & cover)	3	3	-	3
6.	No. of At-Grade stations	7		10	5	5	16
7.	No. of future stations	0		2	1	Quadrupling section	4
8.	No. of Interchange stations	3	Nil	2	1		1
9.	No. of Existing ROB on the corridor	10		6	3		6
10.	No. of Existing FOB on the corridor	6		3	5		0
11.	No. of Existing LCs on the corridor	10		11	3		11
12.	No. of LCs' under sanction for RUB/ROB	1		2	1		2
13.	No. of Existing LCs to be eliminated in At-Grade locations	6		7	1		11
14.	No. of LCs where Suburban track is elevated	3		3	1		1
15.	Private Land required (Vacant / Built-up), Ha	4.90		2.07	8.39	-	17.31
16.	Private land required for Depots (Devanahalli and Soladevenahalli), area in Ha	25.21					

Source: Feasibility Report prepared by RITES Consultant for BSRP Project in 2019 & Design updation as on 04.12.2023.

Key map of the Bengaluru Suburban Railway Project corridors are presented in **Figure 2.1**.

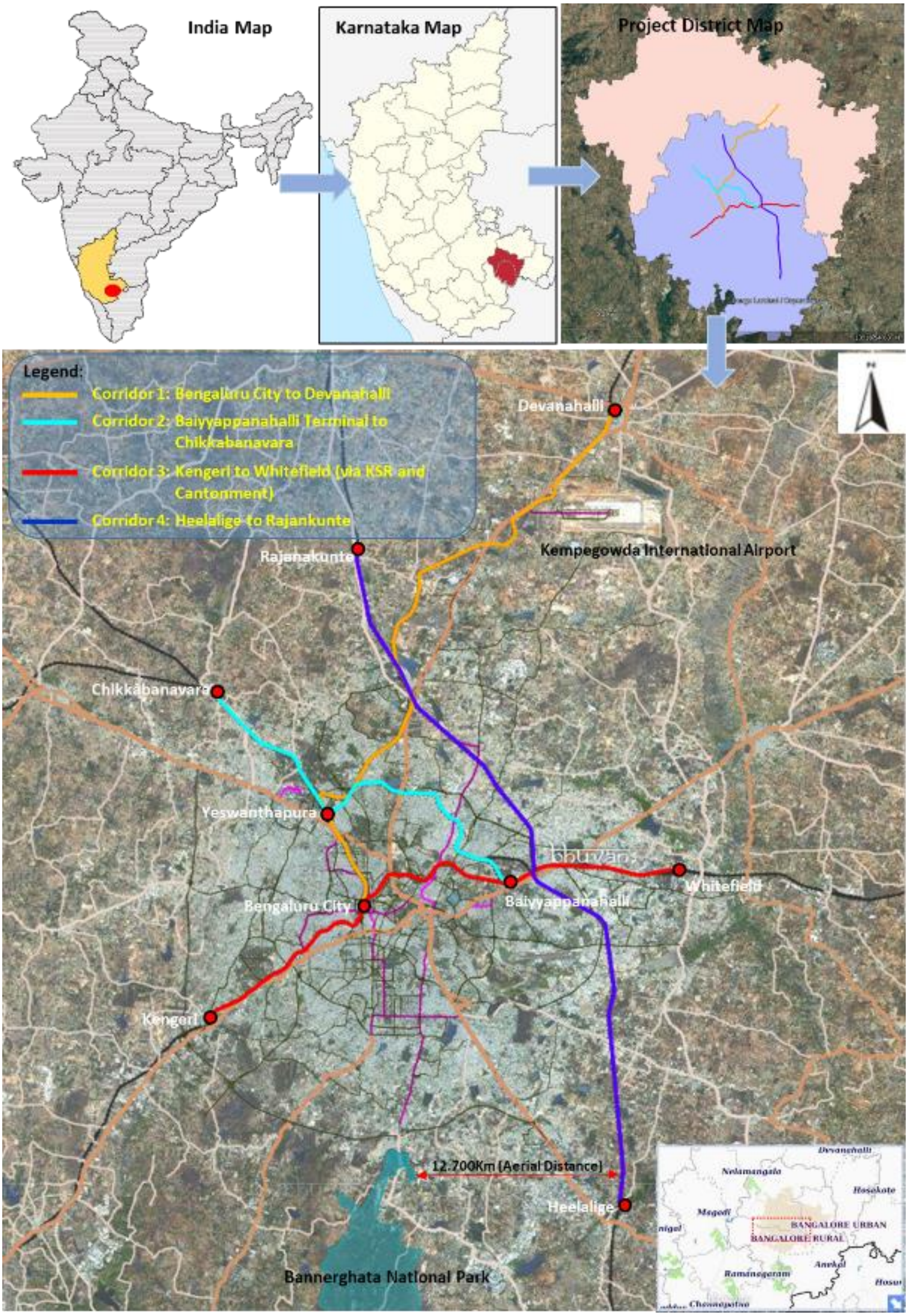


Figure 2.1. Key Map of the Bengaluru Suburban Railway Project Corridors

2.5. Need for the Project

Development and rapid growth of Information Technology (IT) and other commercial activities resulting in drastic increase in population in Bengaluru city. Due to increase in population and limited road network, there is a demand for public transport system in the city. In the absence of adequate public transport system, people are using the personalized modes which is not only leading to congestion on limited road network but also increasing environmental pollution. On an average, a citizen of Bengaluru spends more than 240 hours stuck in traffic every year. Such delays result in loss of productivity, reduced air quality, reduced quality of life, and increased costs for services and goods.

During the feasibility study, it was found that, presently Bengaluru's transport system is facing the following challenges;

- Road network capacity is inadequate. Most of the major roads are four lane or less, with limited scope for widening. This indicates the need for judicious use of available road space. The junctions are closely spaced and many junctions in core area are with 5 arms. This makes traffic circulation difficult. There is need to optimise the available capacity by adopting transport system management measures and by making use of intelligent transportation systems.
- Traffic composition on roads indicate very high share of two wheelers and cars. V/C ratios on most of the roads are more than one. Overall average traffic speed is about 12 kmph in peak hour. This not only indicates the need for augmenting road capacity but also to plan high capacity mass transport systems on many corridors.
- Outer cordon has high through-traffic to the city. This points to the need of road bypasses not only for Bengaluru Metropolitan Area (BMA) but also for Bengaluru Metropolitan Region (BMR). High goods traffic also indicates the need of freight terminals at the periphery of the city.
- Bengaluru is characterised by mutation corridors where residential areas also has commercial activities. In view of this, there is high pedestrian traffic not only in core area but also in other areas of the city. Footpath facilities are generally not adequate and their condition is deteriorating. Therefore, up gradation of their facilities is very important. Share of cycle traffic has declined over the years. This mode of transport needs to be promoted by providing cycle tracks along the roads.
- Parking is assuming critical dimensions in Bengaluru. Parking facilities need to be augmented substantially. In the long run, city-wide public transport system is the only option not only to reduce congestion on roads but also to reduce parking demand.
- As per Karnataka State Disaster Management Plan, over 3000 road accidents occurs every year in Bengaluru Metropolitan Region. Major reason is potholes in roads as well as restricted road width.
- BMA Master Plan has provided for densification of existing areas, Mutation corridors, hi-tech areas etc. in various parts of the city. This is likely to have a major impact on traffic demand. The transport network including mass transport system needs to be planned taking the proposed development in to consideration.

- Major developments have been proposed in the suburban towns of Bengaluru by BMRDA in the BMR. This is likely to increase interaction between Bengaluru and these suburban towns. Thus, there is a need to provide commuter rail services to these towns from Bengaluru.

To overcome all the above issues/challenges, city needs urgent public transport augmentation measures with better commuter facilities. Proposed dedicated Suburban rail project will definitely become a milestone not only in reducing the traffic congestion but also to synergise multiple modes of public transport and deliver seamless mobility solutions for commuters within the urban limits as well as immediate rural extensions.

2.6. Expected Benefits from the Project

- Bengaluru Suburban Rail Project is a prestigious project of Government of Karnataka, which will link Bengaluru to its satellite townships, suburbs, surrounding areas and provide a mass rail based rapid transit system.
- The project will enhance rural-urban connectivity, ease traffic congestion, and provide a cleaner mobility solution to lakhs of daily commuters.
- The fares will be at affordable rates compared to other existing modes of public transport, providing an economical alternative to lakhs of daily commuters.
- The project is intended to provide Air Conditioned trains with safe, better, comfortable and fast connectivity through four dedicated rail corridors within a period of six years.
- BSRP will integrate multiple modes of transport and provide a convergent transit solution to commuters. At more than 60% of its stations, passengers will be able to interchange with other modes of transport like Indian Railways and local Metro network.
- The project will enhance the air quality in Bengaluru city due to introduction of Suburban Railway as there will be drastic reduction in vehicular traffic resulting in the reduction in greenhouse gas emissions.

2.7. Various Studies/ Reports being prepared for the Project

K RIDE has undertaken various design studies for the development of Suburban rail project in Bengaluru city. Detailed Feasibility Study has been conducted by engaging Rail India Technical and Economic Service Limited (RITES Ltd.) in the year 2018-19. The objective of the study is to provide additional dedicated rail corridors i.e., 3th & 4th lines in the entire section either at-grade or elevated, based on the availability of land. Assessing techno-financial feasibility of the project by studying

1) Availability and acquisition of Government or Private land at locations where railway land is inadequate.
2) Crossing of ROBs / FOBs / Metro tracks by the elevated corridors.
3) Identifying existence of cables, pipelines and any such other utilities etc., alongside railway track which need to be relocated.
4) Requirement of line blocks (including power blocks) for execution of elevated corridor.
5) Constraints regarding execution of works in restricted/congested areas including leading of material and temporary requirement of land for casting depots, material storage etc.
6) Possible remedy to overcome these constraints and costs involved.

7) Measures required for safety of existing services during construction process.
8) Estimating budget for implementation of the project

In order to have design standards for Elevated Stations, the authority prepared Design Basis Report for elevated stations in the year 2021. The objective of this document is to establish common procedure for the design of Elevated Suburban Station for BSRP corridors. K RIDE has engaged design consultants for development of land parcels and stations, where the consultants are undertaking studies for maximum utilization of available land with Indian Railway and designing of stations for all the BSRP corridors.

2.8. Structure of the Report

The Environmental Assessment Report is organized in accordance with World Bank's Environmental Social Standards, guidance note, General EHS guidelines and Railway specific EHS Guidelines and other relevant Good International Industry Practices (GIIPs) and guidelines stipulated in Environmental Impact Assessment Notification for linear projects by MoEFCC. The report has been organized into following chapters:

Chapter 1: Report starts with Executive Summary of the Environmental Impact Assessment Report

Chapter 2: Introduction gives the details of the project, project proponent, description of the project, overview of major project activities, need for the project, expected benefits from the project, various studies / reports being prepared for the project and structure of the project.

Chapter 3: Project Description, a brief description of the project corridors is given focusing on proposed improvements of corridors, transport demand analysis, intermodal analysis, suburban railway improvements, design details of stations and elevated structures, utility details, economic and financial analysis, etc.

Chapter 4: Environment Regulatory Framework presents the legal and administrative framework of KfW & EIB, World Bank, Government of India and Government of Karnataka. It also presents the gap analysis between World Bank's ESS and National and State regulations. This section underlines various permissions involved for the project corridor at the State level and at the Central level.

Chapter 5: Baseline Environmental Profile pronounces the existing environmental conditions along the corridors ascertained by a reconnaissance survey along with collection of secondary information pertaining to the corridors. Primary data for various environmental parameters was generated using suitable monitoring devises and methodology as stipulated by Central Pollution Control Board and RDSO.

Chapter 6: Stakeholder's consultation presents the views obtained on the project in general and the suggestions received with respect to the suburban railway project corridors and prevailing conditions of environment.

Chapter 7: Analysis of Alternatives was carried out by design consultant for railway alignment, stations, Depots, technology options and assessed the "with project" and "without project scenario" in this chapter.

Chapter 8: Environmental Risks and Impacts, likely risks and negative impacts caused on various environmental and social parameters by activities proposed for the project corridors were recorded and positive impacts of the project Environmental Impacts Mitigation Measures and Management Plan, this chapter presents appropriate mitigation measures for the identified impacts and detailed management plans for the impacts caused due to various activities.

Chapter 9: This chapter details the positive environmental impacts resulted from the development of BSRP corridors.

Chapter 10: This chapter details the environmental Management plan with monitoring plan, institutional arrangements, capacity building, training, GRC and reporting mechanism for successful implementation of the EMP.

Chapter 11: This chapter proposes cost estimation for implementation of EMP for the project. Also it proposes plans for monitoring different parameters for various project phases and budgetary allocation for the implementation of the same.

Chapter 12: Conclusion and Recommendations, the outcome of the environmental Impact assessment and management plan exercise for the project is presented in this Chapter.

Chapter 13: References gives the details of references used for the preparation of this report.

Chapter 3. Description of the Project

3.1. Introduction

In order to provide better public transport system, decongest road traffic and enhance the connectivity to the outskirts of the city, GoK and Ministry of Railways proposed to introduce suburban railway project. To increase the share of public transport in Bengaluru, GoK and Railways had commissioned many studies though RITES Ltd., for introduction of Commuter Rail Services (CRS) in Bengaluru. The studies analyzed the existing rail network and suggested improvements / augmentation by way of doubling / quadrupling etc.

However, to run Commuter Rail System in Bengaluru, separate tracks need to be provided, which may involve land acquisition. The land acquisition is generally a costly and time consuming affair and hence, most of the earlier proposals remained non-starter.

Railways have now decided to explore the possibility of introducing / enhancing the Commuter Rail Services in Bengaluru, with minimum land acquisition. Towards this end, Railways entrusted the work of carrying out the Feasibility of running Suburban Rail services along the existing rail network of Bengaluru to RITES Ltd.

3.2. Transport Demand Analysis

The study area includes Bengaluru Metropolitan Area (BMA) of about 1306 sq.km. (including part BMICAPA area – 65.31 sq.km.) and adjoining areas of Bengaluru International Airport Area Planning Authority (BIAAPA). Adjoining BIAAPA area has been included in the study area as public transport corridors are connecting Kempegowda International Airport and some of the localities where proposed development has been listed out in BIAAPA Master Plan. The horizon year for the study is 2041. The effect of traffic coming from outside Bengaluru and using Bengaluru's transport system has also been taken into account.

Bengaluru's road network length exceeds 3,000 km and consists of ring roads, arterial roads, sub-arterial roads and residential streets. The city road network is mainly radial, converging in the center. Some of the National Highways and State Highways pass through Bengaluru which also form the radial roads crossing the city.

Bengaluru is an important and a major junction on the South-Western railway network. There are three major railway stations in Bengaluru - City Railway Station, Cantonment Railway Station and Yeshwantpur Railway Station. Bengaluru is served by 5 radial rail corridors.

1) B.G. line from Chennai on east
2) B.G. line from Mumbai-Pune on north-west
3) B.G. line from Guntakal on the north
4) B.G. line from Salem / Trivandrum from east
5) B.G. line from Mysuru from south-west

Bengaluru is served by Rapid transit system called the Namma Metro, being built in stages. At present, Phase-1 covers a length of 43 km on two lines i.e. Mysuru Road to Baiyyappanahalli and Nagasandra to Yelachenahalli. Both the lines are under operation, carrying about 4.4 lakh passengers per day. The Phase 2, 2A and 2B are under implementation.

Bengaluru is served by Kempegowda International Airport (KIA) located near Devanahalli which has been operational since May 2008. The Kempegowda International Airport is located north of the city at a distance of 40 cm from the city centre.

The city has very good bus transport systems in the country. BMTC has 40 depots in and around Bengaluru city. The daily ridership is approximately 50 lakh passengers. BMTC operates 578 city and 1756 Suburban routes per day. BMTC is catering to the transport services in city as well as suburban areas of Bengaluru.

Auto rickshaws and taxis are the Intermediate Public Transport (IPT) facility available in Bengaluru. Apart from the autos, regular small cars (Maruti Omni vans and Indica diesel cars) and ola cabs as taxis are provided by several operators commonly referred to as City Taxis. The autos are also used for various trip purposes and to a large extent by the visitors to the city.

3.2.1. Zoning System

The entire study area has been divided into 198 internal urban & 17 zones of Bengaluru International Airport Area Planning Authority and 10 external traffic zones. The traffic zone system map has been shown in **Figure 3.1** and **Figure 3.2.**

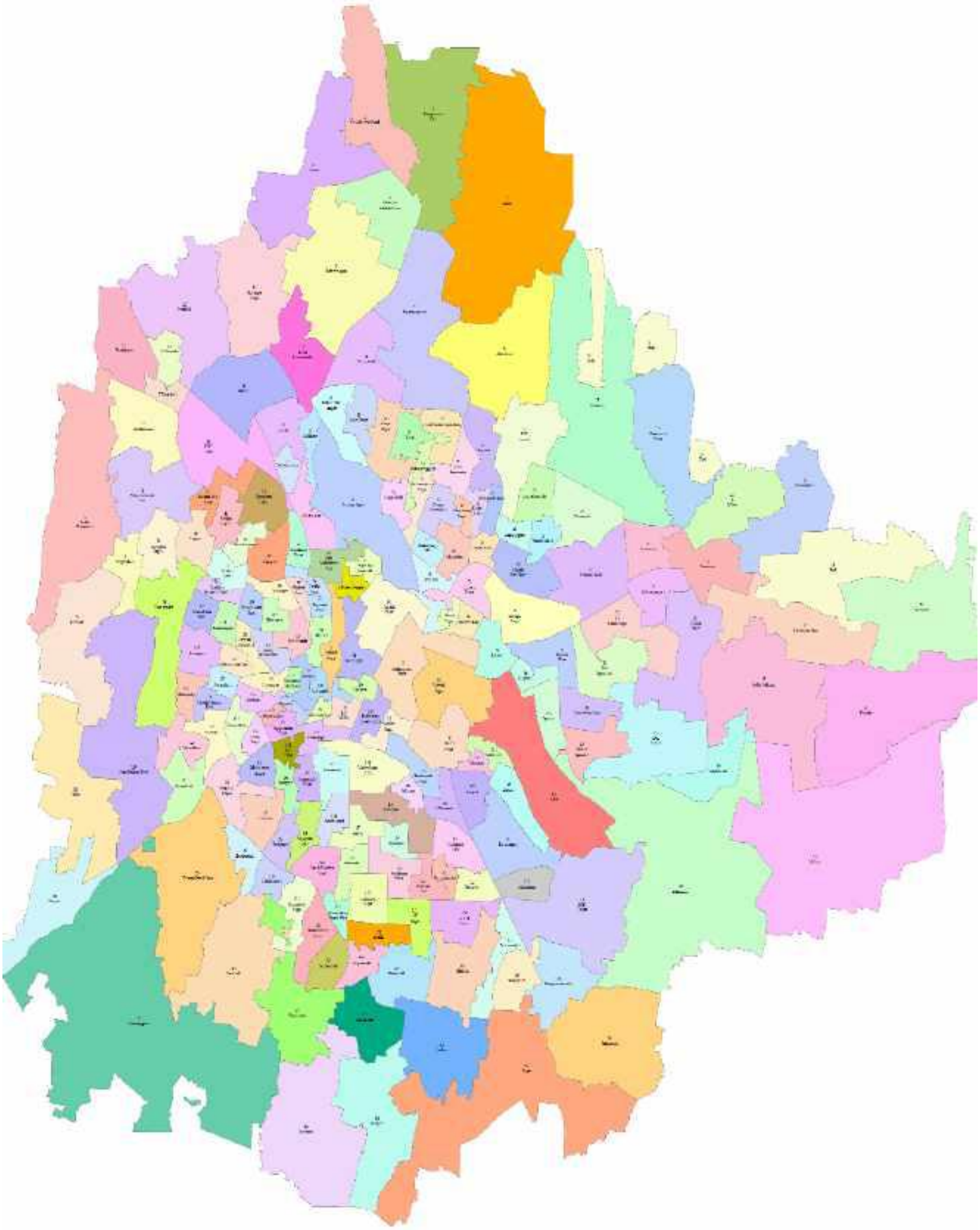


Figure 3.1. Traffic Zone System

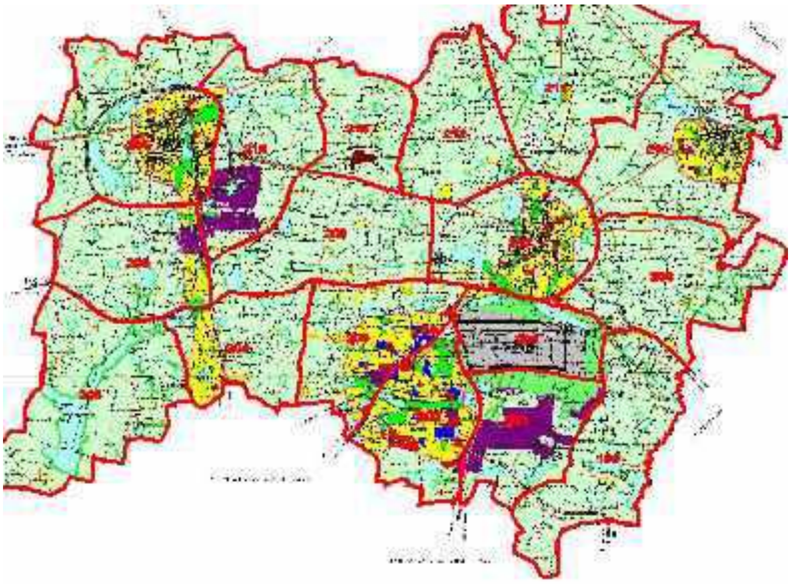


Figure 3.2. Traffic Zone System of BIAAPA

3.2.2. Socio-Economic Characteristics

Household surveys indicate that about 8% of the households have up to 2 members and about 16% of the households belong to the category of households which have 5-6 persons per household. Majority of households (75%) have between 3 and 4 persons per households. The average household size is 3.7.

Vehicle ownership data indicates that about 60% of households have 2-wheeler while 19.6% of household have car and only 2.2% of households have cycle.

From the occupational data of households in Bengaluru, it is observed that 38% of individuals are engaged in occupations such as Government Service, Private Service and Business. The number of students and housewives together accounts for about 26%.

Individuals of sampled households according to their education, it is observed that about 44% of individuals who are either non-matriculates or have completed matriculation or intermediate (12^{th} class). Graduates and post-graduates together account for nearly 26%.

3.2.3. Travel Characteristics

Trips by Mode of Travel is observed and it is noticed that about 26% of the trips are pedestrian trips. However, the trips performed by 2-wheelers are about 27% and that of Public transport modes including bus, minibus, school bus, chartered bus and metro together accounts for 32%. The trips performed by auto rickshaw and taxis are about 7%. Per capita trip rate including pedestrian trips is 1.24 and that of motorized trips is 0.91.

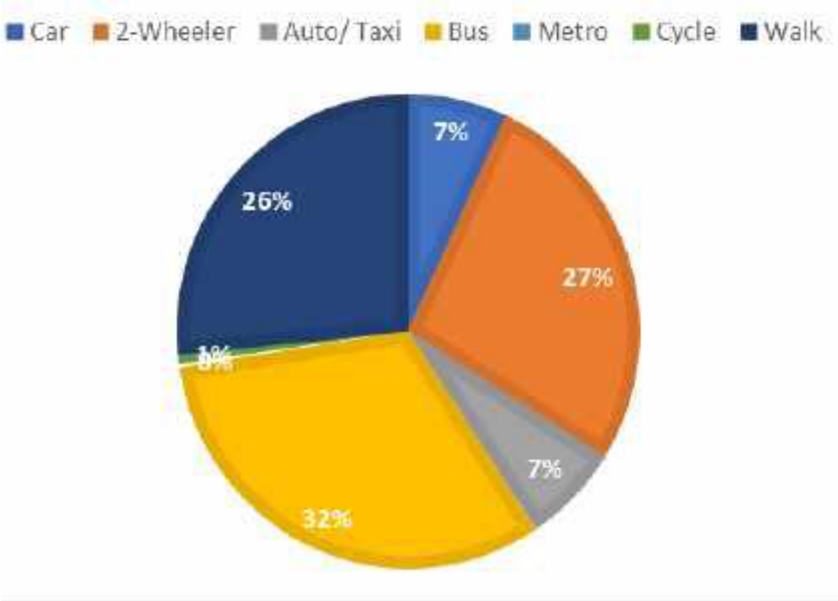


Figure 3.3. Modal Split - 2015 (Including Walk Trips)

From the above data of distribution of Trips by Purpose, it is observed that about 25% of the trips are performed for work and business purposes together, where as 15% of the trips are performed to go to educational institutions and about 10% trips includes trips for shopping, social, health and recreational purposes

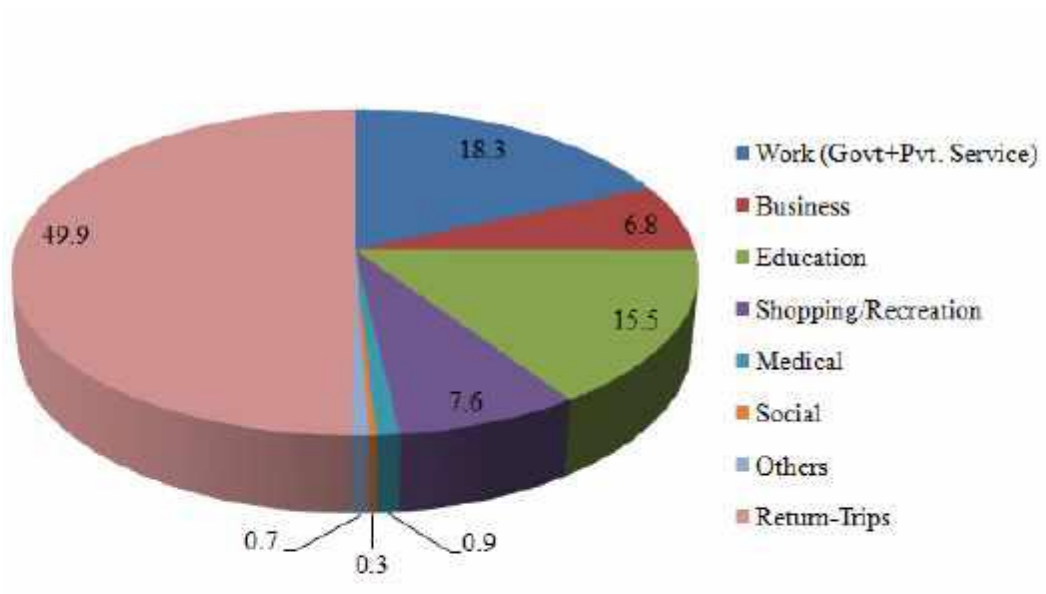


Figure 3.4. Purpose-wise Distribution of Total Trips

From the above data depicting distribution of Trips by Trip Length, the average trip length is observed to be 2 km for pedestrians, 8.1 km for 2- wheeler passengers, 12.2 km and 12.7 km for car and taxi respectively and 9.7 km for Bus passenger trips. Household opinion survey was carried out to obtain preference of commuters about shifting to good public transport system. About 96% of the households have responded that they are willing to shift to a good public transport system where as about 4% of households want to use their existing mode of travel.

A total of 198 internal zones & 17 zones of Bengaluru International Airport Area Planning Authority and 10 external zones have been considered for the study. According to census of India, the population of Bengaluru city is about 84.5 lakh and BIAAPA Area population is about 5 lakh in 2011. The total population of the study Area is about 120 lakh in 2018.

A four stage travel demand model has been developed for transport demand forecasting. Total daily ridership on the Suburban Rail System corridors for the years 2025, 2031 and 2041 is expected to be 9.84 lakh, 13.41 lakh and 17.60 lakh passengers respectively (**Table 3.1**). The Peak Hour Section loads are presented in **Table 3.2.**

Table 3.1. Daily Trips On Suburban Rail System

S No.	Corridor Name	Daily Trips		
		2025	2031	2041
1	KSR Bengaluru City - Devanahalli	282154	378901	536046
2	Baiyyappanahalli Terminal - Chikkabanavara	203317	266316	341561
3	Kengeri - White Field	164180	219644	271906
4	Heelalige - Rajanukunte	334724	476304	611005
Total Daily Trips		9,84,374	13,41,165	17,60,518

Table 3.2. Maximum Section Loading (PHPDT) on Suburban Rail System

S No.	Corridor Name	Maximum Section Load(PHPDT)		
		2025	2031	2041
1	KSR Bengaluru City - Devanahalli	11775	13750	19135
2	Baiyyappanahalli Terminal - Chikkabanavara	9009	10923	13858
3	Kengeri - White Field	6442	7951	10289
4	Heelalige - Rajanukunte	7646	11919	13527

3.3. Ground Survey and Alignment

3.3.1. Engineering Survey

The drone base aerial survey has been conducted to ascertain the existing infrastructure and constraints all along the existing railway boundary of the study area. Four independent corridors have been studied as part of this assignment and survey has been done for the complete length.

Corridor – 1: KSR Bengaluru City to Devanahalli

Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara

Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)

Corridor – 4: Heelalige to Rajanukunte

The Ground Control Point (GCP) of known coordinates have been established with traditional surveying methods or have been obtained from other sources (LiDAR, older maps of the area, Web Map Service) as they significantly increase the absolute accuracy of the data collected. The minimum number of GCPs required for this project has been considered and accordingly the GCP's have been marked on ground at appropriate locations. The total GCPs marked on ground are of 644 numbers which is approximately 4 GCPs per km length.

Drone was flown over the corridors length according to the flight path and acquired the images through photo chromatic camera with Pix4Dcapture software using grid option.

Image Processing and Ortho-rectification has been done. Pre-Processing and Ortho rectification of imagery and pre-processing of acquired Images by way of digital surface models, digital terrain model generation and Ortho-Rectification of satellite Images has been undertaken.

3.3.2. Major Constraints

There are serious space constraints within railway ROW for laying additional tracks. There are number of private buildings at edge of the railway boundary on Kengeri - K.S.R Bengaluru City (Corridor 3), also from Ch: 354/900 to 355/150 on KSR Bengaluru City - Cantonment corridor. In some areas, temples are constructed either in railway boundaries or adjacent to railway boundaries on Kengeri - KSR Bengaluru City section and Hebbal - Banaswadi section corridors. Please refer System map in Figure 3.5 to locate these sections.

These constraints with respect to non-availability of railway RoW and construction of temples in railway boundaries will be resolved either by proposing elevated corridors or acquiring fresh land during detailed design stage, which will be undertaken by Contractor. .

3.3.3. Planning and Design Norms

Salient features of planning and design norms are given in the table below:

Table 3.3. Salient Features and Design Norms

Sl. No.	Item Description	Salient Features
1	Tracks	BG Tracks (1676mm)
2	Centre to Centre Spacing of existing IR tracks at-Grade	5.30m
3	Centre to Centre Spacing of Proposed tracks in elevated structure	4.725m
4	Width of Proposed Viaduct	10.9m for two tracks
5	Distance of Proposed At-grade nearest Sub urban track from Centre line of nearest IR track	7.8m
6	Distance of Proposed Centre line of viaduct from Centre line of nearest IR track	8.5m
7	Design Speed	90 Kmph
8	Types of track proposed	(a) Ballast-less track for elevated structure. (b) Ballast cushion of 350mm for At- Grade track
9	Horizontal Curves	Minimum radius of 200mm for at grade/ elevated

Sl. No.	Item Description	Salient Features
10	Radius of curves	1000m at stations
11	Cant Deficiency	Not to exceed 100mm
12	Actual Cant	Not to exceed 125mm
13	Vertical Curves	(a) Radius of vertical curve is 3000m (normal circumstances) & 2500m in exceptional circumstances
		(b) Minimum length shall be 20m
14	Gradient	(a) Elevated station -Level (or) 1 in 1000, At-Grade – Existing grade
		(b) At mid sections - Not Steeper than 2 % (May be 3% for elevated section in
		exceptional situation) (c) At par with existing IR tracks in mid locations at grade
15	Turnouts/Crossovers	(a) Main lines/ other running lines 1 in 12
		(b) Depot/Yard lines 1 in 8.5
16	Depot Yards	(a) Lines are normally flat/level in yards , may not be steeper than 1 in 1200
		(b) Curves in yards shall have radii not less than 175mm
		(c) Stabling lines shall have clear standing length of 350m for one rake length

3.3.4. Proposed Alignment

Corridor – 1: KSR Bengaluru City to Devanahalli:

Total length is 47.380 km out of which, length of airport line is 5.95 Km. The elevated section is 22.530 km and at-grade is 24.850 kms. Stations on Corridor-1 are seventeen (17) out of which eight (8) stations are elevated and seven (7) Stations are at-grade. Two (2) stations are proposed in airport line.

Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara:

Total length is 28.720 km out of which elevated section is 9.250 km and at-grade is 19.470 km. stations on Corridor-2 are fifteen (15), out of which eight (10) stations are at-grade stations, three (03) stations are elevated and two (2) stations are future stations.

Corridor – 3: Kengeri to Whitefield:

Total length is 35.52 km out of which the suburban corridor considered for the present study is only between Kengeri and KSR Bengaluru – Bengaluru Cantonment. The length of this section between Kengeri and Bengaluru Cantt. is 18.47 km. A stretch of 17.05 km between Bengaluru Cantonment and Whitefield is being taken up by the SWR for quadrupling. Once this is completed and becomes operational, two lines of the same shall be utilized for the Suburban services. Stations on C-3 are Nine (9) out of which five (5) stations are at-grade and three (3) stations are elevated and one (1) station is future station. And about five (05) stations are proposed in quadrupling section.

Corridor – 4: Heelalige to Rajanukunte:

Total length is 47.740 km out of which elevated section is 9.480 km, at-grade is 38.270 km. Stations on C-4 are twenty (23) out of which three (3) stations are elevated and sixteen (16) stations are at-grade and four (4) stations are future stations. Yelahanka is an inter-change station.

Toposheets prepared by Survey of India showing corridor wise project alignment is presented in **Annexure 5.1.**

Table 3.4. Salient Features Of Alignment

Sl No	Item Description	Salient Features
1	Alignment	(a) Proposed along parallel to existing IR Tracks. (b) Proposed within Railway ROW to Minimize the private land acquisition.
2	Crossings	Bare minimum crossing proposed to reduce cost & avoid disturbances to train Operations of IR.
3	Height of Deck	15.0m to be maintained above existing rail level.
4	Thickness of Elevated Deck Girder	Varies from 2.45m to 2.75m (based on span design)

Table 3.5. Salient Features of Corridors

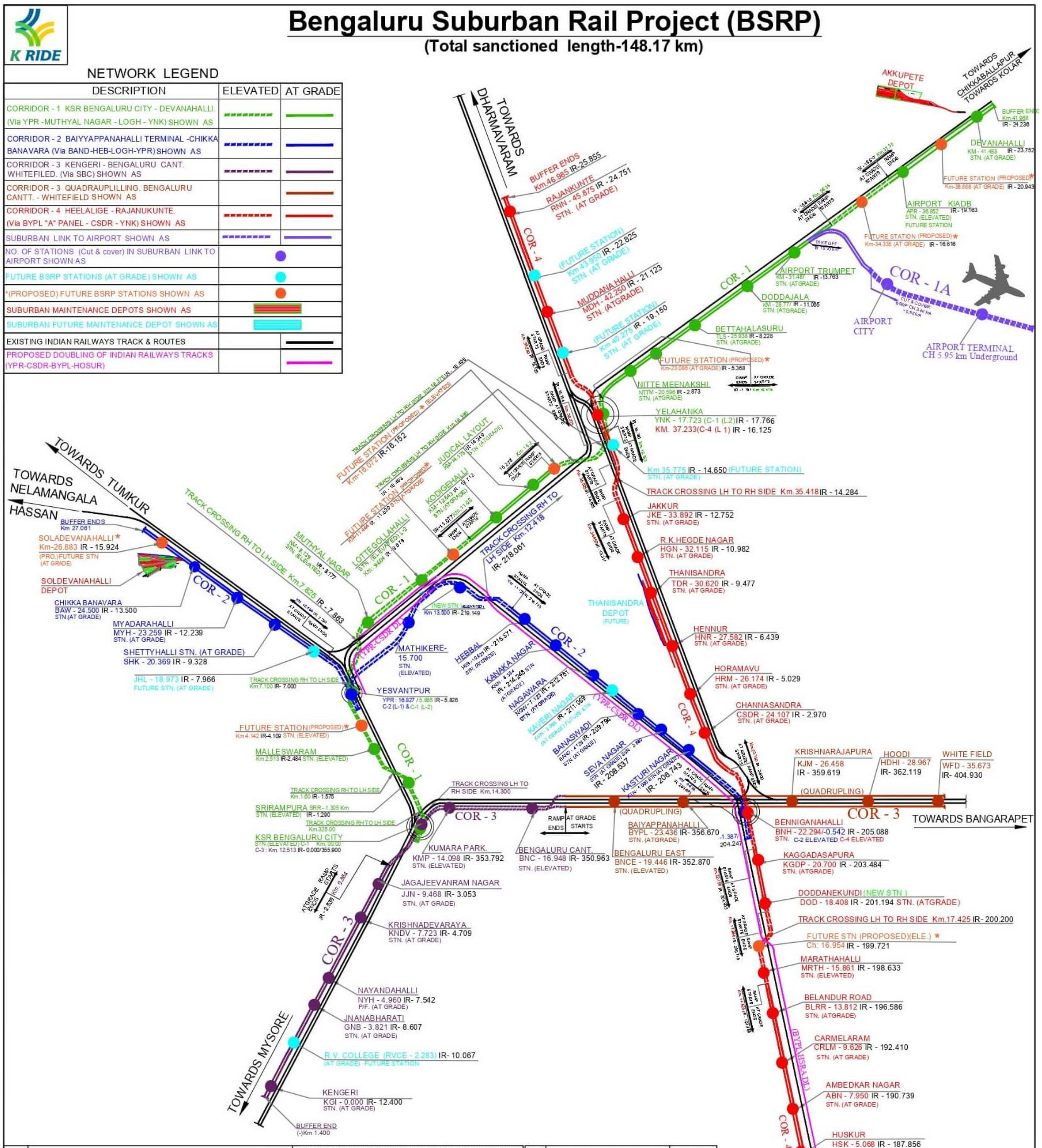
Sl. No.	Item Description	Corridor 1		Corridor 2	Corridor 3		Corridor 4
		KSR Bengaluru City to Devanahalli	Airport Line	Baiyappanahalli Terminal to Chikkabanavara	Kengeri to Cantonment	Cantonment to Whitefield	Heelalige to Rajanukunte
1	Length of corridor (Km)	41.43	5.95	28.72	18.47	17.05	47.74
2	Length of elevated section (Km)	18.98	3.55	9.25	10.40	-	9.48
3	Length of At-Grade section (Km)	22.45	2.40	19.47	8.07	17.05	38.27
4	Number of stations	15	2	15	9	5	23
5	No. of Elevated stations	8	2 (cut & cover)	3	3	-	3
6	No. of At-Grade stations	7		10	5	5	16
7	No. of future stations	0		2	1	Quadrupling section	4
8	No. of Interchange stations	3	Nil	2	1		1
9	No. of Existing ROB on the corridor	10		6	3		6

Sl. No.	Item Description	Corridor 1		Corridor 2	Corridor 3		Corridor 4
		KSR Bengaluru City to Devanahalli	Airport Line	Baiyappanahalli Terminal to Chikkabanavara	Kengeri to Cantonment	Cantonment to Whitefield	Heelalige to Rajanukunte
10	No. of Existing FOB on the corridor	6		3	5		0
11	No. of Existing LCs on the corridor	10		11	3		11
12	No. of LCs' under sanction for RUB/ROB	1		2	1		2
13	No. of Existing LCs to be eliminated in At-Grade locations	6		7	1		11
14	No. of LCs where Suburban track is elevated	3		3	1		1
15	Land to be acquired (Vacant / Built-up) (Acres)	4.9		2.07	8.39		16.31
16	Private land to be acquired for Depot. Area in Sq.m	25.21					
17	Temporary Land Requirements	The EPC contractor will identify temporary land requirements for workers camps, stores, yards, etc. and enter into rental/ lease agreements with land owners. These lease agreements will be submitted to the promotor. Presently, the designs are under process, once these are approved, temporary land requirement for working space will be assessed, impacts due to such temporary land requirement will be included in the respective RAPs.					

Source: Feasibility Report prepared by RITES Consultant for BSRP Project in 2019 & Design updation as on 04.12.2023.
Note: On Corridor – 3, the stretch of Bengaluru Cantonment to Whitefield of 17.05 km is not taken for the study since Quadrupling is in progress and on completion the same will be merged with Suburban system. However, 5 stations are identified on this stretch and all the 5 are existing stations.

The private open land of about 28.63 hectares and private built-up land of about 12.52 hectares will have to be acquired for implementation of the project. The total railway land required is about 132.33 hectares.

System map of BSRP corridors is presented as **Figure 3.5.**



S.No	BSRP CORRIDOR DETAILS	STATUS OF NUMBER OF BSRP STATIONS				
		PRESENT		FUTURE		TOTAL
		ELEVATED	AT GRADE	ELEVATED	AT GRADE	
1	CORRIDOR-1 (C-1)(KSR Bengaluru City-Devanahalli)	8	7	0	0	15
2	CORRIDOR-1 (C-1A)(Airport Link)	2* (Cut & Cover)		0	0	2*
3	CORRIDOR-2(C-2)(Baiyyappanahalli-Chikkabanavara)	3	10	0	2	15
4	CORRIDOR-3 (C-3)(Kengeri-Whitefield)	3 + 5*	5	0	1	14
5	CORRIDOR-4 (C-4)(Heelalige-Rajankute)	3	16		4	23
	Total Number of Stations	17 + 5*	37	0	8	62+2*+5*

- (*) Includes 2 Nos. of stations (Cut & cover) in Airport Link
- (*) Includes 5 Nos. of stations between (Bangalore Cantt.- Whitefield) section : (Quadrupling Project)
- Note: Proposed no. of future BSRP stations (as indicated in BSRP network map) are not considered in the total no. of BSRP stations.

S.No	BSRP INTEGRATED STATIONS	CORRIDOR
1	KSR Bengaluru city	1 & 3
2	Yesvantapur	1 & 2
3	Yelahanka	1 & 4
4	Benniganahalli	2 & 4
5	Airport Trumpet	1 & 1A
	Total No. of Integrated stations :	5

S.No	NAME OF THE CORRIDOR	ELEVATED (in Km)	AT GRADE (in Km)	TOTAL (in Km)
1	CORRIDOR-1 (C-1)	18.98	22.420	41.4
2	AIRPORT LINK(C-1A)	3.55	2.40	5.95
3	CORRIDOR-2 (C-2)	9.25	19.472	28.722
4	CORRIDOR-3 (C-3)	10.400	8.070 +17.050(QDR)	18.47 +17.050(QDR)
5	CORRIDOR-4 (C-4)	9.475	38.268	47.743
	TOTAL	51.655	90.63	142.285+17.05

Figure 3.5. System Map of the Bengaluru Suburban Railway Project Corridors

3.3.5. Design Modification in BSRP Corridors

Due to some design change, there are few changes made in the Stations locations, levels, included new stations and depot. Details of design modification are incorporated in the project are given in the following table.

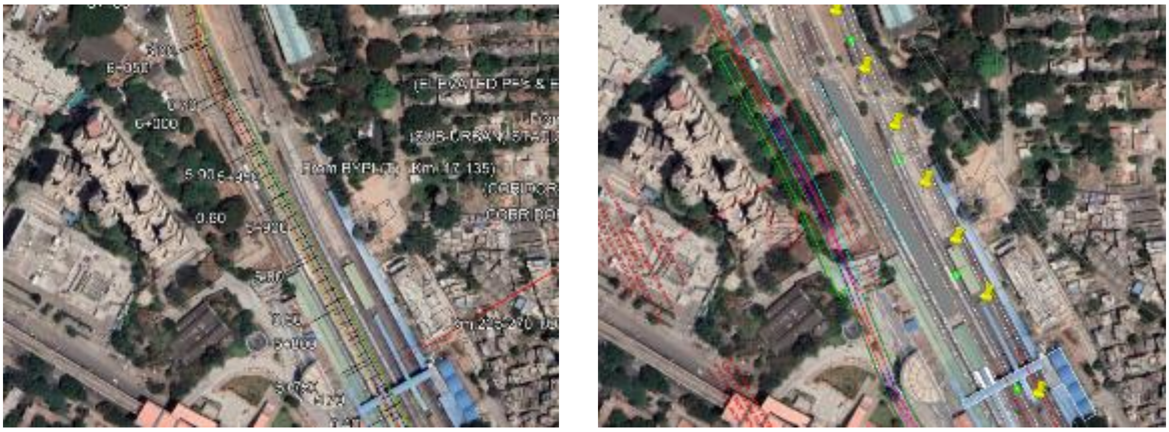
Table 3.6. Modification in Design for BSRP Corridors

Corridor no.	Stations	Updates
Corridor 1	KSR Bengaluru Station	Change in location of Station to Railway Station Road
	Srirampura Station	Conversion of Future Station to Present Station
	Yesvantpur Station	Change in level and location of the station (to front side of existing station)
	Yelahanka Station	Sharing of station with Corridor 4 at Level-1 & Corridor 1 at Level-2
	Nitte Meenakshi & Doddajala	Change in location of station towards KSR Bengaluru City
	Airport KIADB	Conversion of present station to future Station
	New Future Station	Inclusion of a future station between Airport KIADB and Devanahalli Stations
Corridor 2	Hebbal Station	Change in the location shifted towards Banaswadi side after Hebbal Flyover
	New Station @ Km 13/460	New station is proposed over storm water drain
	Lottegollanahalli Station	Change in location shited towards Mathikere Junction
	Soladevanahalli Depot	Extension of alignment till Soladevanahalli Depot
Corridor 4	Yelahanka Station	Sharing of station with Corridor 4 at Level-1 & Corridor 1 at Level-2
	New future station	Inclusion of a future station between Marathahalli and Doddanekundi Stations

Before and after google images of modification done in suburban rail corridors are presented in **Figure 3.6.**

Corridor 1 - KSR Bengaluru Station

Corridor 1 - Srirampura Station



Corridor 1 - Yeswantpur Station

Corridor 1 - Yelahanka Station

Corridor 1 - Nitte Meenakshi & Doddajala

Corridor 1 - Airport KIADB

Corridor 1 - New Future Station


Corridor 2 - Hebbal Station


Corridor 2 – New Station is proposed @ Km 13/460

Corridor 2 - Lottegollanahalli Station

Corridor 2 - Soladevanahalli Depot (Newly Proposed Depot, Ref. Figure 3.24.)

Corridor 4 - Yelahanka Station

Corridor 4 - New future station @ Km 16+950 (IR Km 199+700)

Figure 3.6. Google Images Shows Before and After Pictures of Modification in Proposed in BSRP

3.4. Utilities

- A large number of sub-surface, surface and over-head utility services viz. sewers, water mains, storm water drains, gas pipe lines, telephone/ communication cables, overhead power transmission lines, power cables, traffic signals, etc. exist all along the proposed alignment.
- Apart from the above utilities, South Western Railway's huge network of Traction Power cables, Traction Power Installations, DC and AC traction substations, SPs and SSPs, Signal & Telecommunication cables, traction OHE masts and structures, Signal posts, power supply cubicles, location boxes etc. are spread along and cross the entire alignment.
- The proposed corridors have been planned within Railway's ROW and some of the utility services and Railways vital installations are encountered at a number of locations.
- These utility services are essential and have to be maintained in working condition during different stages of construction, by temporary / permanent diversions and relocation or by supporting in position.
- Any interruption to these will have serious repercussions on sensitive Suburban services and direct impact on the commuters, besides setback in construction and project implementation schedule.

3.4.1. Concerned Organizations/ Departments

The data on various utilities has been collected from following organizations (**Table 3.7**).

Table 3.7. Organisation/ Department Responsible for Utilities

S.No.	Organization/ Department	Utility Services
1.	BESCOM	Underground Electrical cables
2.	Vodafone	OFC cables Including Telecom cables.
3.	Defense	Other cables including telecom cables.
4.	BWSSB	Storm water drainages, Water Pipe Lines
5.	Gail (Gas Pipe)	Gas or Oil Pipe lines.
6.	KPTCL	UG Cables Electrical cables, H.V powertransmission Lines
7.	Reliance Jio Infocom	OFC cables Including Telecom cables.
8.	BSNL	OFC cables Including Telecom cables.

3.4.2. Station Planning

Out of 57 stations (5 Station between Bengaluru Cant. and Whitefield), 5 typical stations of different categories have been identified for planning and intermodal integration are given in **Table 3.8**.

Table 3.8. Details of Five Identified Stations

S. No.	Name of the station	Corridor Name	Interchange Type	Platform Type (Proposed)
1.	Kengeri Station	Kengeri – White Field	Rail - Metro	Two side platform (Elevated)
2.	Bengaluru City Station(SBC)	Kengeri – White Field and Bengaluru City - Rajanukunte	Rail – Rail andRail - Metro	Two side and oneIsland platform (Elevated)
3.	Bengaluru Cantonment (BNC)	Kengeri – WhiteField	-	Two side platform (Elevated) on curve
4.	Muthyalanagar	Bengaluru City – Yelahanka -Devanahalli	-	Two side platform (Elevated)
5.	Chikkabanavara	Chikkabanavara – Yeshwantpur - Baiyyappanahalli	Bus/IPT	Two side platform (Elevated)

These corridors are presented in **Figure 3.7.**

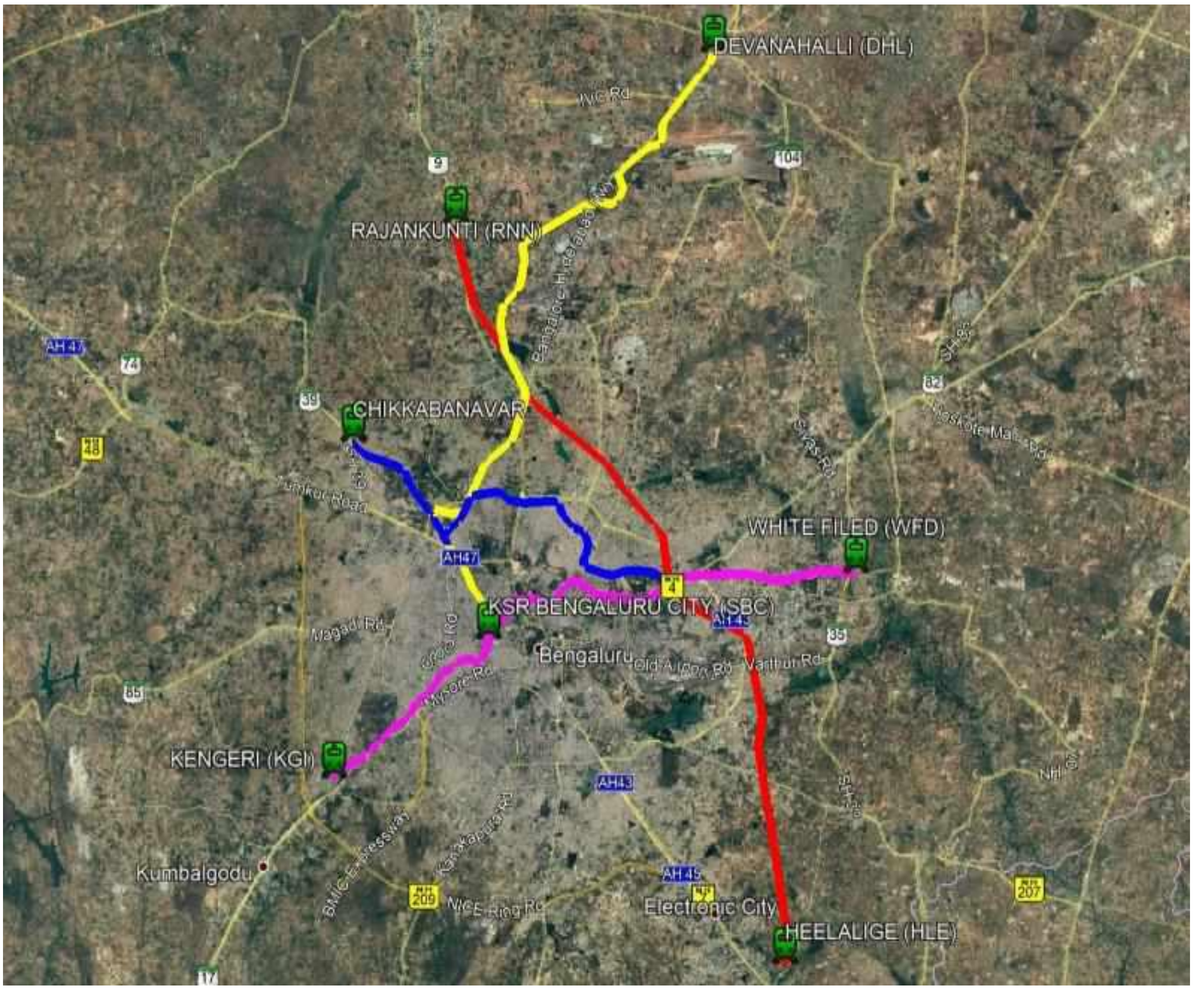


Figure 3.7. Proposed Suburban Rail Corridors in Bengaluru

3.4.3. Salient Features of a Typical Station

- The stations are divided into public and non-public areas (those areas where access is restricted). The public areas are further subdivided into paid and unpaid areas.
- The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.
- The platform level in elevated stations is about 15 m, and up to 21 m above ground level.
- The concourse contains automatic fare collection system in a manner that divides the concourse into distinct areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.
- The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators.
- Ticket machines and AFC gates are positioned to minimize crossflows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been allowed at the ticketing gates.

- Station entrances are located with particular reference to passenger catchment points and physical constraints of the site.
- Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:

  1) Minimum distance of travel to and from the platform and between the platforms for transfer between lines.
  2) Adequate capacity for passenger movements.
  3) Safety and security, including a high level of protection against accidents.

- The DG set, bore well pump houses and ground tank would be located generally in one area on ground.
- The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:

  1) Minimum distance of travel to and from the platform and between the platforms for transfer between lines.
  2) Adequate capacity for passenger movements.
  3) Safety and security, including a high level of protection against accidents.

- Following requirements have been taken into account:

  1) Minimum capital cost is incurred consistent with maximizing passenger attraction.
  2) Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.
  3) Flexibility of operation including the ability to adapt to different traffic conditions, changes in fare collection methods and provision for the continuity of operation during any extended maintenance or repair period, etc.
  4) Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
  5) Provision of display of passenger information and advertising.

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

3.4.4. Conceptual Planning for Selected Typical Stations

The block plans indicating the proposed layouts and configuration of representative stations w.r.t. the existing Suburban system and surrounding urban development are presented in the following paragraphs.

Kengeri Station

This is the first elevated suburban station of corridor Kengeri to Whitefield and has two-side platform. The overall size of the station is 205m x 26m. At northern side, it has two entries/exit, parallel to the station and approach from ground to concourse level. At southern side, one entry/exit is placed in open space on ground, parallel to the station. At southern side, a connection with existing FOB is shown at unpaid concourse area. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame.

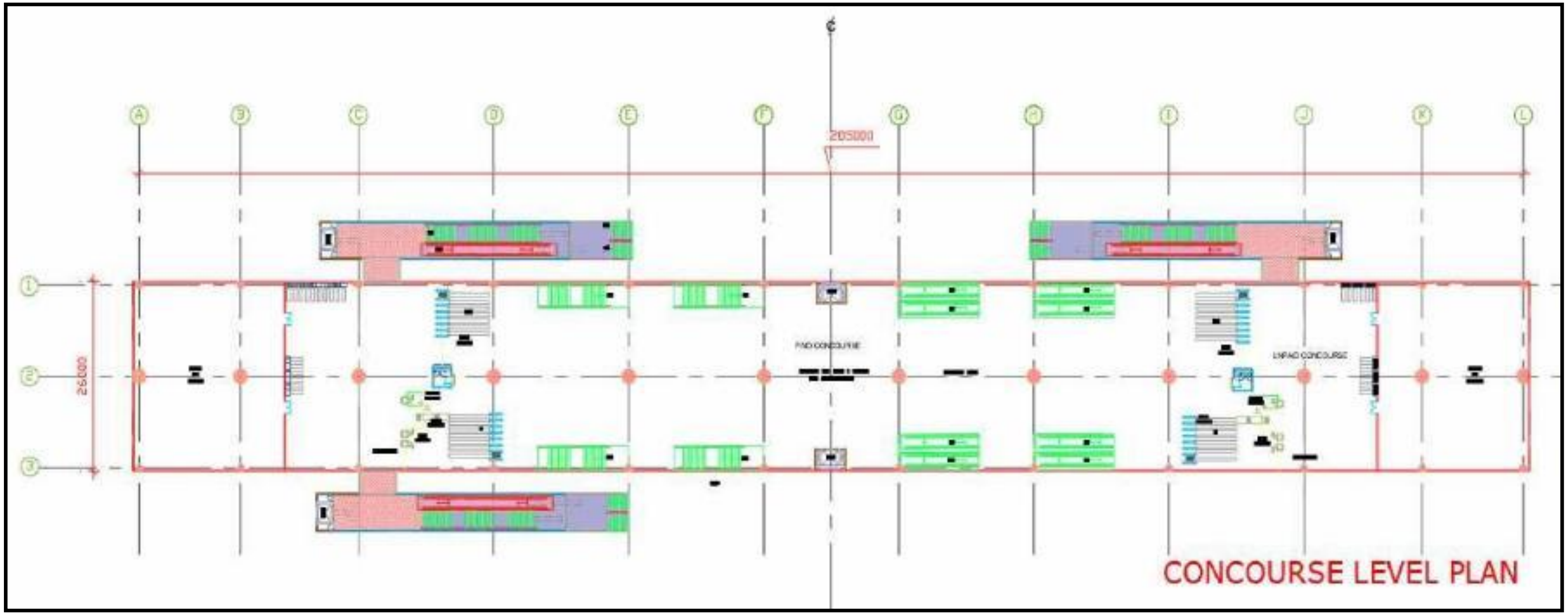


Figure 3.8. Kengeri Suburban Station (Concourse Level Plan)

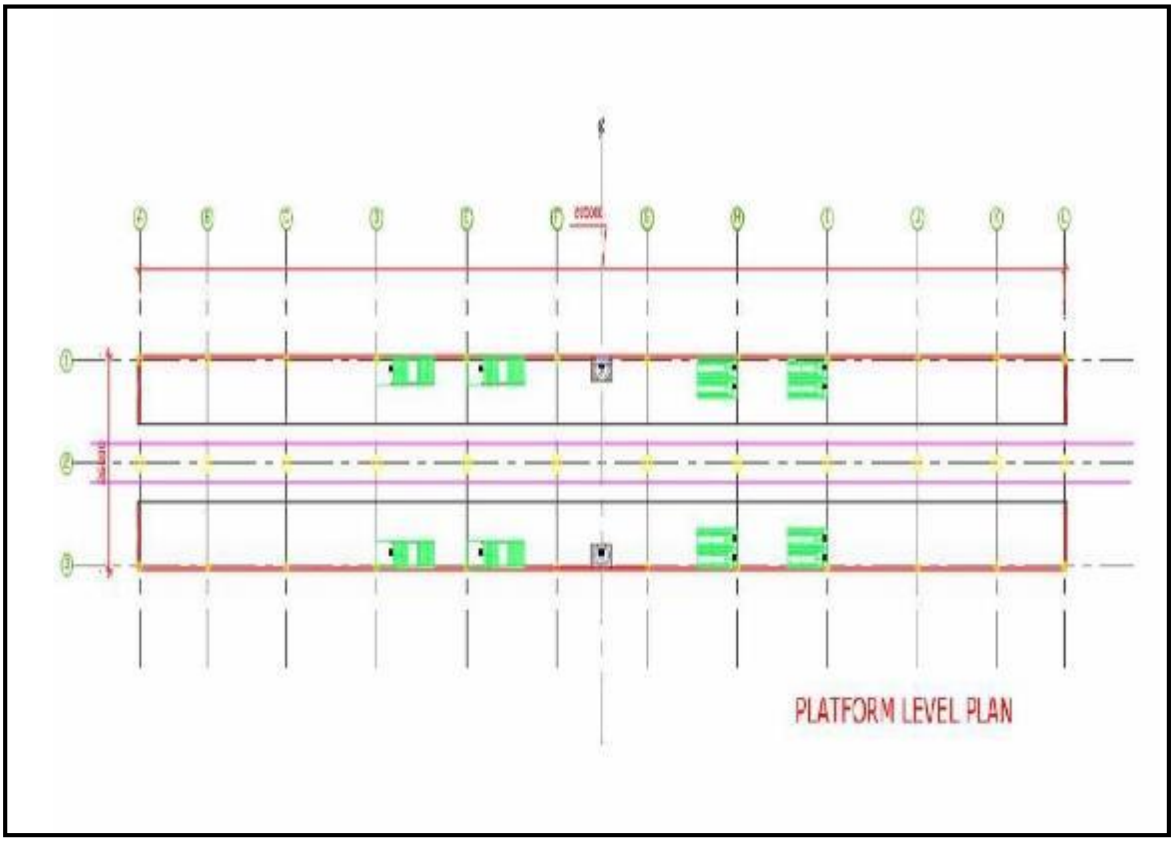


Figure 3.9. Kengeri sub station (Platform Level Plan)

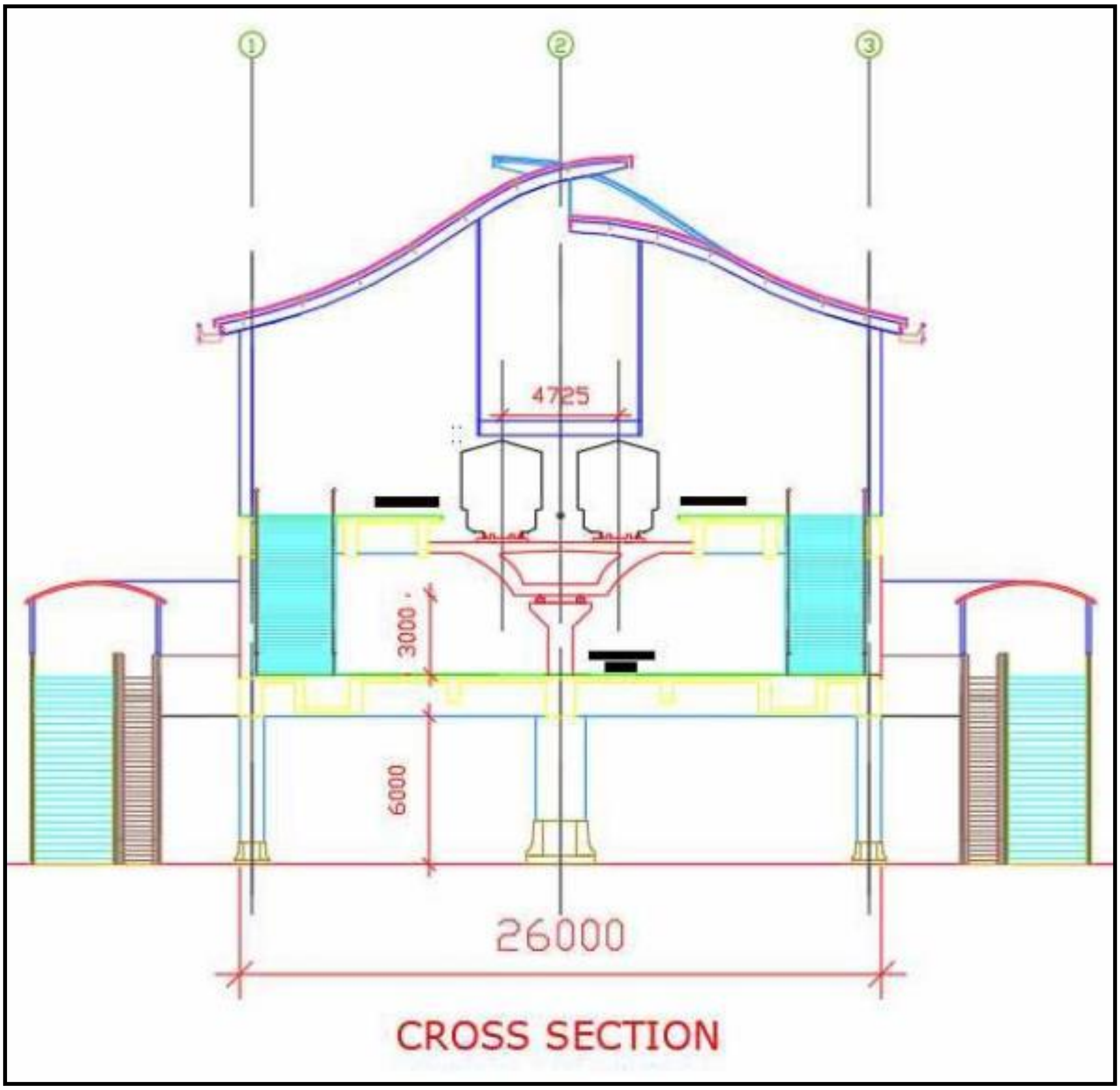


Figure 3.10. Kengeri Suburban Station (Cross-Section)

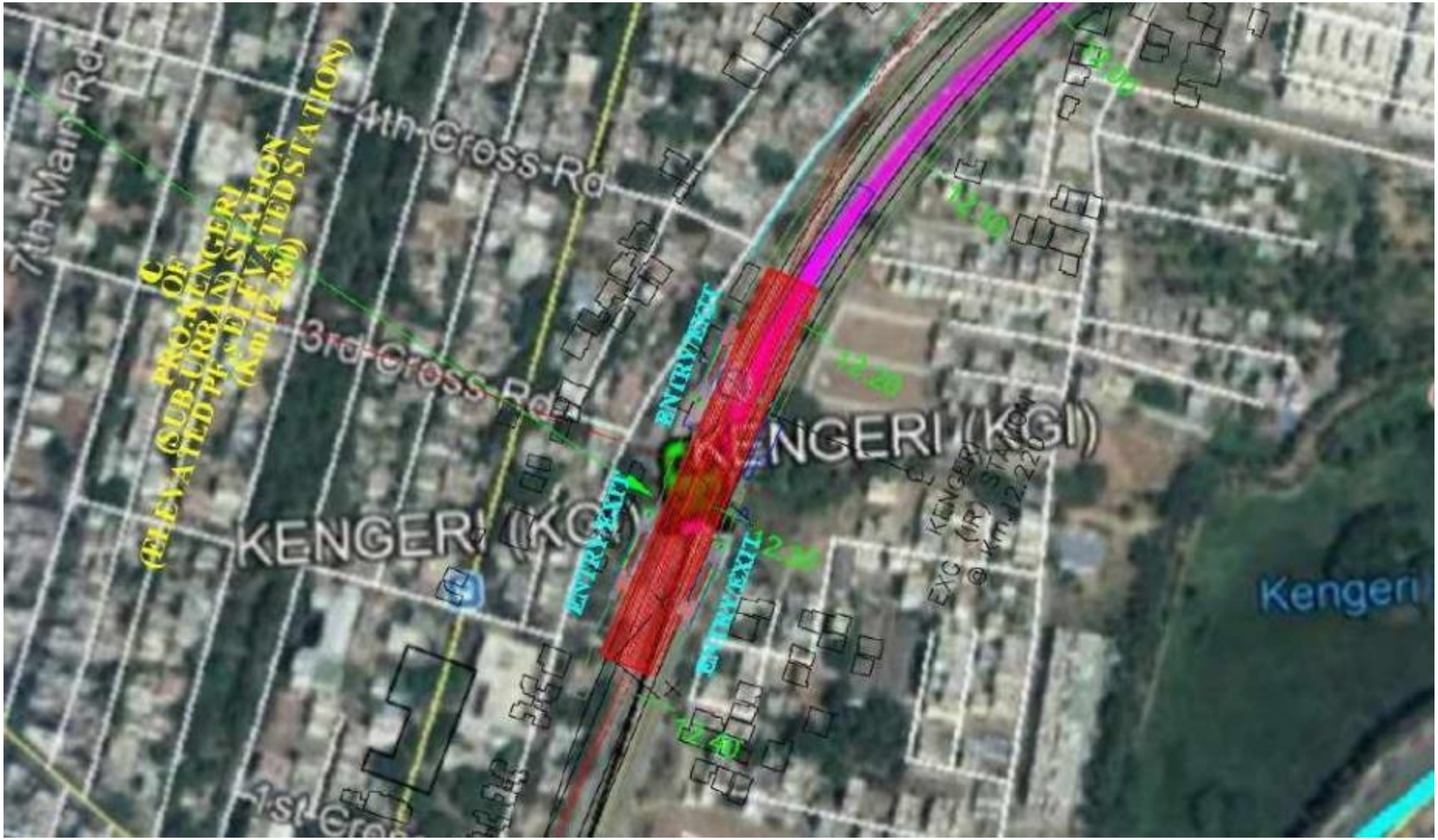


Figure 3.11. Proposed Kengeri Suburban Station on Site

KSR Bengaluru City Station

There are two sides and one island platform for this proposed elevated station are planned for four lines. At this location, two lines are for Bengaluru City to Rajanukunte corridor and two lines are for Kengeri to Whitefield. The length of the station is taken as 205 m. One entry/exit at northern side is placed to access passengers from left side and also passengers from the metro station. Southern side connectivity shall be placed at a suitable place either outside of the existing station or on a suitable platform i.e. first platform of the existing station. Centre connectivity will be with existing FOB. Another connectivity will be with existing FOB with some distance away from the station building.

Bengaluru Cantonment Station

Bengaluru Cantonment is existing station of Kengeri to Whitefield corridor. The proposed station is slightly away from existing one. It is along a curved road. The proposed station is elevated, concourse is at first level and two-side platforms at second level. Front side connectivity is from ground but another side connectivity is through proposed FOB. At one side, it connects with existing Bengaluru Cantonment station and it may be connect with future FOB on the other side.

Muthyalanagar Station

The station is on corridor Bengaluru City – Yelahanka – Devanahalli and it is a proposed station. The station has two-side platform. At northern side, it has two entries/exit, parallel to the station and approach from ground to concourse level. At southern side, one entry/exit is placed in open space on the ground level. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame.

Chikkabanavara Station

This is the elevated suburban station of corridor Chikkabanavara – Yeshwantpur - Baiyyappanahalli. The station has two-side platform. The overall size of the station is 205m x 26m. At northern side, it has two entries/exit, parallel to the station and approach from ground to concourse level. At southern side, it has one entry/exit parallel to the station. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame. Entries/exits are placed parallel to the station and approach from ground to concourse level. At southern side, one entry/exit is placed in open space on ground. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame.

Figure 3.12. Proposed KSR Bengaluru City Station (SBC) on Site

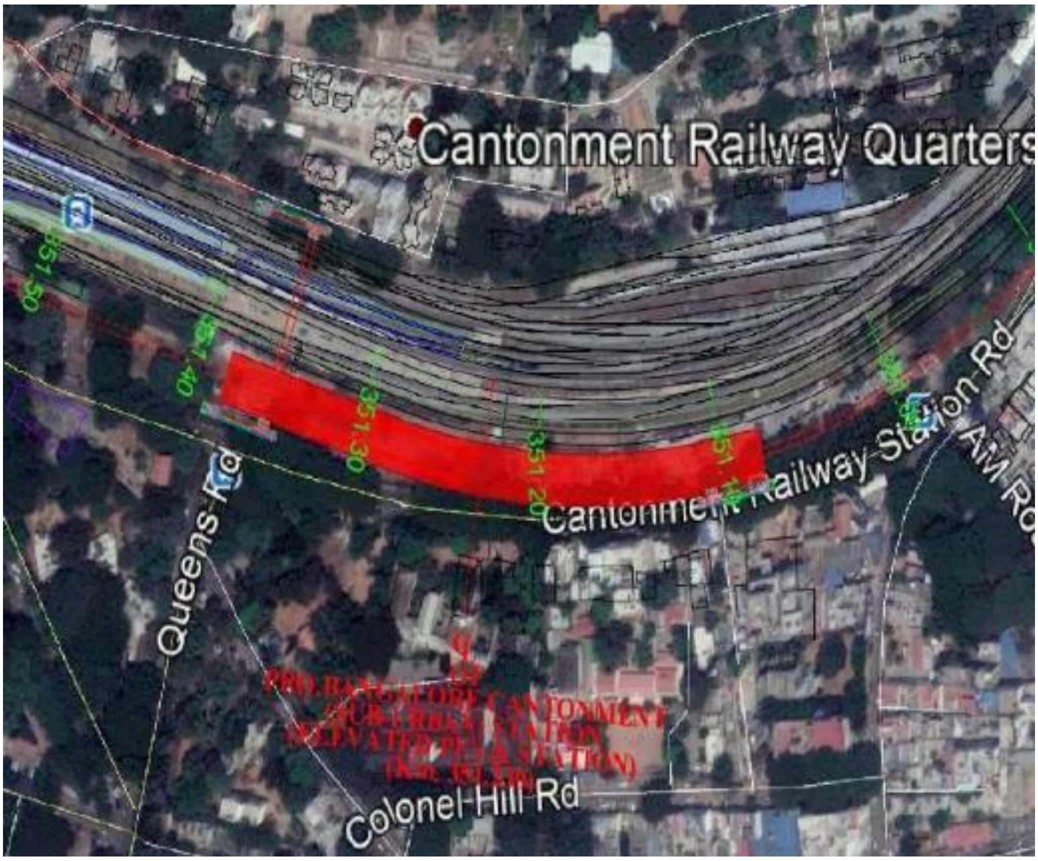


Figure 3.13. Proposed Bengaluru Cantonment Station on Site

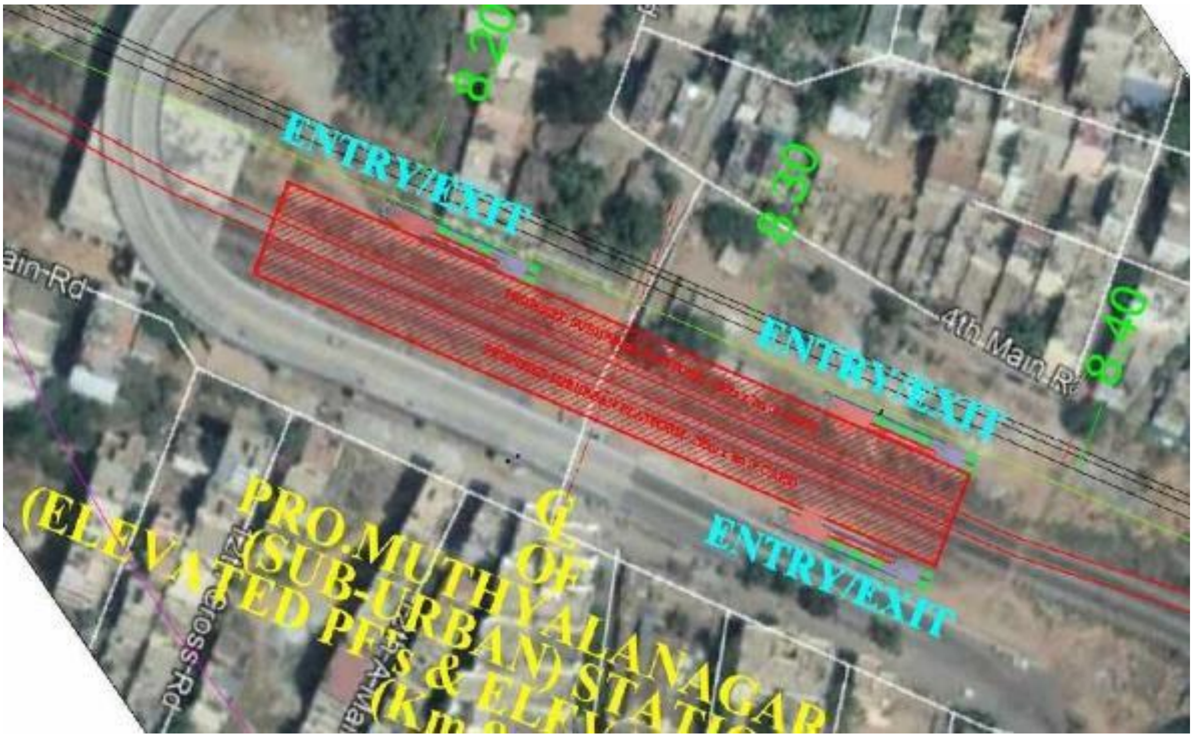


Figure 3.14. Proposed Muthyala nagar Station on Site

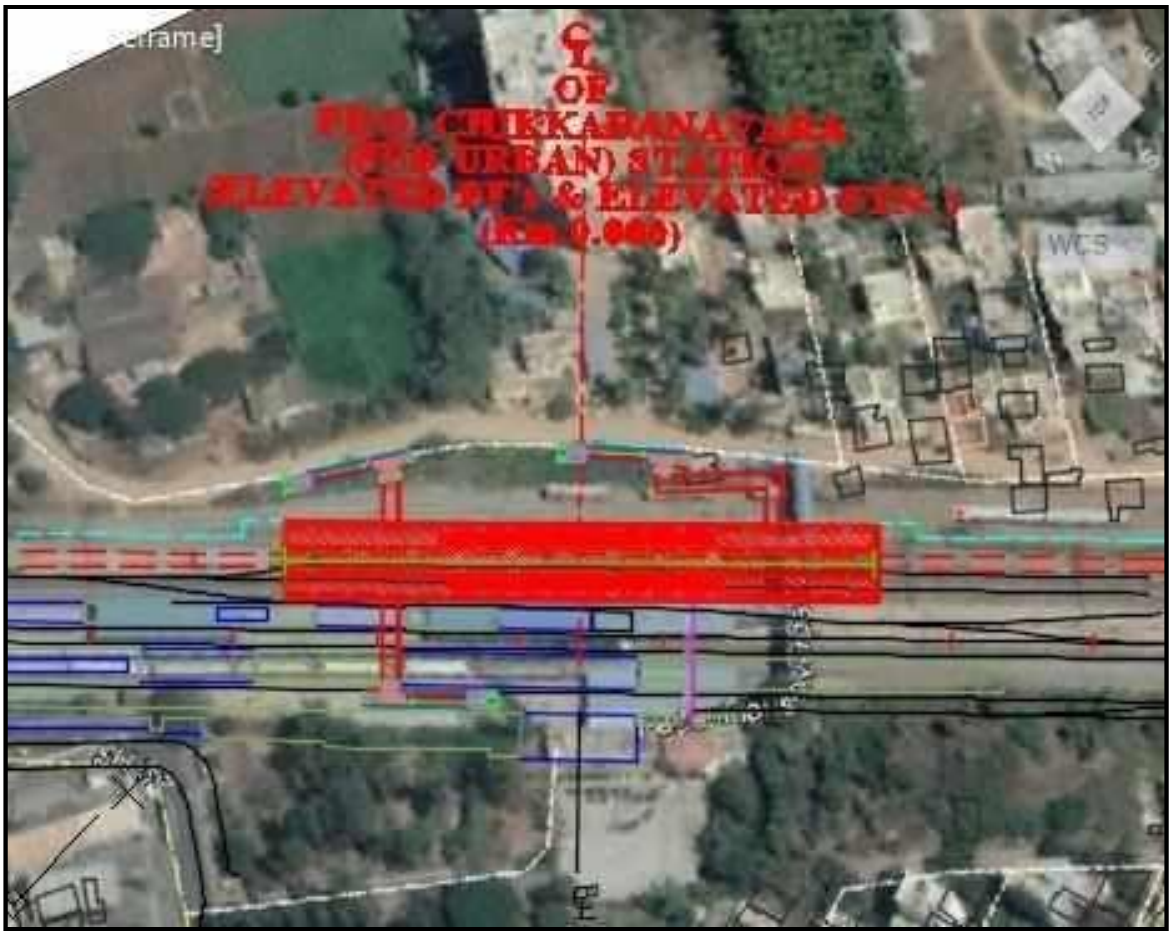


Figure 3.15. Proposed Chikkabanavara Station on Site

3.5. Intermodal Integration and Dispersal Facilities

Intermodal Integration is planned to provide first and last mile connectivities for commuters. A public transit system will be able to function seamlessly if there is intermodal integration. The suburban rail network will have to be provided with enhanced convenience of interchanging facility with other transport modes for better mobility and reduction in travel time for commuters. Interchange facility with secondary/intermediate transport modes is important for seamless transfer of commuters.

The preferable mode of choice to be opted for access/dispersal to/from the nearest station to the surrounding neighborhood can be classified based on the distance of catchment from the station area (**Figure 3.16**).

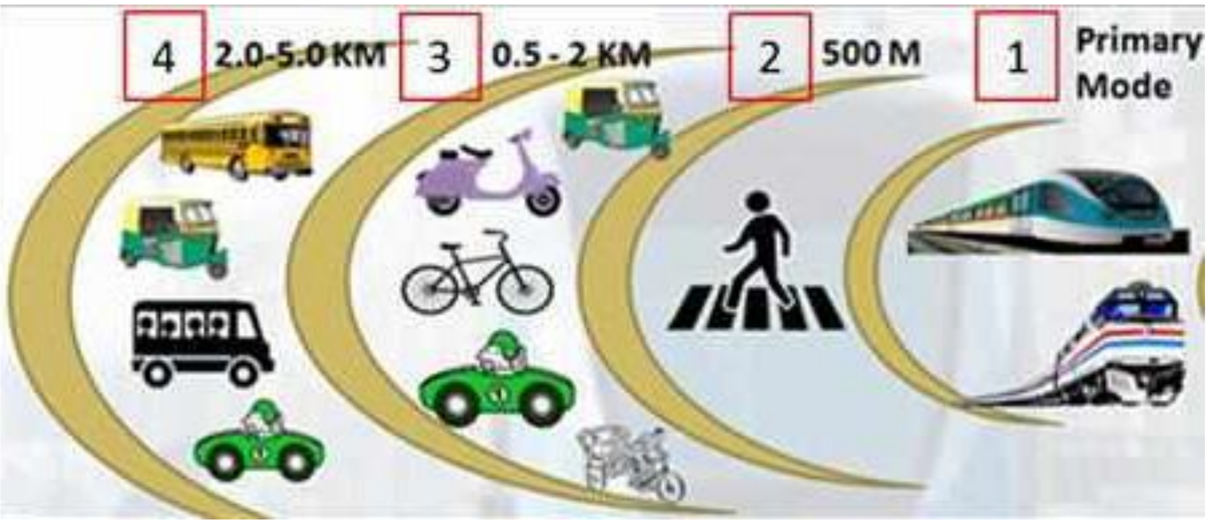


Figure 3.16. Intermodal Integration with Different Modes

3.5.1. Principles of Integration

The planning principles taken into account for intermodal integration at the station locations are as follows:

- Seamless connectivity to and from catchment area of the station - Passenger movement from the station area to the nearby land-use area to be seamless i.e. obstruction free movement.
- Integration with all possible modes including other mass transport systems - The transit system is to be well integrated with other transit modes i.e., PT modes, IPT modes, private modes and footpaths.
- There should be an integrated ticketing system to simplify the transfer between different transport modes. Smart Card ticketing facilitates a genuinely seamless multimodal transport system.
- Priority to pedestrians followed by public transport - To provide convenient and safe access to pedestrians to the station area and its vicinity and to promote walkability.
- Minimizing pedestrian/vehicle conflict - Proper design of circulation area adjoining the station building to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrian and vehicular traffic.

- Provision of pick/drop and parking facilities for all modes - Station area with adequate parking space, designated space for embarking and disembarking for vehicular traffic (pick-drop zones) and feeder modes such as busses, IPTs and NMT.
- Disabled friendly design considerations.

3.5.2. Proposed Suburban Rail Corridors

Proposed Bengaluru Suburban Rail Network has four corridors with a total length of 149.184 km. Out of 57 stations (5 stations between Bengalruru Cant. and Whitefield), 14 typical stations of different categories have been identified for multimodal integration. The details of identified stations are presented in **Table 3.9.**

Table 3.9. Details of Identified Stations for Multimodal Integration

SN	BMRCL		BSRP	
	Station Name	Corresponding BMRCL Phase/Line.	Station Name	Corresponding Corridor No.
1	Sampige Road	Green Line (Phase-1)	Srirampura	C-1
2	Yeswanthpura	Green Line (Phase-1)	Yeshwantpur	C-1 & C-2
3	Majestic	Purple & Green Line	KSR/SBC	C-1 & C-3
4	Jnanabharathi	Purple Line (Phase 2)	Jnanabharathi	C-3
5	Nayandahalli	Purple Line (Phase 2)	Nayandahalli	C-3
6	Baiyyappanahalli	Purple Line (Phase 2)	Baiyyappanahalli	C-3
7	Whitefield	Purple Line (Phase 2)	Whitefield	C-3
8	Benniganahalli (Jyothipuram)	Purple Line (Phase 2)	Benniganahalli	C-2 & C-4
9	Cantonment	Pink Line (UG line-6)	Cantonment	C-3
10	Krishnarajapuram	Blue & Purple Line	K.R.Puram	C-3
11	Doddanekundi	Blue Line (Phase 2A/B)	Doddanekundi	C-4
12	Marathahalli	Blue Line (Phase 2A/B)	Marathahalli	C-4
13	Kasturi Nagar	Blue Line (Phase 2A/B)	Channasandra	C-4
14	Hebbal	Orange Line (Phase 3A)	Hebbal	C-2

Note: Future BSRP stations from all four corridors are excluded.
Airport Trumpet station & Airport Terminal station are not included.

3.5.3. Existing Traffic Dispersal Arrangements

It is observed that apart from the walk, Buses and IPTs in the form of autos/ taxis are the other modes of traffic dispersal. Private vehicles and drop-offs also form a significant component of the feeder trips. The summary of common issues identified at all four stations is presented below:

- For most of the stations, good connectivity has been provided from only one side. There is either no connectivity or poor connectivity from the other side.
- On-street parking of private vehicles and autos is observed on the carriageway and footpath of the main access road which reduces the carriageway capacity.
- An encroachment is also observed on the main carriageway.
- Pick-up and drop-off of passengers from autos and taxis is occurred on the access road. There is no segregation of pick-up and drop-off points.

- At-grade pedestrian crossing to reach the station from car parking area increases the pedestrian vehicular conflicts.

3.5.4. Proposed Traffic Dispersal and Circulation Plans

The conceptual intermodal integration proposals have been formulated for facilitatingtraffic dispersal and circulation facilities based on the following considerations:

- Proper design of circulation area adjoining the station building to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrianand vehicular traffic.
- Facilitating passenger interchange with other transit systems.
- Provision of FOBs and skywalks to reduce the passenger travel time and pedestrian load on the roads
- Circulation area with adequate parking space, designated space for pick-drop zones and feeder modes such as Buses and IPTs.

The station wise intermodal integration proposals are presented in subsequent paragraphs.

Kengeri Station

- Pick-up/drop-off points and parking slots for autos and private vehicles has been proposed on the existing 2-wheeler parking area.
- One-way movement of vehicles has been proposed to reach the station
- Pick-up and drop bays have been provided in front of the station building. Parking for private vehicles has been proposed on the vacant land in front of the station building
- The station has been proposed to be integrated with metro station and bus terminal.

KSR Bengaluru City Station

- The pick-up and drop bays for private vehicles (cars & two wheelers), autos and taxis have been provided in addition to parking.
- The minor road with 9m width has been proposed to be connected to the main road (Old Mysore Road) to provide connectivity to the station from the west side
- Parking area has been proposed on the existing railway ground due to unavailability of space.
- There is an existing skywalk which connects the metro station with bus terminal. It has been proposed to extend this skywalk to connect the station FOB.

Bengaluru Cantonment Station

- Existing parking area given towards south side of the station has been retained as parking area for cars
- The pick-up and drop bays for cars, autos and taxis has been proposed to be given in front of the station building along with bus bay
- Auto and Taxi Stands have also been proposed along with parking for two-wheelers
- Since car parking is given on other side of the road, the existing FOB has been proposed to be extended to parking area.

Muthyalanagar Station

- Only pick-up and drop and auto/ taxi stand has been proposed on the east side of the station due to space constraints.
- On the west side, the pick-up and drop and auto/taxi stand along with parking have been proposed over the vacant land abutting the railway track.
- The pedestrian walkway has been proposed adjacent to the existing underpass to access the station entry.

Chikkabanavara Station

- East side road has been proposed to be strengthened. Only pick-up and drop and auto stand has been proposed on the east side due to space constraints.
- The access road on west side is proposed to be widened to 9 m.
- The pick-up and drops, auto/ taxi stands, car & two-wheeler parking have been proposed on the vacant land near the station on the west side. In addition, bus bay has been proposed on Hesaragatta Main Road.

Figure 3.17. Conceptual Intermodal Integration Plan at Muthyalanagar Station

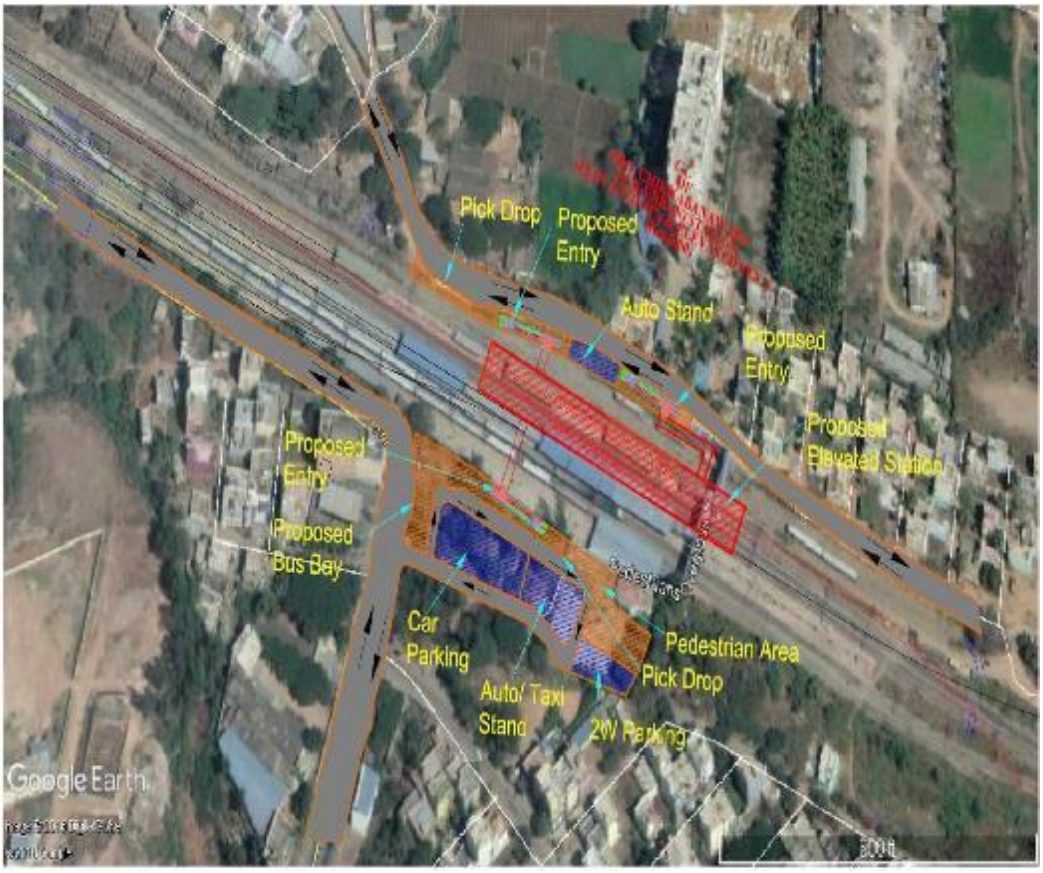


Figure 3.18. Conceptual Intermodal Integration Plan at Chikkabanavara Station

3.6. Construction Planning

The proposed network of Suburban rail of 148.006 km is divided into four corridors as discussed in the earlier chapters. The planning for construction is to be made keeping in view the following:

- As the proposed alignment is almost running parallel to the existing line, planning of construction of new lines to be finalized strictly in consultation with the Railways, keeping in view the operation of existing trains, safety aspects etc.
- The construction activity may be taken up in phases to minimize the operational constraints / line block.
- At places of space constraints, mainly at LCs / Stations / ROBs / RUBs etc., traffic diversion shall be taken up in consultation with concerned ULBs (viz, BBMP, Traffic Police etc.).
- As the construction is of huge magnitude, resource planning for labour and material has to be done meticulously.
- More than 60% of proposed alignment is within the metropolitan city limits. Hence, shift-wise construction is essential to avoid peak hour road traffic as materials and equipment have to be brought to the construction site only by road.

3.6.1. System Design and Maintenance Facilities

3.6.1.1. Rolling Stock

To meet the traffic demand, 3.66 m wide AC rolling stock is recommended for running suburban rail services in Bengaluru. Other parameters of the proposed system are given below.

Table 3.10. Parameters Proposed in BSRP Railway System

Particulars	Details
Train speed – Designed	90 kmph
Acceleration at peak load on tangent track	0.82 M/Sec.Sq.
Deceleration with Full service Brake	1.00 M/Sec.Sq
Emergency brake	1.3 M/Sec.Sq
Jerk rate	0.82 M/Sec.Sq
Service brake response time	2.0 Sec
Emergency Brake response time	1.5 sec. Max.
SB and EB release time	2.0 Sec.

3.6.2. Traction and Power Supply

- 25 KV OHE traction system has been proposed for the corridors.
- The Power supply will be through TSS (Traction Sub Stations), as identified for the corridors.

1) Corridor – 1: - Yelahanka (SU YNK)
2) Corridor – 2: - Hebbal (SU HEB)
3) Corridor – 3: - Bengaluru Cantonment (SU BNC)
4) Corridor – 4: - Benniganahalli (SU BNGH)

3.6.3. Train Operation Plan

The train operation plan is based on the following:

- Train operation with 6 car train.
- Running of services for 19 hours of a day (5 AM to Midnight) with station dwell time of 30 seconds.
- Make up time of 5-10% (on the tangent track) with 8-12% coasting.
- Average speed of 33 kmph.
- Adequate services to ensure comfortable journey for commuters during peak periods.

Based on the traffic demand, train operation plans and requirement of coaches for the suburban corridors is given in **Table 3.11**.

Table 3.11. Corridor Wise Train Operation Plan & Coach Requirement

Corridor	Item	2025	2031	2041
Corridor 1 (KSR Bengaluru City	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	600	514	400
	Trains/hr	6	7	9

Corridor	Item	2025	2031	2041
- Devanahalli)	Capacity Provided	13548	15806	20322
	PHPDT	11775	13750	19135
Corridor 2 (Chikkabanavara-Baiyyappanahalli)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	900	720	514
	Trains/hr	4	5	7
	Capacity Provided	9032	11290	15806
	PHPDT	9009	10923	13858
Corridor 3 (Kengeri - White Field)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	1200	900	720
	Trains/hr	3	4	5
	Capacity Provided	6774	9032	11290
	PHPDT	6442	7951	10289
Corridor 4 (Heelalige to - Rajanukunte)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	900	600	600
	Trains/hr	4	6	6
	Capacity Provided	9032	13548	13548
	PHPDT	7646	11919	13527

The total number of rakes required for the Bengaluru Suburban Railway corridors for different horizon years is given in **Table 3.12**.

Table 3.12. Requirement of Rake & Coach in 2025, 2031 & 2041

Horizon Years	2025	2031	2041
Rake requirement	51	65	78
Coach requirement	306	390	468

Prestressed concrete sleepers (PSC) are proposed to be used in at-grade section. Ballast-less track is proposed in Elevated corridor for the reduced maintenance.

3.6.4. Level Crossings

There are about 34 level crossing identified in the BSRP Corridors. All the level crossings are eliminated by providing ROBs or RUBs. Details of Proposed ROBs/RUBs locations are presented in **Table 3.13**. Google image of the proposed ROB/RUB locations is presented in **Figure 3.19** and typical cross section and typical arrangements of RUB & ROBs are given in **Figure 3.20** & **Figure 3.21**.

Table 3.13. Details of Proposed ROBs/RUBs locations

SL. No.	From -To	Location	LC No.	ROB/RUB
Corridor 1				
1	Km:11/300-400	Kodigehalli	LC NO.9	ROB/RUB
2	Km:4/000-100	Behind Yelahanka Airforce STN	LC NO. 2	RUB
3	Km:6/800-900	Bettahalasoor BSRP STN	LC NO. 4	ROB
4	Km:12/400-500	Doddajala BSRP STN	LC NO. 10	ROB
5	Km:19/700-800	Airport KIADB BSRP STN	LC NO. 15	RUB
6	Km:20/400-500	Devanahalli BSRP STN	LC NO. 16	RUB
7	Km:21/100-200	Devanahalli BSRP STN	LC NO. 17	RUB
8	Km:21/900-22/000	Devanahalli BSRP STN	LC NO. 18	RUB

SL. No.	From -To	Location	LC No.	ROB/RUB
Corridor 2				
9	Km:12/000-100	Myadarahalli BSRP STN	LC No. 6	RUB
10	Km:208/200-300	Garrison Banaswadi	LC NO. 137	RUB
11	Km:211/900-212/000	Kaveri Nagar Future BSRP STN	LC NO. 140	RUB
12	Km:212/300-400	Nagawara BSRP STN	LC NO. 141	RUB
13	Km:212/600-700	Nagawara BSRP STN	LC NO. 142	RUB
14	Km:213/200-300	Kanakanagar BSRP STN	LC NO. 143	RUB
15	Km:213/800-900	Kanakanagar BSRP STN	LC NO. 144	RUB
16	Km:214/400-500	Kanakanagar BSRP STN	LC NO. 144A	RUB
Corridor 3				
17	Km:9/300-400	Janabharati BSRP STN	LC NO. 9	Alignment not finalised
18	Km:10/900-11/000	R V college future BSRP STN	LC NO. 10	Alignment not finalised
Corridor 4				
19	Km:185/600-700	Singena Agrahara BSRP STN	LC NO. 125	RUB
20	Km:187/100-200	Huskur BSRP STN	LC NO. 126	RUB
21	Km:187/600-700	Huskur BSRP STN	LC NO. 127	RUB
22	Km:191/600-700	Ambedkar Nagar BSRP STN	LC NO. 130	RUB
23	Km:193/300-400	Carmelaram BSRP STN	LC NO 132	ROB
24	Km:197/800-900	Marathahalli BSRP STN	LC NO. 133	RUB
25	Km:199/800-900	Marathahalli BSRP STN	LC NO. 134	ROB/RUB
26	Km:203/100-200	Kagadaspura BSRP STN	LC No. 136	ROB
27	Km:5/800-900	Hennur BSRP STN	LC NO. 6	RUB
28	Km:11/600-700	Hegde Nagar BSRP SN	LC NO. 9	RUB
29	Km:12/800-900	Jakkur BSRP STN	LC NO. 10	ROB
30	Km:18/300-400	KPCL Gas Power Plant Yelahanka	LC NO. 15	RUB
31	Km:19/800-900	Muddanahalli BSRP STN	LC NO. 17	RUB
32	Km:21/800-900	Parallel to Doddabalpura Main Road	LC NO. 18	RUB
33	Km:23/000-100	Rajanukunte BSRP STN	LC NO. 20	RUB
34	Km:24/500-600	Rajanukunte STN Yard	LC NO. 21/Sub way	RUB

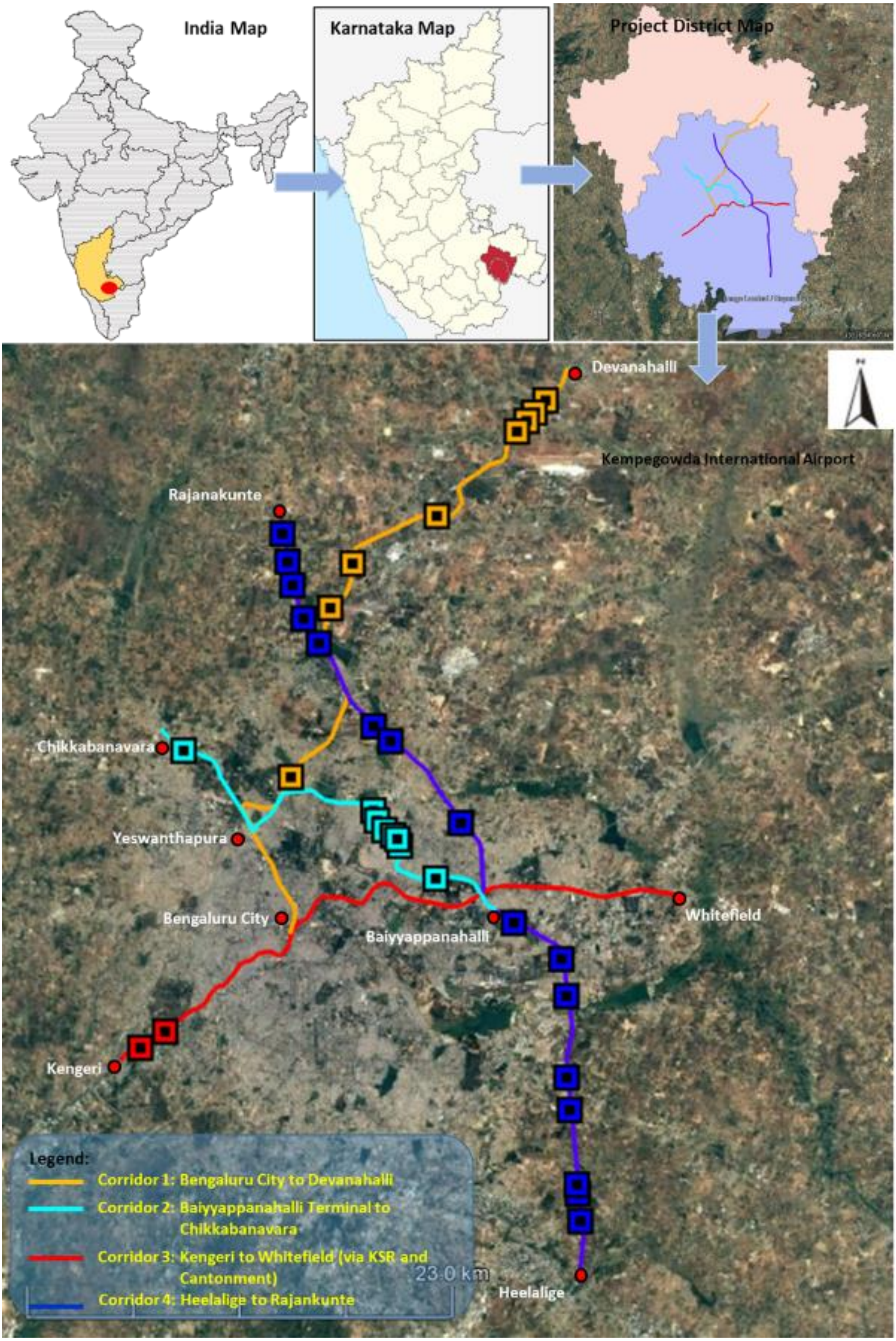


Figure 3.19. Corridor wise Level Crossing Locations

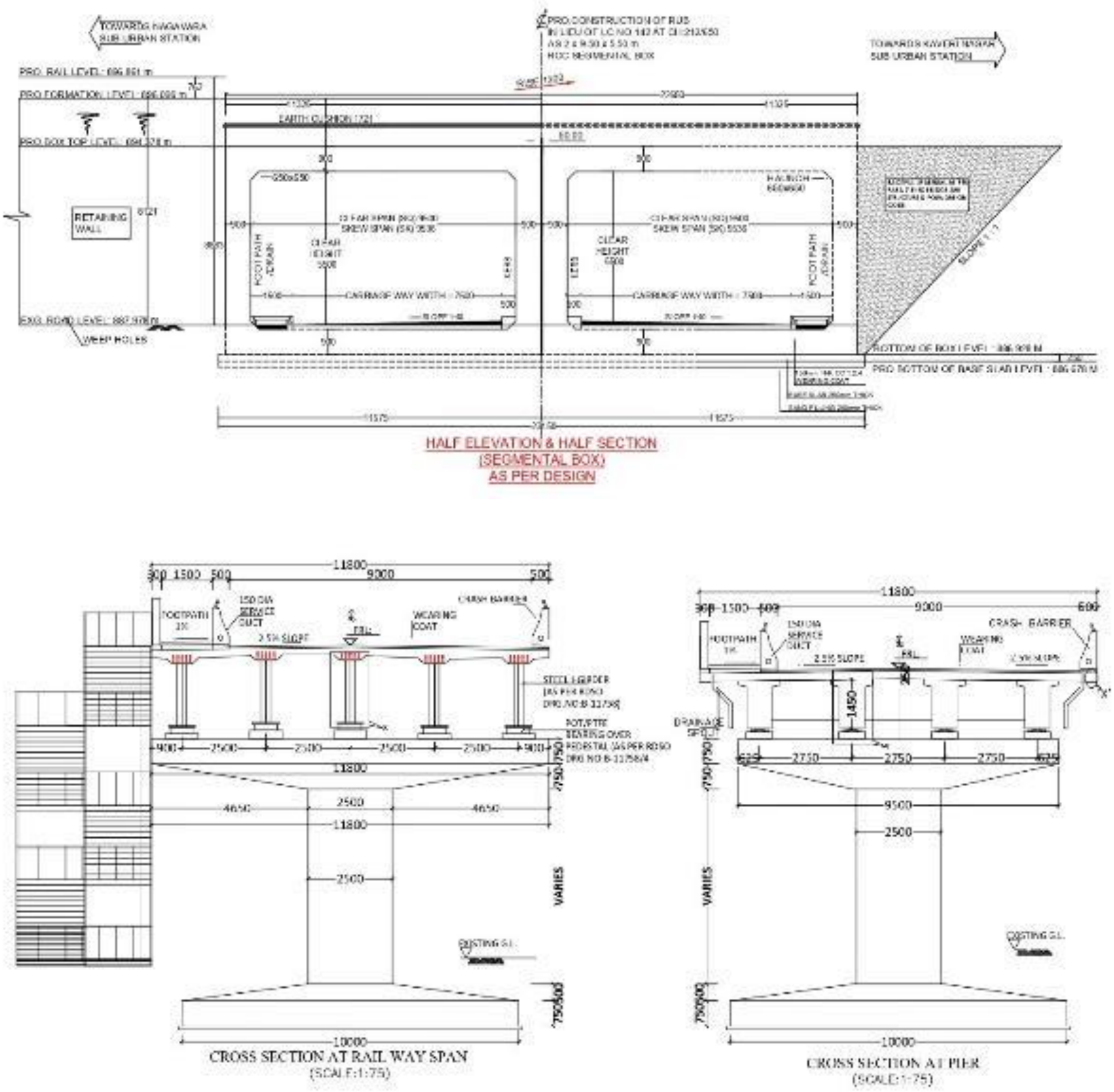


Figure 3.20. Typical Cross Section of RUB & ROB Proposed in BSRP

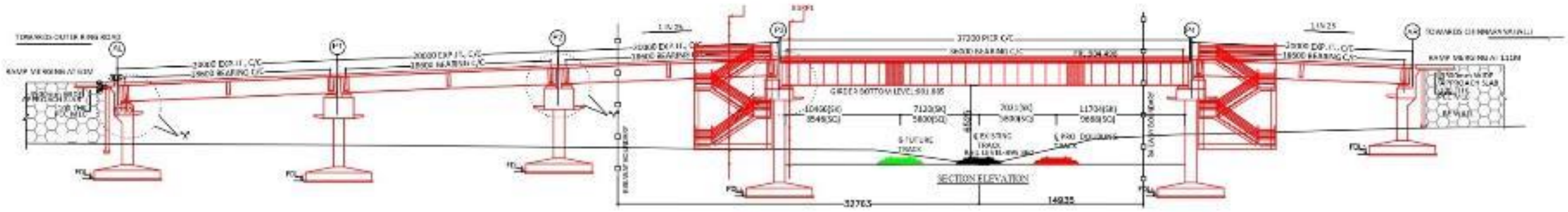


Figure 3.21. Typical Arrangement of RUB Proposed in BSRP

3.6.5. Construction Materials & Equipment Requirements

Assessed quantities based on the various nature of activities.

a. At grade - Per Corridor

Concrete Quantity required For – 1.2 lakh cum.

Reinforcement – 1000 MT

Borrow Earth – 1126799 MT

b. Elevated - Per Corridor

Concrete Quantity required For – 1.4 lakh Cum

Reinforcement – 26000 MT

MS Structure – 150000 Kg

Stainless Steel – 10000 Kg

Tiles Work – 1700 sq.m

c. Construction Machinery – Per Corridor

Crushers - 02 nos.

Batching Plants - 02 nos.

Gantry Cranes – 06 nos.

Threader Rail Machines - 06 nos.

Grinding rail machines – 02 nos.

Power Generators – 10 nos.

Backhoe – 05 nos.

Cranes – 08 nos.

Compressors – 02 nos.

Welding Equipment – 15 nos.

Grinders – 02 nos.

Excavators – 04 nos.

Dump Tracks – 20 nos.

Girder Launching Equipment Vehicles – 04 nos.

Dozers – 10 nos.

Rollers – 10 nos.

Pile hydraulic rig – 04 nos.

Soil Characteristics Required for Borrow Earth or Cutting materials

As per RDSO guidelines, for Design of Railway Formation, the soils for their use in Indian Railway Embankment have been grouped based on percentage of fines present in the soil, as given below:

Description w.r.t. Fine-Particles (size less than 75 micron)	**Soil Quality Class,**
Soils containing fines > 50 %	SQ1
Soils containing fines from 12% to 50%	SQ2
Soils containing fines < 12%	SQ3

3.6.6. Physical Characteristic of the Project

Construction and Demolition Waste: Due to proposed improvement of the project, there will be debris and demolition waste generation during construction stage. These wastes will be generated mainly from demolition of affected structures, levelling of land and cutting of earth. Total 26135.35 m3 of construction and demolition waste is estimated to be generated from the project.

BSRP Corridors	Corridor 1	Corridor 2	Corridor 3	Corridor 4	Total Quantity in m3
Quantity Construction/ Demolition waste generated in m3	8262.6424	4982.13	3679.32	9211.26	26135.35

Land use: The project district is having mixed landuse and land cover pattern, where predominant part of the district is occupied with agricultural land (42.65%) followed by built-up area (40.77%), forest land (6.03%), etc. Detailed description on varying landuse pattern along the project corridors are presented in Section 5.5.3.

3.6.7. Estimation of Emissions, Quantity and Type of Waste Generated

Emission and Pollution Generation: During construction phase, there will be pollution generation due to operation of equpment and machinaries. Apart from this, due to tree felling, there will be increase in Carbon Emission during Pre-construction phase, which is estimated to 710Tons/Year and reduction in Oxygen is 1596 Tons/Year. However, during commissioning of the suburban rail, there will reduction is emission of Cabon and Green House gases due to trans-model shift.

Reduction in CO2 & GHG (in Tonnes/year)				
Year	**2025**	**2031**	**2041**	**2051**
Total Vehicles	12851678	15043635	17810214	21065159
CO	17042	19949	23618	27934
HC	3348	3919	4639	5487
NOX	13447	15741	18636	22042
PM	742	868	1028	1216
CO2	1966166	2301512	2724768	3222739

Quantity & Type of Waste Generation: During construction phase, about waste water generation 4,92,075 KL & Municipal solid waste generation 1600 Kg per day (400gm/capita waste generation). During operation phase, about 1.4 to 1.5 Tons/day of MSW and about 1 to 4 Tons/day of MSW is likely to be generated from the Depot and Stations respectively.

3.6.8. Status of Work Progress in Corridor 2

M/s Larsen & Toubro has been appointed by K RIDE as contractor to implement the Corridor 2 project. At present, the contractor has undertaken following activities.

K RIDE

Bengaluru Suburban Railway Project (BSRP) Corridor - 2

Replies for Engineer's comments received vide letter ref. GC/BSRP/KRIDE/L&T/C-2/2023/0058 dated 09.02.2023

LARSEN & TOUBRO

Sl. No.	Activity Desription	Details Required		Remarks
1	Establishment of Batching Plant, Casting Yard, Construction Camp & Labour Camp quarry sites and earth borrow sites with detailed information necessary sketches and google maps showing distance from alignment.	- Layout of Batching plant cum construction camp & labour camp @ Benninganahalli, Hebbal & Jalahalli are enclosed as Annexure - 1. - It is planned for procurement of aggregates from external sources and hence no quarry sites are planned. - Sketch showing the location of identified borrow site, as communicated vide our letter no. 233 dated 03.02.2023 is enclosed as Annexure - 2.		
2	Number & Type of Equipment / contruction vehicle equipment used for the activities	Type of Equipment	Number	
		GTI Machines Mobilized to Site	1	
		Backhoe Loader Mobilised to Site	1	
		Mobile Crane Mobilised to Site	1	
		Survey Instruments Mobilised to Site	TS - 6 No's Auto Level - 10 No's	
		Mini Truck	1	
		Piling Rig Machine	1	
		Batching Plants 30Cum-2 ,67cum -1	3	
		DG - 250 KVA	2	
		DG - 62.5 KVA	1	
		DG - 30KVA	10	
		DG - 15KVA	6	
		DG - 10KVA	5	
		DG - 5KVA	1	
		DG - 3KVA	2	
		DG - 2.5KVA	1	
		Weighbridge 100T	1	
		Tele-Lighting Mast	3	
		Bar Bending Machine	10	
		Bar Shearing Machine	7	
		Mobile Service Unit	1	
		Multistage Pump	1	
		Nuclear Density Guage	1	
3	Fuel Consumption	No of days working	158	Till 28.02.2023
		Fuel Consumption	5,600 Lit	
	Waste generations	No waste generated as construction works not commenced.		
	Emission Quantification	CO2 emission	2522 Kgs	
	Water consumption	Drinking Purpose	23,500 Lit	
		Construction Purpose	2,70,000 Lit	
4	Materials used in GTI activities or any other and quantifications	Bentonite	4,700 Kgs	Till 28.02.2023

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K RIDE

Bengaluru Suburban Railway Project (BSRP) Corridor - 2

Replies for Engineer's comments received vide letter ref. GC/BSRP/KRIDE/L&T/C-2/2023/0058 dated 09.02.2023

LARSEN & TOUBRO

Sl. No.	Activity Desription	Details Required		Remarks
5	Labour welfare measures	**Jalahalli Yard**		
		Drinking water Station	1	
		Rest Shelter	0	
		Portable toilet	1	
		Hebbal Yard		
		Drinking water Station	1	
		Rest Shelter	0	
		Portable Toilet	1	
		Beniganahalli Yard		
		Drinking water Station	1	
		Rest Shelter	0	
		Portable Toilet	0	
6	Activity wise labours employed include Highly skilled, skilled, semi skilled and Unskilled	Batching plant & Office establishment (Skilled)	11	
		Steel cutting & bending (Skilled)	8	
		GTI works (Unskilled)	3	
		Area development (Unskilled)	11	
		Manual Trenching works (Unskilled)	5	
		Loading & Unloading works (Unskilled)	4	
		Survey works (Unskilled)	4	
		QA/QC laboratory works (Unskilled)	2	
		Material handing @ Store (Unskilled)	4	
7	Information on surplus soil generated or quantity of soil is generated for the formation of batching plant, casting yard, construction camp etc.	No surplus soil generated as construction works not commenced and excavated soil at Batching plant / Construction camp are reutilized.		
8	Use of any hazardous materials, chemicals and quantification waste generation	No hazardous materials / chemical waste generated as construction works not commenced.		
9	Construction and General Refuse generated	No Construction / General refuse generated as construction works not commenced.		
10	Any Construction materials procured and how it is stored and maintained.	Construction materials procured till date is mainly the Reinforcement bars, which are properly stored in elevated platforms and covered with Tarpaulin.		
11	Welfare measures at the camps and site. Any GRM is placed to address the problems of labour?	Refer Pt. No. 5 above. Grievances, if any, are identified by means of frequent interaction with the workmen and are being timely addressed.		
12	Number of trees translocated / felled / retained with necessary details including photographs.	**Transplantation of Trees**	Number	Photographs enclosed as Annexure 3.
		From Section 1	2	
		From Section 2	7	
		From Section 3	2	
		From Section 4	-	
		Total Trees translocated	11	
		Felling of Trees	Number	
		Section 1	51	
		Section 2	-	
		Section 3	11	
		Section 4	-	
		Total Trees felled	62	

LARSEN & TOUBRO LTD. * K R PURAM CORRIDOR-2 BANGALORE

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Bengaluru Suburban Railway Project (BSRP) Corridor - 2

Replies for Engineer's comments received vide letter ref. GC/BSRP/KRIDE/L&T/C-2/2023/0058 dated 09.02.2023

Sl. No.	Activity Desription	Details Required		Remarks
13	Details of training conducted to Employees and Labours, Tool box talks with necessary details information and photographs.	**Training Conducted to Staffs**	**No of Persons**	Photographs enclosed as Annexure 4.
		IRC Work Zone Safety	17	
		Fire Safety	29	
		Basic First Aid with CPR	30	
		IR Safety	11	
		IR Safety by Indian Railways	30	
		Usage of Utility Detector	9	
		HIRA	20	
		Training Conducted to Workmen		
		HIV Awareness Training (Lottegahalli)	17	
		Safety Precautions while working in Vicinity of IR Track (Beniganahalli)	8	
		Piling Safety	5	
		Safety Precautions while working in Vicinity of IR Track (Hebbal)	13	
		Safety Precautions while working in Vicinity of IR Track (Jalahalli)	27	
		Tool Box Talk	**Number of Sessions**	
		Section 1&2 (Beniganahalli)	15	
		Section 3 (Hebbal)	5	
		Section 4 (Jalahalli)	59	
		Total Manhours of Training combining all above programmes	**No. of Hours**	
		Feb-23		
		Training man hours Staffs	1	
		Traininig man hours FLS	0	
		Traininig man hours Workmen	48	
		Jan-23		
		Training man hours Staffs	573	
		Traininig man hours FLS	4	
		Traininig man hours Workmen	14	
		Dec-22		
		Training man hours Staffs	101	
		Traininig man hours FLS	1	
		Traininig man hours Workmen	23	
		Nov-22		
		Training man hours Staffs	96	
		Traininig man hours FLS	10	
		Traininig man hours Workmen	106	
14	Details of utilities identified above the ground infringing in ROW and joint inspection with concerned authorities with necessary details information and photographs.	The details of all utilities found along the project alignment have been identified by GPR survey and the report have been submitted vide our letter no. 113 dated 29.11.2022.		

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K RIDE

Bengaluru Suburban Railway Project (BSRP) Corridor - 2

Replies for Engineer's comments received vide letter ref. GC/BSRP/KRIDE/L&T/C-2/2023/0058 dated 09.02.2023

LARSEN & TOUBRO

Sl. No.	Activity Desription	Details Required		Remarks
15	Current Activites details as follows but not limited to			
15a	Marking of ROW, Establishment of Ground Control Points (GCPs), temporary bench marks and survey completion	- The ROW marking based on boundary points mentioned in Tender drawing has been done at site. - The Primary & Secondary control points and TBMs have been established at site and details of the same are submitted alongwith the Topo survey report.		
15b	No of GTI completed details enclosed in abstract format	Elevated Viaduct between Ch:(-) 0.575 and Ch:0.050	13	
		Elevated Viaduct between Ch 11.137 to 18.350	76	
		At grade portion other than elevated portion of alignment	29	
		Structures	66	
		Total GTI boreholes completed	**184**	
15c	Regulatory permissions from concerned authorities	- Consent For Establishment obtained for Yeshwanthpur & Hebbal Batching Plants. - Labour license obtained		
15d	Any other details relevant shall also be provided.	-		

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3.7. Signalling and Telecommunication

Train control requirements of the Suburban network are planned to be achieved by adopting Continuous Automatic Train Control (CATC) based on the Communication Based Train Control (CBTC) System. The CBTC system offers following advantages:

1) High reliability, better availability and less prone to failures.
2) Easier to maintain.
3) Provides higher traffic capacity.
4) They are reported to be more energy sufficient systems compared to DTG signalling.
5) Adaptable to any Grade of Automation and scalable too.

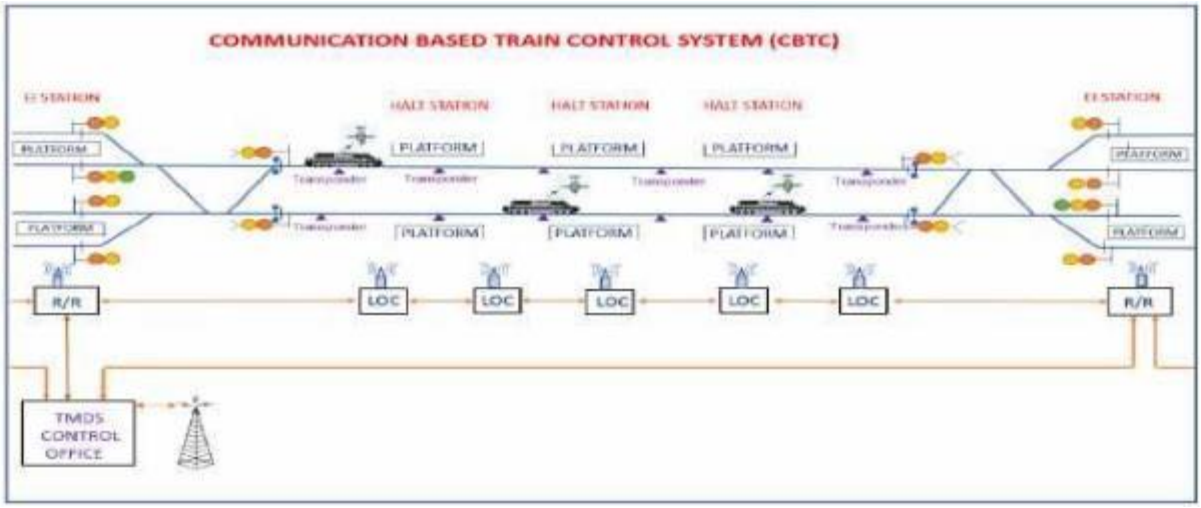

Figure 3.22. Communication Based Train Control System

3.7.1. Maintenance Depot and Workshop

The Maintenance facilities for the Corridors Chikkabanavara - Baiyyappanahalli (Corridor-2), Kengeri - Whitefield (Corridor-3) and Heelalige - Rajanukunte (Corridor-4) and for Bengaluru City - Devanahalli (Corridor-1), the facilities are proposed at Akkupete near Devanahalli and Soledevanahalli Depot at Soladevanahalli.

All the rakes will be serviced at maintenance Depot cum workshop for the scheduled inspections, major schedules viz. Periodical overhaul (POH) and major unscheduled repairs. The main depot will also house Operation Control Centre (OCC), Administrative Building, maintenance facilities for Civil – track, buildings, water supply; Electrical – traction, E&M; Signalling & Telecomm.; Automatic Fare Collection etc. apart from necessary facilities viz. stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock operational on the corridor.

For starting the morning services, some rakes will have to be kept at terminal stations and stabling facilities for the remaining rakes will have to be provided at the Depot.

Following aspects of Depot are covered:

- Conceptual design of Stabling lines, Inspection Shed and Workshop to provide maintenance facilities and stabling facilities for the rolling stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply system etc.
- Location for Depot cum Workshop

The rake induction and withdrawal from depot to the open line will have to be planned in such a way to ensure that the headway of open line is not affected. For the purpose, facilities for simultaneous receipt and dispatch of trains from depot to open line should be created. The stabling area should be interlocked with the open line so that the induction of train from the stabling can be done without loss of time. The rake washing can be done at automatic coach washing plant provided at the entry of depot i.e. before the rake is placed on stabling lines.

The other movements in the depot, viz. from the stabling to the inspection shed or workshop and vice versa may be non-interlocked. An ART (Accident Relief Train) line and two emergency re-railing lines will be provided from which emergency rescue vehicles can be dispatched to open line in the event of any emergency. To cater to the peak requirements, all trains except trains under maintenance would be in the service. However, during the off-peak hour in daytime, approximately half of the trains will be withdrawn from the service. To economize on the air-conditioning energy, 50% of total stabling lines would be under covered stabling shed. There would be pathways between the stabling lines, which are necessary for the “Safe to Run” examination and to facilitate the workers to move trolleys for the sweeping work. The scheduled inspections are envisaged to be carried out during the day off-peak hours and night.

The stabling and the yard layout would be at-grade level for least power requirements in shunting movements and to avoid accidental rolling of the rolling stock resulting into accidents and damages to the property.

The servicing requirement is to be determined from the Rolling Stock manufacturer. Depending upon manufacturer's requirements, servicing facilities may be provided to include the ability to carry out the inspection, maintenance, overhaul and repair of the rolling stock fleet, including the following components:

- Body;
- Bogies;
- Wheels
- Traction motors;
- Electrical components;
- Electronics; PA/ PIS
- Mechanical components;
- Batteries;
- Rolling stock air conditioning;
- Brake modules;
- Vehicle doors, windows and internal fittings.

The proposed arrangement for stabling and maintenance facilities of all the corridors is given in **Table 3.14**.

Table 3.14. Maintenance Depots for All Corridors

Infrastructure	Corridor-1	Corridor-2	Corridor-3	Corridor-4
	Akkupete Depot	Soladevanahalli Depot		
Stabling Lines	29 lines of 6 car	14 lines of 6 car	13 lines of 6 car	21 lines of 6 car
Inspection Lines	6 lines	4 lines		
Workshop Lines	3 lines	3 lines		

Table 3.15. Stabling Line Requirements

Corridor	Detail	
KSR Bengaluru City - Devanahalli	Stabling Requirements	48
Chikkabanavara– Baiyyappanahalli	Inside Depot for Maintenance +POH	6
Kengeri - White Field	Stabling Lines in Depot	42
	Stabling Lines at Terminal stations	4
Heelalige - Rajanukunte	Stabling Requirements	29
	Inside Depot for Maintenance +POH	4
	Stabling Lines in Depot	28
	Stabling Lines at Terminal stations	4

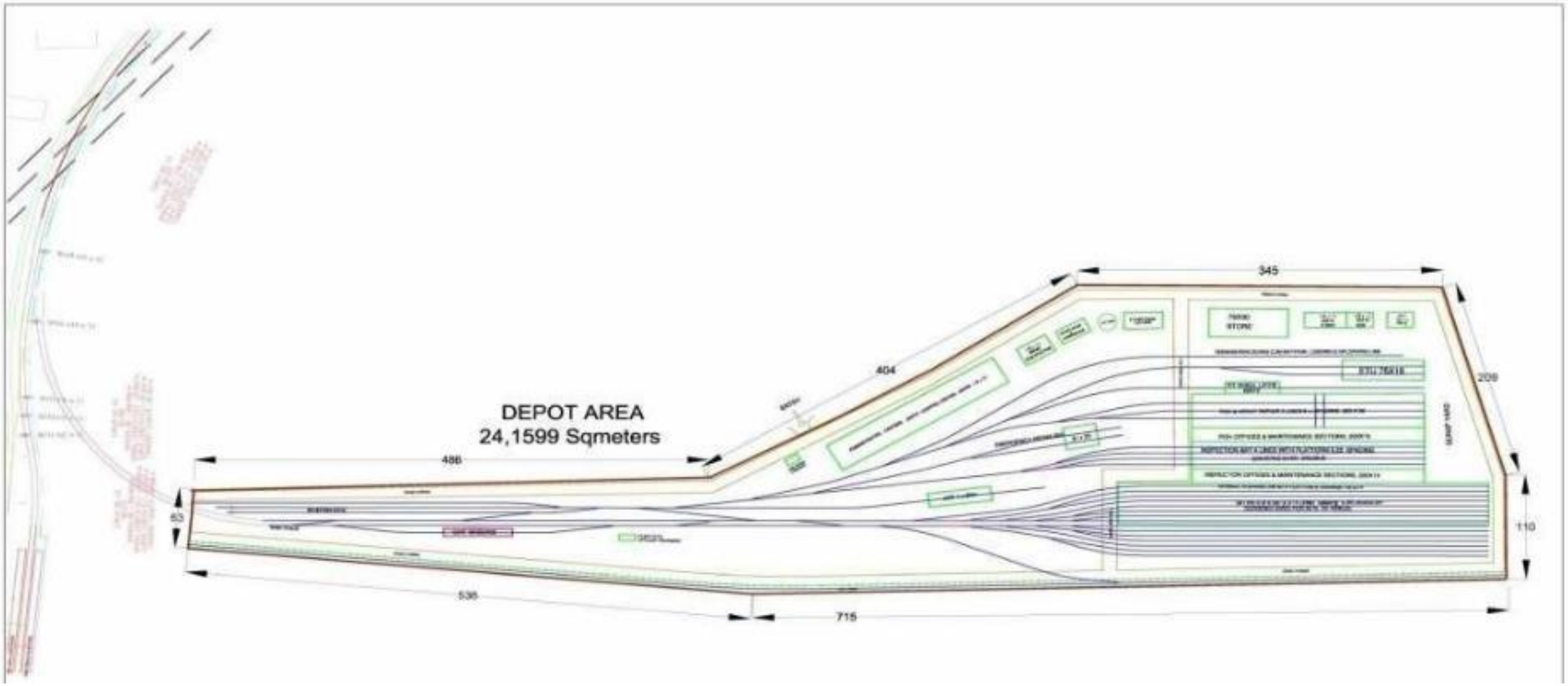

Figure 3.23. Akkupete Depot Location for Corridor-1 near Devanahalli

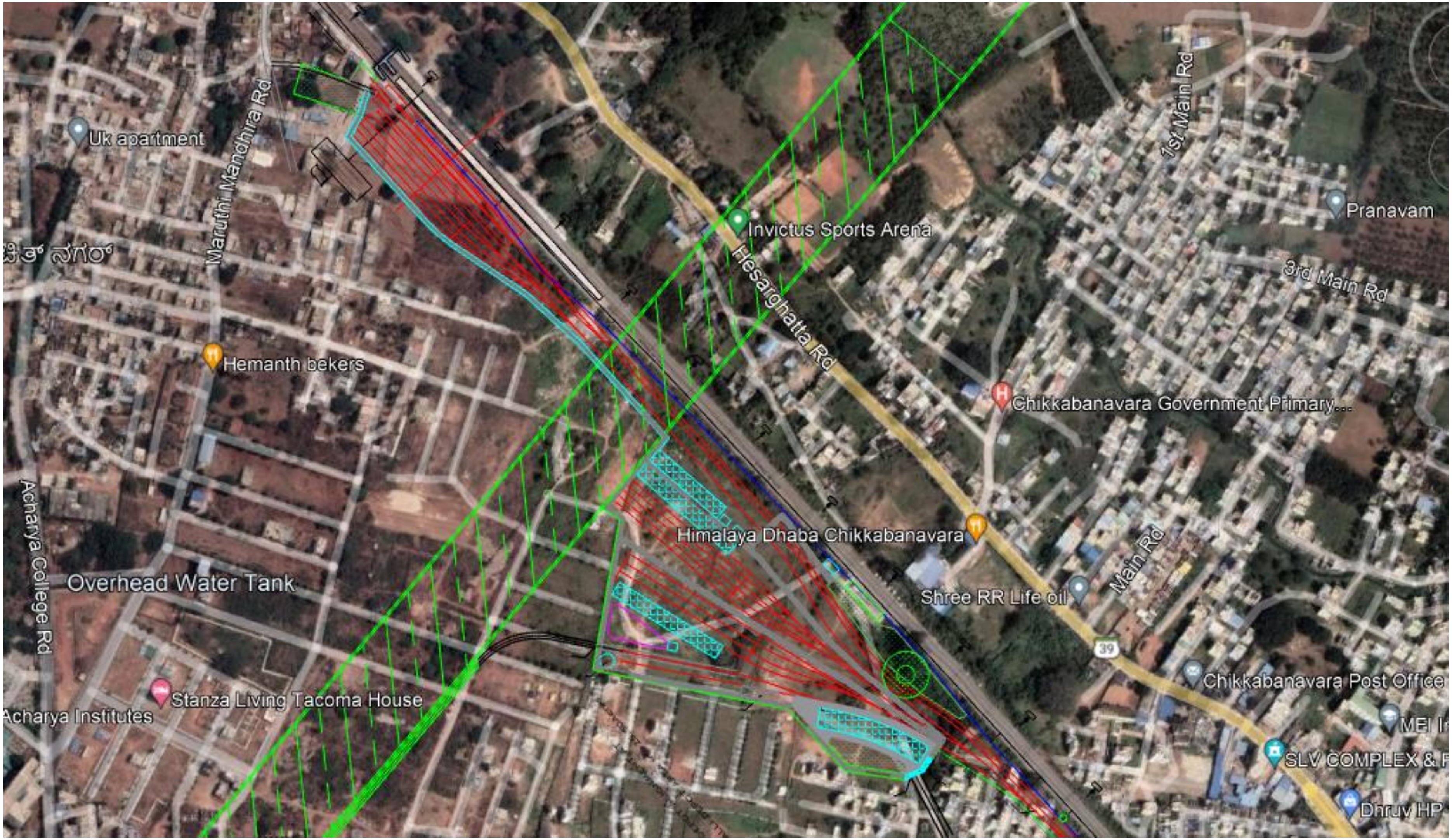

Figure 3.24. Soladevanahalli Depot Location for Corridor-2 near Soladevanahalli

3.7.2. Micro-Depots

Every train is planned to undergo maintenance in a period of 3 days, 15 days and 45 days' time. The total cost of dry run of all the trains to perform the above scheduled maintenance is works out to Rs 75 crore/year which is 25% of the yearly maintenance cost. Hence, micro depot is introduced to reduce the above cost and proposed at Heelalige and Kengeri stations.

Provisions like Air brake checking equipment, Pit Bay, Cat walk, Automatic Wash plan unit will be accommodated in the proposed Micro Depots.

Figure 3.25. Micro Depot Integrated with Heelalige Station in Corridor-4

3.7.3. Roads

- Roads inside the major depots shall be concrete roads.
- Access to Depot will be made either by sharing the existing roads or roads will be made parallel to the existing roads.
- RoB/RuBs will be constructed in case abutting the existing village roads.

3.8. Disaster Management Measures

The main objectives of the DMP are as follows:

- Save life and alleviate suffering
- Provide help to stranded passengers / commuters and arrange their prompt evacuation
- In-still a sense of security amongst all concerned by providing accurate information
- Protect Suburban Rail & IR property

- Expedite restoration of train operations
- Lay down the actions required to be taken by staff, in the event of any disaster in the corridors Suburban train services, to ensure handling of crisis situation in coordinated matter.
- To ensure that all the officials who are responsible to deal with the situation are thoroughly conversant with their duties and responsibilities, in advance. It is also important that these officials and workers are adequately trained to avoid any kind of confusion and chaos at the time of actual situation and to enable them to discharge their responsibilities with alertness and promptness.
- A detailed Disaster Management Manual need to be prepared with action plan and duties of the Officials during any disaster arising over Suburban rail system.
- Exclusive locomotive of diesel or battery operated, should be available at least one in each corridor so that same will be moved on any emergency of power failure or disabled train.
- A self-propelled road cum rail car or Accident relief train should be available in good fettle at the Depot in readiness to move on any emergency arising over the corridors. The car should be well equipped with tools and machineries to handle any situation of track failures derailments etc.

3.8.1. Recommendations

- The GoK & SPV in association with SDMA need to formulate an integrated DMA to facilitate a cohesive approach to comprehensively address all aspects of disaster management.
- SPV & SDMA should have infrastructure of relief equipment, facilities in hospitals and initiate effective measures to maintain the relief equipment fully equipped and in a state of operational readiness.
- The SPV & SDMA should, on priority, address the issue of operational constraints imposing speed restrictions, positioning of relief / medical vans, etc., to optimize response time, which is the essence of any response mechanism.
- SPV & SDMA should quickly provide effective communication system for transmission of real time information from the disaster site, which in turn is essential for assessing the gravity of the disaster and in organizing rescue and relief.
- SPV & SDMA need to constitute dedicated teams and initiate tangible measures to hasten the pace of providing specialized training in order to develop a trained team to handle the disaster.
- SPV need to enhance surveillance mechanism in the railway stations and institute an effective mechanism to prevent unauthorized entry into station premises.
- Since the suburban system tracks are aligned parallel to the existing IR tracks SPV should ensure while designing and executing the structures it should be in conformity with the IRS Bridge Rules A&C slip No. 48 dated 22.06.2017.

3.9. Airport Connectivity

- Direct connectivity to airport from Bengaluru City Station will serve central and northern parts of Bengaluru.

- This link will be of about 5.5 km length with about 0.50 km as elevated, and 5.00 km at-grade. This will have only one elevated station at the airport above the parking.
- The approximate cost of the airport connectivity is about 251.90 crore, the approximate area of land required is 15.96 acres, however the land cost has not been considered as it is Govt. land.

Figure 3.26. Proposed Airport Link

3.10. Alternate Sources for Financing

3.10.1. Introduction

Since the suburban rail like any infrastructure project requires large capital outlay and resources having long gestation period (stipulated time for the current project is six years), the rate of return required by the private sector is typically higher at 14% or more for such projects considering the risks involved. Since the current project offers lesser IRR than that is required by private entity, it is proposed that the initial capex be made available through government budgetary allocations and mix of equity and debt via a Special Purpose Vehicle (SPV).

However, it is desirable to augment the resources through alternate sources of finances given the constraints of government treasury. These alternate sources can be explored once the initial risk of construction and requirement of large capital outlay has been assumed by the SPV and subsequent project becomes commercially viable for the private entity.

Some of the forms of PPP that can be explored by the SPV are described below:

3.10.1.1. O&M PP

Fixed infrastructure by SPV, operation & maintenance of the Suburban system is in the hands of private entity. Fixed annual payment shall be paid in such arrangement.

3.10.1.2. Leasing of Rolling Stock and its maintenance (Wet Lease)

Fixed infrastructure by SPV, operational independence with SPV, maintenance of the Suburban system is in the hands of private entity. Availability based payment shall be paid in such arrangements.

Besides the above forms of PPP, the SPV can also employ innovative contracting tools involving private sector that hold great potential as established with various MRTS Rail projects in the country, such as Lifts & Escalators on O&M Model, AFC – Advanced systems that can be bid out with branding and Platform Screen Door can be taken up as O&M model. Since these components are essential in the overall suburban infrastructure construction, these will need to be worked out at the time of taking up the implementation of the project.

3.10.2. Property Development on Railway Land

Property development across the world is currently being utilized for augmenting the resources; this is usually done by developing real estate on the land parcels available with the SPV/ IR. Indian Railways (SWR) has about 141.30 Ha of land that can be utilized for the property development. This land is located at various locations of the city along the rail route and station area.

Indian Railways / SWR may monetize the land by way of leasing. The land parcels are situated as:

- Vacant land parcels adjacent to station and rail network.
- Land with old structures such as quarters, utilities that can be redeveloped
- Station areas where the current or proposed stations are located
- Track areas where there are tracks, pit lines, etc.

Table 3.16. Availability of Land

Sl. No.	Stations	Vacant Land for commercial exploitation (in Ha)	Area above Railway Track (in Ha)	Total Area(in Ha)
1.	SBC	24.33	20.27	44.60
2.	YPR	53.81	14.09	67.89
3.	BNC	9.39	8.59	17.98
4.	YNK	3.29	7.18	10.47
5.	BYPL	5.80	3.37	9.17
6.	KJM	0.68	3.41	4.09
7.	WFD	4.33	2.78	7.11
8.	CSDR	9.66	2.91	12.57
9.	HEB	14.84	5.89	20.72
10.	MWM	0.00	1.69	1.69

Sl. No.	Stations	Vacant Land for commercial exploitation (in Ha)	Area above Railway Track (in Ha)	Total Area(in Ha)
11.	BAND	2.00	5.43	7.43
12.	LOGH	0.33	0.98	1.32
13.	KGI	1.62	2.84	4.46
14.	HLE	10.07	1.88	11.95
15.	NYH	1.15	1.74	2.90

Development on these parcels of land offers challenges of varying degree as the corridor traverses the city of varying development potential. The prices of land and built up area are also varying. Property development or real estate development is dictated by the location, economic condition of the surrounding areas, the size of the parcel and mainly the regulations determined by the Master Plan documents. Further, the criteria for attractiveness comes from the size of the land parcel, whether it is contiguous, has good access, frontage and as well as supporting external infrastructure.

3.10.3. Vacant lands and Redevelopment

The Vacant lands which are of considerable size and potential can be developed with the partnership of the private players.

Redevelopment of the lands can be taken up with private participation but the substantial costs for redevelopment are expended. The higher FAR framework will allow for re-organizing and redeveloping the property by housing the existing function within smaller land component and developing the rest optimally.

3.10.4. Integrated Station with Land

The lands adjacent to the station that may be smaller in size and are dependent on the station improvement/development can be developed in an integrated manner along with the station. The concourse area of the proposed stations can also be put for rentals according to the passenger movement and real estate market conditions. The investment will be along with the station development and may be guided to be developed along with the project phasing. This will allow for rentals from leasing activity.

3.10.5. Vacant Land Parcels

The following stations have been identified for possibility of real estate development. Few structures may require relocation to realize full potential of real estate at these locations.

Table 3.17. Stations for Real Estate Development

S. No.	Description	Land Parcel Code	Area In Sqm	Planning Authority
1	KSR Bengaluru City - KSR - Opp Krishna Mill	SBC - C	12140.60	BDA
2	Cantonment Station	BNC- A and B	49,836	BDA
3	Yeshwanthpur	YPR –A & YPR- B	109,296	BDA
4	Channasandra	CSDR – A & CSDR -B	62,758	BDA
5	Baiyyappanahalli	BYP-A,B,C,D	55312	BDA
6	Chikkabanavara	BAW – B	3765	BDA
7	Devanahalli	DHL	30,644	BIAPPA

The vacant area that is available for immediate exercise is about 323751.6 sq.m or 32.38 Ha of land. Based on the Guideline value for the standalone vacant land parcels at the locations - SBC, BNC, YPR, CSDR, BYPL, BAW, DHL, the valuation of the land are as follows:

Table 3.18. Valuation of Land

Sl. No.	Name of Station	Description	Area		Value(Lease Basis)	Land Value (INR)	Ext. Devpt. Infra (` In Crores)	Net Value (in Crore)
			Ha	Sq. Mtr				
1	SBC	Krishna Mill	1.2	12140.60	161500.00	1960706900.00	0.00	196.07
2	YPR	Site A	6.9	68816.00	44000.00	3027904000.00	15.00	
		Site B	4.0	40480.00	44000.00	1781120000.00		465.90
3	BNC	Site A	4.9	49036.00	94800.00	4648612800.00	0.00	464.86
4	CSDR	Site A	1.5	14950.00	35600.00	532220000.00	0.00	
		Site B	4.8	47808.00	35600.00	1701964800.00		223.42
5	BAW	Site B	0.4	3765.00	17500.00	65887500.00	0.00	6.59
6	BYPL	A, B, C, D	5.5	55312.00	10700.00	591838400.00	5.00	54.18
7	DHL	Site A	3.1	30644.00	13557.60	415459094.40	0.00	41.55
Total						**1472.57**	**20.00**	**1452.57**

For about 32.28 Ha or 3, 22,951.60 sq.m – INR 1452 Cr

Table 3.19. Value of Land on Redevelopment Parcels

Sl. No.	Name of Station	Description	Area		Value (Lease Basis)	Land Value (INR)	Ext. Devpt. Infra (In Crores)	Net Value (In Crore)
			Ha	Sq. Mtr				
1	SBC	Site A	6.07	60720.00	120000.00	7286400000.00	25.00	
		Site B	7.23	72297.28	120000.00	8675673600.00		1571.21
2	BNC	Site B	1.16	11622.00	100000.00	1162200000.00	7.50	599.08
Total								**2170.29**

For land about – 14.46 Ha or 144639.28 sq.m – the value is about 2170.29 Crore. The total value of land for the above based on prevailing guideline value is about INR 3622.86 Crore.

3.11. Recommendations

- The project has good EIRR &FIRR and may be considered for implementation in order to take care of the city's long term traffic needs.
- The corridors under the present assignment may be extended beyond their proposed terminal station to the nearest important town in order to cater some additional catchment.
- The direct connectivity to Kempegowda International Airport through suburban rail system is also recommended, as it will serve central and northern parts of Bengaluru.
- Additional sources of revenue including commercial development needs to be explored to support the project.
- SWR may consider appointing financial, legal and institutional consultants to take up the project implementation forward.
- The implementation of Corridors may be taken up in phases and the priority of corridors is given below:

1) KSR Bengaluru City to Devanahalli
2) Baiyyappanahalli to Chikkabanavara
3) Heelalige to Rajanukunte
4) Kengeri to Whitefield

- The study is restricted only within the Bengaluru Urban limits. However, based on the patronage and the ridership along the corridors, the corridors may be extended in future to the nearest towns as listed below:

  1) Corridor – 1 (KSR Bengaluru City –Devanahalli) – may be extended up to Chikkaballapura on Northern side of the city.
  2) Corridor – 2 (Baiyyappanahalli – Chikkabanavara) – may be extended up to Tumakuru on North – Western side.
  3) Corridor – 3 (Kengeri – Whitefield) – may be extended up to Ramanagara on South Western side and up to Mallur/Bangarpet on North Eastern side.
  4) Corridor–4 (Heelalige–Rajanukunte) – may be extended up to Doddaballapura on Northern side and up to Hosur on Heelalige side.

- Items like Automatic Fare Collection (AFC) gates, Lifts, Escalators and Platform Screen Doors (PSD) can be taken under PPP model.
- During construction, SPV may explore the procurement of Rolling stock requirement under PPP model.

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Chapter 4. Environmental Regulatory Framework

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.

4.1. External Funding Agencies Environmental Policies and their Implications / Application in the BSRP Context

4.1.1. KfW Environmental and Social Requirements

The primary purpose of KfW Development Bank is to promote economic, social, environmental and cultural dimensions of sustainable development in developing countries. The principle of sustainable development are central to KfW Development Bank's funding activities along with associated environmental and social sustainability and climate protection. The main objectives of KfW are to fight against poverty and inequalities, including gender inequalities; to promote human rights, education and health; to support processes of ecological, energy, demographic, digital, territorial and participatory transitions and climate change.

KfW Development Bank finances investments and related advisory services in developing and emerging countries on behalf of the German Federal Government, which are implemented by local partners as the executing agency. More specifically, KfW Development Bank uses funds from the federal budget, which are topped up by the bank's own funds, in order to support the construction of economically and socially beneficial infrastructure, the development of efficient financial sectors, and the implementation of environmental and climate protection measures and programmes to preserve natural resources. The most important objective of KfW Development Bank's promotional activities is to help the Federal Government of Germany and its partner countries to achieve their overarching development goals.

The Guideline has the following objectives:

- To define a common binding framework to incorporate environmental, social and climate standards into the planning, appraisal, implementation, and monitoring of FC-measures;
- To enhance transparency, predictability and accountability in the decision-making processes of the internal environmental and social due diligence (ESDD) and climate assessments

Projects funded by KfW Development Bank contribute to France's ODA strategy, the implementation of the 2030 global agenda and the 17 Sustainable Development Goals (SDGs), as well as the 2015 Paris Climate Agreement.

In view of the above objectives and targets, all the projects funded by the KfW are subjected to environmental and social assessment as well as other relevant development aspects. The priority areas of KfW's activities in developing countries include social development, environmental and climate protection and conservation of natural resources. The KfW Development Bank assessment standards are the Environmental and Social Standards of the World Bank Group, i.e. Environmental and Social Standards (ESS) and the IFC Performance Standards (PS) and their General and sector-specific Environmental, Health and Safety (EHS) Guidelines as well as the Core Labour Standards of the International Labour Organization (ILO).

Categorization of the environmental and social risk: As per KfW's environmental and social safeguard policy, there is requirement of conducting environmental and social assessment study of all the projects requiring financial assistance from KfW Development Bank. As per the Policy, the KfW analyses and classify all the potential projects into four risk category based on the extent of environmental and social risks:

- Category A: High Environmental and Social Risks
- Category B+: Substantial Environmental and Social Risks
- Category B: Moderate Environmental and Social Risks
- Category C: Low Environmental and Social Risks

The Bank will classify the projects into the above categories taking into account the nature and scale of the operation, the location and sensitivity of the affected area, the severity of the potential environmental and social risks and impacts, as well as the client's capacity to manage them. For the projects of High Risks and Substantial Risks category, full Environmental and Social Assessment is required. However, for the project categorized under high Risk Category due to social impacts, detailed ESA study is required. For the Low Risk category projects there is no requirement of environmental and social assessment.

As per preliminary assessment, the project would be in "A Category- High Environmental and Social Risks" under KfW's environmental and social safeguard policy.

4.1.2. EIB's Environmental and Social Requirements

The EIB Group Environmental and Social Sustainability Framework is an overarching policy framework that allows the Group to focus on sustainable and inclusive development, committing to a just and fair transition and supporting the transition to economies and communities that are climate and disaster resilient, low carbon, environmentally sound and more resource-efficient.

It consists of a Group-wide Environmental and Social Policy and a revised set of EIB Environmental and Social Standards, including a new 11 Standards on Intermediated finance, which describe the requirements that all EIB-financed projects must meet. The 11 E&S Standards includes;

Standard 1: Environmental and social impacts and risks - Standard 1 promotes an integrated approach to impact and risk assessment and management by ensuring that environmental, climate, social and human rights considerations are taken into account and addressed at every step of the project. The standard sets out the promoter's responsibilities for assessing, managing, monitoring and reporting on the potential environmental, climate and social impacts and risks associated with the project and for maximising positive outcomes throughout the project. This is essential to achieve the environmental, climate and social outcomes in line with the EIB Group Environmental and Social Policy and the EIB Environmental and Social Standards.

Standard 2: Stakeholder engagement - Standard 2 promotes an inclusive and systematic approach to engaging constructively with stakeholders. It acknowledges stakeholder engagement as essential for the effective assessment, management and monitoring of environmental, climate and social impacts and risks, and to ensure projects are sustainable and deliver better outcomes. This standard outlines the promoter's responsibilities for implementing continuous and transparent engagement with project stakeholders.

Standard 3: Resource efficiency and pollution prevention - Standard 3 recognises the importance of resource efficiency to relieve pressure on the environment and curb climate change. It encourages the identification, design and use of technologies, processes and services best suited to achieve environmental quality objectives. The standard also strengthens the approach and requirements for projects involving existing activities, facilities, modifications and/or extensions.This Standard recognises the contribution of resource efficiency to relieve pressures on the environment and climate change whilst bringing increased competitiveness through cost savings from improved efficiency, commercialisation of innovation and better management of resources over their whole life cycle. This Standard encourages the identification, design and use of the appropriate technologies, processes and services to achieve environmental quality objectives, including the use of Best Available Techniques (BAT) or emerging techniques, as relevant in increase the efficiency of natural resourse usage and prevension of pollution. It also encaurages circular economy priciples to overcome the pressure on natural resources.

Standard 4: Biodiversity and ecosystems - Standard 4 emphasises that the protection and conservation of biodiversity and ecosystems, and maintaining their ecological functions and processes, are fundamental to environmental and social sustainability. This standard sets out the requirements and measures that the promoter has to adopt throughout the different stages of a project supported by the Bank to achieve a "no loss" of biodiversity and — where required — a net positive impact. Standard 4 also addresses the sustainable management and use of living natural resources, such as plants, trees and forests, and recognises the need to consider the livelihood of project-affected people whose access to, or use of living natural resources may be affected by the project. The standard also emphasises the need to engage with traditional and indigenous communities as key stakeholders in protecting and managing biodiversity and natural resources, while respecting their rights to their land, culture and spirituality.

Standard 5: Climate change - In line with the EIB's enhanced climate action and environmental sustainability ambitions and its 2021-2025 Climate Bank Roadmap, this standard promotes the alignment of projects supported by the EIB with the goals and principles of the Paris Agreement and the EU Sustainable Finance Action Plan. It does so by stipulating that promoters must explicitly address and incorporate climate change mitigation and adaptation considerations into the decisionmaking process for EIB-supported projects throughout the project cycle, by assessing and minimising greenhouse gas emissions and physical climate risk.

Standard 6: Involuntary resettlement - EIB projects sometimes involve land acquisition and/or restrictions on land use, which can result in the temporary or permanent displacement of people from their original places of residence or their economic activities or subsistence practices. A situation when affected individuals or communities do not have the right to refuse such displacement is referred to as involuntary resettlement. Standard 6 seeks to avoid involuntary resettlement in the first instance, and minimise and define the appropriate mitigation measures that should be in place to counter the adverse impacts of involuntary resettlement. It also aims to assist all affected persons so they can improve or at least restore their socioeconomic and cultural conditions.

Standard 7: Vulnerable groups, Indigenous Peoples and Gender - The objective of this standard is to address inequalities and other factors contributing to vulnerability, marginalisation and/or discrimination in an EIB project. The standard also promotes gender equality as a basic human right crucial for sustainable development. It outlines the promoter's responsibilities for assessing, managing and monitoring project impacts, risks and opportunities related to Indigenous Peoples and vulnerable persons/groups.

Standard 8: Labour rights - Good labour practices and the use of appropriate codes of conduct are important to ensure that workers' fundamental rights are respected and that working conditions are fair and decent. This standard aims to ensure that promoters of EIB projects comply with the core labour standards of the International Labour Organization and with national labour and employment laws. It sets the need for a workers' grievance mechanism. It further defines standards to protect migrant workers and workers affected by collective dismissals. The standard also requires the establishment, maintenance and improvement of worker-management relationships and terms and conditions of employment. The standard defines the assessment requirements that are needed for the promoter's own workforce, third-party workers and supply chain workers.

Standard 9: Health, safety and security - Standard 9 outlines the promoters' and workers' responsibilities to safeguard the health, safety and security of workers and affected people and communities. It establishes the importance of putting in place a well-defined health and safety management system, endowed with appropriate resources and expertise. The standard further reinforces requirements to prevent gender-based violence and introduces impact and risk assessment requirements for new areas such as traffic and road safety, natural hazards (including those triggering technological disasters) and pandemics and epidemics.

Standard 10: Cultural heritage - The EIB recognises the central role of cultural heritage as a source of valuable historical and scientific information, an asset for economic and social development and an integral part of people's cultural rights, identity and practices. Consistent with the applicable international conventions and declarations, this standard aims to identify and assess project risks and potential impacts affecting tangible and intangible cultural heritage, and covers the management and monitoring of related mitigation measures. It emphasises the need for a chance find procedure outlining the actions to be taken if previously unknown cultural heritage is encountered.

Standard 11: Intermediated finance - Standard 11 sets out the requirements and processes that financial intermediaries must have in place to assess, manage, monitor and report on the environmental, climate and social impacts and risks associated with the sub-projects it finances, as appropriate to the nature of intermediated financing.

The Project Authority/promoter is responsible for ensuring that, project design, implementation, management, monitoring and reporting in accordance with the relevant legal requirements and the Policy requirements which are reflected in the legal documentation signed with the EIB.

It is the responsibility of the Project Authority/promoter to provide for a holistic and proactive approach to the assessmentand management of impacts and risks by ensuring that environmental, climate and social considerations, as well as their interactions, are integrated into the decision-making process and shall ensure that the mitigation hierarchy is applied to all impacts and risks identified, where relevant. A meaningful and effective stakeholder engagement process is an integral part of this approach.

EIB's environmental and social due diligence is adapted to the nature and scale of the project and is proportional to the level of E&S risks and impacts. For this purpose, during appraisal time, EIB shall categorise all projects, depending on the potential E&S risks on EIB's 11 Environmental and Social

Standards. EIB classifies projects into the following three categories: High risks, Medium risks and Low risks.

- High Risk: projects that are likely to have significant environmental, climate and/or social impacts and risks and require the preparation of an Environmental Impact Assessment (EIA)/Environmental and Social Impact Assessment (ESIA) report and/or any relevant report pertaining to specific topics that may required particular attention due to: ii) national and/or EU Law requirements; or ii) determination made by the competent authorities in the host country and/or by EIB based on a case-by case analysis that takes into account the nature, scale and location of the project;
- Medium Risk: projects that are likely to have moderate/limited adverse environmental, climate and/or social impacts and risks that might be addressed through the application of mitigation hierarchy and for which either the competent authorities in the host country and/or the EIB have determined that the preparation of an EIA/ESIA report is not required;
- Low Risk: projects that are likely to result in minor or no adverse environmental, climate and/or social impacts and risks.

The proposed BSRP project comes under "High Risk category" which is having significant environmental, climate and/or social impacts and risks, mainly its social Impacts and might be addressed through the application of mitigation measures. Hence, the project requires detailed Environmental Impact Assessment.

4.1.3. World Bank's Environmental and Social Framework

KfW Development Bank has adopted the World Bank's prevailing environmental and social operational standards.

The World Bank Environmental and Social Framework sets out the World Bank's commitment to sustainable development, through a Bank Policy and a set of Environmental and Social Standards that are designed to support Borrowers' projects. The Environmental and Social Standards set out the requirements for Borrowers relating to the identification and assessment of environmental and social risks and impacts associated with projects supported by the Bank through Investment Project Financing. The Bank believes that the application of these standards, by focusing on the identification and management of environmental and social risks, will support Borrowers in their goal to reduce poverty and increase prosperity in a sustainable manner for the benefit of the environment and their citizens. The standards will: (a) support Borrowers in achieving good international practice relating to environmental and social sustainability; (b) assist Borrowers in fulfilling their national and international environmental and social obligations; (c) enhance nondiscrimination, transparency, participation, accountability and governance; and (d) enhance the sustainable development outcomes of projects through ongoing stakeholder engagement.

The ten Environmental and Social Standards (ESS) establish the standards that the Borrower and the project will meet through the project life cycle, as follows:

ESS1: Assessment and Management of Environmental and Social Risks and Impacts

ESS1 sets out the Borrower's responsibilities for assessing, managing and monitoring environmental and social risks and impacts associated with each stage of a project supported by the Bank through Investment Project Financing, in order to achieve environmental and social outcomes consistent with the Environmental and Social Standards (ESSs). The term 'environmental and social assessment' is a generic term that describes the process of analysis and planning used by the Borrower to ensure the environmental and social impacts and risks of a project are identified, avoided, minimized, reduced or mitigated.

A. Use of borrower's environmental and social framework

When a project is proposed for Bank support, the Borrower and the Bank will consider whether to use all, or part, of the Borrower's ES Framework in the assessment, development and implementation of a project. Such use may be proposed provided this is likely to address the risks and impacts of the project, and enable the project to achieve objectives materially consistent with the ESSs.

If the assessment identifies gaps in the Borrower's ES Framework, the Borrower will work with the Bank to identify measures and actions to address such gaps. Such measures and actions may be implemented during project preparation or project implementation and will include, where necessary, measures and actions to address any capacity development issues pertaining to the Borrower, any relevant national, subnational or sectoral implementing institution, and any implementing agency. The agreed measures and actions, together with the timeframes for their completion, will form part of the ESCP.

The Borrower will take all actions necessary to maintain the Borrower's ES Framework, as well as acceptable implementation practices, track record, and capacity, in accordance with the measures and actions identified in the ESCP, throughout the project life cycle. The Borrower will notify and discuss with the Bank any significant changes in the Borrower's ES Framework that may affect the project. If the Borrower's ES Framework is changed in a manner inconsistent with the requirement of above paragraph and the ESCP, the Borrower will carry out, as appropriate, additional assessment and stakeholder engagement in accordance with the ESSs, and propose changes, for approval by the Bank, to the ESCP.

B. Environmental and social assessment

The Borrower will carry out an environmental and social assessment of the project to assess the environmental and social risks and impacts of the project throughout the project life cycle. The assessment will be proportionate to the potential risks and impacts of the project, and will assess, in an integrated way, all relevant direct, indirect and cumulative environmental and social risks and impacts throughout the project life cycle, including those specifically identified in ESSs2–10.

The environmental and social assessment will be based on current information, including an accurate description and delineation of the project and any associated aspects, and environmental and social baseline data at an appropriate level of detail sufficient to inform characterization and identification of risks and impacts and mitigation measures. The assessment will evaluate the project's potential environmental and social risks and impacts; examine project alternatives; identify ways of improving project selection, siting, planning, design and implementation in order to apply the mitigation hierarchy for adverse environmental and social impacts and seek opportunities to enhance the positive impacts of the project. The environmental and social assessment will include stakeholder engagement as an integral part of the assessment, in accordance with ESS10.

C. Environmental and Social Commitment Plan (ESCP)

The Borrower will develop and implement an ESCP, which will set out measures and actions required for the project to achieve compliance with the ESSs over a specified timeframe. The ESCP will be agreed with the Bank and will form part of the legal agreement. The draft ESCP will be disclosed as early as possible, and before project appraisal. The ESCP will take into account the findings of the environmental and social assessment, the Bank's environmental and social due diligence, and the results of engagement with stakeholders. It will be an accurate summary of the material measures and actions required to avoid, minimize, reduce or otherwise mitigate the potential environmental and social risks and impacts of the project. A completion date for each action will be specified in the ESCP.

The ESCP will describe the different management tools that the Borrower will use to develop and implement the agreed measures and actions. These management tools will include, as appropriate, environmental management plans, environmental and social management frameworks, operational policies, operational manuals, management systems, procedures, practices and capital investments. All management tools will apply the mitigation hierarchy, and incorporate measures so that the project will meet the requirements of applicable laws and regulations and the ESSs in accordance with the ESCP throughout the project life cycle.

D. Project monitoring and reporting

The Borrower will monitor the environmental and social performance of the project in accordance with the legal agreement (including the ESCP). The extent and mode of monitoring will be agreed upon with the Bank, and will be proportionate to the nature of the project, the project's environmental and social risks and impacts, and compliance requirements. The Borrower will ensure that adequate institutional arrangements, systems, resources and personnel are in place to carry out monitoring. Where appropriate and as set out in the ESCP, the Borrower will engage stakeholders and third parties, such as independent experts, local communities or NGOs, to complement or verify its own monitoring activities. Where other agencies or third parties are responsible for managing specific risks and impacts and implementing mitigation measures, the Borrower will collaborate with such agencies and third parties to establish and monitor such mitigation measures.

Monitoring will normally include recording information to track performance, and establishing relevant operational controls to verify and compare compliance and progress. Monitoring will be adjusted according to performance experience, as well as actions requested by relevant regulatory authorities and feedback from stakeholders such as community members. The Borrower will document monitoring results.

E. Stakeholder Engagement and Information Disclosure

As set out in ESS10, the Borrower will continue to engage with, and provide sufficient information to stakeholders throughout the life cycle of the project, in a manner appropriate to the nature of their interests and the potential environmental and social risks and impacts of the project. For High Risk and Substantial Risk projects, the Borrower will provide to the Bank and disclose documentation, as agreed with the Bank, relating to the environmental and social risks and impacts of the project prior to project appraisal. The documentation will address, in an adequate manner, the key risks and impacts of the project, and will provide sufficient detail to inform stakeholder engagement and Bank decision making. The Borrower will provide to the Bank and disclose final or updated documentation as specified in the ESCP.

ESS2: Labor and Working Conditions

ESS2 recognizes the importance of employment creation and income generation in the pursuit of poverty reduction and inclusive economic growth. Borrowers can promote sound worker-management relationships and enhance the development benefits of a project by treating workers in the project fairly and providing safe and healthy working conditions. The objectives of the ESS2 are;

- To promote safety and health at work.
- To promote the fair treatment, non-discrimination and equal opportunity of project workers.
- To protect project workers, including vulnerable workers such as women, persons with disabilities, children (of working age, in accordance with this ESS) and migrant workers, contracted workers, community workers and primary supply workers, as appropriate.
- To prevent the use of all forms of forced labor and child labor.
- To support the principles of freedom of association and collective bargaining of project workers in a manner consistent with national law.
- To provide project workers with accessible means to raise workplace concerns.

ESS3: Resource Efficiency and Pollution Prevention and Management

ESS3 recognizes that economic activity and urbanization often generate pollution to air, water, and land, and consume finite resources that may threaten people, ecosystem services and the environment at the local, regional, and global levels. The current and projected atmospheric concentration of greenhouse gases (GHG) threatens the welfare of current and future generations. At the same time, more efficient and effective resource use, pollution prevention and GHG emission avoidance, and mitigation technologies and practices have become more accessible and achievable.

This ESS sets out the requirements to address resource efficiency and pollution prevention and management throughout the project life cycle consistent with GIIP. The objectives of this ESS 3 are;

- To promote the sustainable use of resources, including energy, water and raw materials.
- To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
- To avoid or minimize project-related emissions of short and long-lived climate pollutants.
- To avoid or minimize generation of hazardous and non-hazardous waste.

ESS4: Community Health and Safety

ESS4 recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. In addition, communities that are already subjected to impacts from climate change may also experience an acceleration or intensification of impacts due to project activities. ESS4 addresses the health, safety, and security risks and impacts on project-affected communities and the corresponding responsibility of Borrowers to avoid or minimize such risks and impacts, with particular attention to people who, because of their particular circumstances, may be vulnerable. The objectives of ESS4 are;

- To anticipate and avoid adverse impacts on the health and safety of project-affected communities during the project life cycle from both routine and nonroutine circumstances.
- To promote quality and safety, and considerations relating to climate change, in the design and construction of infrastructure.
- To avoid or minimize community exposure to project-related traffic and road safety risks, diseases and hazardous materials.
- To have in place effective measures to address emergency events.
- To ensure that the safeguarding of personnel and property is carried out in a manner that avoids or minimizes risks to the project-affected communities.

ESS5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement

ESS5 recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons. Project-related land acquisition or restrictions on land use may cause physical displacement (relocation, loss of residential land or loss of shelter), economic displacement (loss of land, assets or access to assets, leading to loss of income sources or other means of livelihood), or both. The term “involuntary resettlement”refers to these impacts. Resettlement is considered involuntary when affected persons or communities do not have the right to refuse land acquisition or restrictions on land use that result in displacement.

Experience and research indicate that physical and economic displacement, if unmitigated, may give rise to severe economic, social and environmental risks: production systems may be dismantled; people face impoverishment if their productive resources or other income sources are lost; people may be relocated to environments where their productive skills are less applicable and the competition for resources greater; community institutions and social networks may be weakened; kin groups may be dispersed; and cultural identity, traditional authority, and the potential for mutual help may be diminished or lost. For these reasons, involuntary resettlement should be avoided. Where involuntary resettlement is unavoidable, it will be minimized and appropriate measures to mitigate adverse impacts on displaced persons (and on host communities receiving displaced persons) will be carefully planned and implemented. The objectives of ESS5 are;

- To avoid involuntary resettlement or, when unavoidable, minimize involuntary resettlement by exploring project design alternatives.
- To avoid forced eviction.
- To mitigate unavoidable adverse social and economic impacts from land acquisition or restrictions on land use by: (a) providing timely compensation for loss of assets at replacement

ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

ESS6 recognizes that protecting and conserving biodiversity and sustainably managing living natural resources are fundamental to sustainable development. Biodiversity is defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems. Biodiversity often underpins ecosystem services valued by humans. Impacts on biodiversity can therefore often adversely affect the delivery of ecosystem services.

ESS6 recognizes the importance of maintaining core ecological functions of habitats, including forests, and the biodiversity they support. All habitats support complexities of living organisms and vary in terms of species diversity, abundance and importance. This ESS also addresses sustainable management of primary production and harvesting of living natural resources.

ESS6 recognizes the need to consider the livelihood of project-affected parties, including Indigenous Peoples, whose access to, or use of, biodiversity or living natural resources may be affected by a project. The potential, positive role of projectaffected parties, including Indigenous Peoples, in biodiversity conservation and sustainable management of living natural resources is also considered.

ESS8: Cultural Heritage

ESS8 recognizes that cultural heritage provides continuity in tangible and intangible forms between the past, present and future. People identify with cultural heritage as a reflection and expression of their constantly evolving values, beliefs, knowledge and traditions. Cultural heritage, in its many manifestations, is important as a source of valuable scientific and historical information, as an economic and social asset for development, and as an integral part of people's cultural identity and practice. ESS8 sets out measures designed to protect cultural heritage throughout the project life cycle. The objectives of this ESS are;

- To protect cultural heritage from the adverse impacts of project activities and support its preservation.
- To address cultural heritage as an integral aspect of sustainable development.
- To promote meaningful consultation with stakeholders regarding cultural heritage.
- To promote the equitable sharing of benefits from the use of cultural heritage.

ESS10: Stakeholder Engagement and Information Disclosure

This ESS recognizes the importance of open and transparent engagement between the Borrower and project stakeholders as an essential element of good international practice. Effective stakeholder engagement can improve the environmental and social sustainability of projects, enhance project acceptance, and make a significant contribution to successful project design and implementation. Stakeholder engagement is an inclusive process conducted throughout the project life cycle. Where properly designed and implemented, it supports the development of strong, constructive and responsive relationships that are important for successful management of a project's environmental and social risks. Stakeholder engagement is most effective when initiated at an early stage of the project development process, and is an integral part of early project decisions and the assessment, management and monitoring of the project's environmental and social risks and impacts.

4.1.4. Assessment of Applicability of the World Bank's and EIB's ESS for the Project

The project is to comply with above mentioned World Bank's and EIB's Environmetal and Social Standards, as applicable. This section provides an overview of the World Bank's and EIB's, policy equirements on Environment and Social Safeguards as per Environmental and Social Framework, and its relevance and applicability for the project.

Assessment of applicability of WB's and EIB's ESS for the BSRP project is as follows;

Table 4.1. Assessment of Applicability of World Bank's & EIB's ESS for the BSRP Corridors

World Bank's ESS	EIB's ESS	Corridor 1	Corridor 2	Corridor 3	Corridor 4
ESS-1: Assessment and Management of Environmental and Social Risks and Impacts	Standard 1: Environmental and social impacts and risks	√	√	√	√
ESS-2: Labour and Working Conditions	Standard 8: Labour rights	√	√	√	√
ESS-3: Resource Efficiency and Pollution Prevention and Management	Standard 3: Resource efficiency and pollution prevention	√	√	√	√
ESS-4: Community Health and Safety	Standard 9: Health, safety and security	√	√	√	√
ESS-5: Land- Acquisition Restrictions on Land Use and Involuntary Resettlement	Standard 6: Involuntary resettlement	√	√	√	√
ESS-6: Biodiversity Conservation	Standard 4: Biodiversity and ecosystems				
ESS-7: Indigenous Peoples	Standard 7: Vulnerable groups, Indigenous Peoples and Gender				
ESS-8: Cultural Heritage	Standard 10: Cultural heritage	√			
ESS-9: Financial Intermediaries	Standard 11: Intermediated finance				
ESS-10: Stakeholder Engagement and Information Disclosure	Standard 2: Stakeholder engagement	√	√	√	√
-	Standard 5: Climate change	√	√	√	√

Environmental Impact Assessment will be conducted as per the principals/ standards lied out in World Bank's and EIB's ESS standards. This will be supported by World Bank's General EHS Applicablility of the ESS for the Project is presented in above table, where Risks and Impack assessments for all the applicable ESS will be carried out by undertaking qualitative and quantitative study. International and national measures, best practices will be incorporated in order to minimize the impacts and to make the project environmentally sustainable.

4.1.5. Environmental Health and Safety Guideline of World Bank's IFC Group

The projects submitted by contracting authorities must also be implemented in compliance with the World Bank Group's Environmental, Health and Safety Guidelines (EHSG). These are reference technical documents, with general and specific examples of international good practices in the industry.

4.2. Policies of MoEF&CC, Government of India

4.2.1. 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 pre-cautionary approach

4.2.2. Compensatory Afforestation

As per Compensatory Afforestation Policy of MoEFCC, if forest land is to be diverted for non-forest purposes, compensatory afforestation should be carried out in equal area of private land or double the area of degraded forest land. The project proponent has to pay the compensatory afforestation cost and net present value of forest land to be diverted.

4.2.3. Compensatory Plantation

For each tree to be cut, ten trees should be planted as compensatory plantation, as per the Tree Act.

4.2.4. Ground Water Recharge

As per the MoEFCC guidelines, groundwater recharging structures should be constructed along the Rail Corridor wherever possible for ground water recharge.

4.3. National Environmental Acts and their Implications / Application in the BSRP Context

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.

4.3.1. 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, the Environmental Impact Assessment Notification, 2006 and the Amendments thereto and various other notifications.

4.3.2. EIA Notification, 2006

The EIA notification, 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 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 the Ministry of Environment, Forests and Climate Change (MoEF&CC) on the recommendations of an Expert Appraisal Committee (EAC) and Category "B" projects require prior environmental clearance from State or Union territory Level Environment Impact Assessment Authority (SEIAA) on the recommendations of a State or Union Territory Level Expert Appraisal Committee (SEAC). In the absence of a duly constituted SEIAA or SEAC, a category "B" project shall be treated as a Category "A" project. List of project/activities requires Environmental Clearance under EIA Notification, 2006 is presented in Schedule-I.

Since, Railway project is not listed in Schedule-I of EIA Notification, 2006, Environmental clearance is not required for suburban rail project including all its facilities and activities.

4.3.3. 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 forest land for non-forest purposes).

The project anticipates diversion of 18.6Ha of forest land for the construction of depot at Akkupete village near Devanahalli town. Hence, forest clearance under Forest (Conservation) Act, 1980 is applicable for the project. The normal expected time for obtaining the Stage-I Forest clearances is one year after submitting the duly filled application and relevant documents.

4.3.4. The Wildlife (Protection) Act, 1972

This act is promulgated to provide for the protection of wild animals, birds and plants and for matters connected therewith. The Wildlife Protection Act has allowed the government to establish a number of National Parks and Sanctuaries to protect and conserve the flora and fauna of the state. The provisions under this Act are as followed:

Section 9 of the Act mentions that no person shall hunt any wild animal specified in Schedule-I. The Act prohibits picking, uprooting, damaging, destroying, acquiring any specified plant from any forestland.

It bans the use of injurious substances, chemicals, explosives that may cause injury or endanger wildlife in a sanctuary. No alteration of the boundaries of a National Park shall be made except on a resolution passed by the Legislature of State. Destruction or damage of wildlife property in a National Park is prohibited.

Further, the Wild Life (Protection) Amendment Act, 2002 is proposed the setting up of National Board for Wildlife to promote the conservation and development of wild life and forests. This is a statutory body with the prime minister as Chairperson. The Act also proposed the setting up of State Boards for Wildlife with the Chief Minister as the Chairperson. The Act specifies that no alteration of the boundaries of a National Park by the State Government shall be made except on a recommendation of the National Wild Life Board.

As per the latest circular by Wildlife division of MoEF&CC, projects proposed to be developed inside the Protected area should be considered for approval from the Standing Committee of National Board for Wildlife (NBWL). The normal time required for obtaining the clearance is about one & half year from the date of submission of application with relevant documents.

BSRP corridors are not passing/abutting any protected area. Hence, provisions of this act is not applicable for this project.

4.3.5. The Water (Prevention & Control of Pollution) Act, 1974

This act is for the prevention and control of water pollution and the maintaining and restoring the wholesomeness of water. 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 Contractor has to obtain consent to establish for construction camps from Karnataka State Pollution Control Board as per the Water (Prevention and Control of Pollution) Act of 1974, since it involves discharge of waste water from construction camps.

4.3.6. The Air (Prevention & Control of Pollution) Act, 1981

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

The SPCB is empowered to set air quality standards and monitor and prosecute offenders under The Air (Prevention and Control of Pollution) Act, 1981. The Contractor has to obtain consent to establish for construction camps from Karnataka State Pollution Control Board as per the Air (Prevention and Control of Pollution) Act of 1981, since it involves operation of Diesel Generator Sets.

4.3.7. 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 m 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.

4.3.8. The Ancient Monuments and Archaeological Sites and Remains Act, 1958 and it's Amendment, 2010

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

ASI notified two archeologically important structures ie,. 1) Fort, Devanahalli and 2) Tippu Sulthan's Birth Place, Devanahalli are situated at an aerial distance of 228m and 271m respectively from the boundary of the protected monument to railway alignment of Corridor 1. As per the act, this zone is designated as Regulated Area (as mentioned above). Therefore, prior permission from the National Monument Authority, New Delhi should be obtained before commencement of any work. The normal expected time period for getting the permission is four months from the date of submission of application with all relevant documents.

4.4. State Environmental Acts and their Implications / Application in the BSRP Context

4.4.1. The Karnataka Preservation of Trees Act, 1976 and amendments

The above Act has put restriction on felling of trees in the State unless and until permitted by the Tree Officer. Any person desiring to fell a tree shall apply in writing to the tree officer for permission in that behalf. It further defines clauses for planting adequate number of trees, planting in place of fallen/destroyed trees, preservation of trees and adoption of trees. The proposed project requires felling trees. Hence, this act is applicable to the project.

4.4.2. The Karnataka Tank Conservation and Development Authority Act, 2014 and amendment Act, 2018

Aftermath of Honorable Supreme Court had nullified the National Green Tribunal's Order on "No development Buffer Zone", Karnataka Government has issued Government Order No. UDD 11 BMR 2017, Bengaluru dated 20.07.2019 stipulating the 'Buffer Zones' from the water bodies (Lakes and Rajakaluves) for taking up construction activities as below.

- A buffer zone of 30 m from the periphery of water body or Lakes;
- A buffer zone of 30 m from the edge of the primary Rajakaluves (Natural drains);
- A buffer zone of 15 m from the edges of the secondary Rajakaluves and
- A buffer zone of 10 m from the edges of the tertiary Rajakaluves

Since, small stretch of Corridor 1 & 4 abuts/ crosses some of the Lakes and Rajakaluves, a permission is required under the KTCDA act for implementation of project.

4.4.3. The Karnataka Ancient Monuments and Archaeological Sites and Remains Act, 1961

Archaeological site and remains means any area which contains or is reasonably believed to contain ruins or relics of historical or archaeological importance which have been in existence for not less than one hundred years. Under Section 4 (1) of the provisions of the KAMASR Act, 1961, identify and protects monuments, sites and remains of importance. There are six protected monuments identified under the act, which are falling Bengaluru Urban district such as 1) Basaveshwara Temple, 2). Bowring Institute, 3) Gavi Gangadhareshwara Temple, 4). KempeGowda's Watch Towers (4No.), 5). Mallikarjuna Temple and Boulder Inscriptions and 6) Kotte Venkataramanaswamy Temple. And in Devahanahalli Taluk of Bengaluru Rural District, there are 3 monuments such as 1) Inscriptions in Ardeshahalli, 2) VenugopalaKrisha Temple in Devanahalli, 3) Someshwara Temple and Inscriptions in Gangavara. However, none of the protected monuments falls adjacent to the project railway alignment. Hence, provisions of this act is not applicable for the project.

4.5. Other Legislations Applicable for BSRP Project

Environmental risks & issues during Suburban rail construction stage generally involve equity, safety, and public health issues. The railway construction agencies require complying with laws of the land, which include inter alia, the following.

- **Workmen's Compensation Act 1923** (the Act provides for compensation in case of injury by accident arising out of and during the course of employment);
- **Payment of Gratuity Act, 1972** (gratuity is payable to an employee under the Act on satisfaction of certain conditions on separation if an employee has completed 5 years);
- **Employees PF and Miscellaneous Provision Act, 1952** (the Act provides for monthly contributions by the employer plus workers);
- **Maternity Benefit Act, 1951** (the Act provides for leave and some other benefits to women employees in case of confinement or miscarriage, etc.);
- **Contact Labor (Regulation and Abolition) Act, 1970** (the Act provides for certain welfare measures to be provided by the contractor to contract labour);
- **Minimum Wages Act, 1948** (the employer is supposed to pay not less than the Minimum Wages fixed by appropriate Government as per provisions of the);
- **Payment of Wages Act, 1936** (it lays down as to by what date the wages are to be paid, when it will' be paid and what deductions can be made from the wages of the workers);
- **Equal Remuneration Act, 1979** (the Act provides for payment of equal wages for work of equal nature to Male and Female workers and not for making discrimination against Female employees);

- **Child Labour (Prohibition and Regulation) Act; 1986** (the Act prohibits employment of children below 14 years of age in certain occupations and processes and provides for regulation of employment of children in all other occupations and processes. Employment of child labour is prohibited in Building and Construction Industry);
- **Inter-State Migrant Workmen's (Regulation of Employment and Conditions of Service) Act, 1979** (the inter-state migrant workers, in an establishment to which this Act becomes applicable, are required to be provided certain facilities such as housing, medical aid, traveling expenses from home to the establishment and back, etc.);
- The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Cess Act of 1996 (all the establishments who carry on any building or other construction work and employs 10 or more workers are covered under this Act; the employer of the establishment is required to provide safety measures at the building or construction work and other welfare measures, such as canteens, first-aid facilities, ambulance, housing accommodation for Workers near the workplace, etc.);
- **Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996** (this rule provides for operation of on-site and Off-site Emergency Plans during chemical disaster)

4.6. International/National Conventions and their Implications/Application in the Sub-project Context

4.6.1. Ramsar Convention

The Ramsar Convention (The Convention on Wetlands of International Importance, especially as Waterfowl Habitat) is an international treaty for the conservation and sustainable utilisation of wetlands, i.e., to stem the progressive encroachment on and loss of wetlands now and in the future, recognising the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value. It is named after the town of Ramsar in Iran.

The convention was developed and adopted by participating nations at a meeting in Ramsar on February 2, 1971, and came into force on December 21, 1975. The Ramsar List of Wetlands of International Importance now includes 2,455 sites, of which 64 are in India with a surface area of 12,50,361 Ha. However, none of the Ramsar sites are situated within 5 km from the project corridors.

4.6.2. World Heritage Convention

This is a convention concerning the protection of the world cultural and natural heritage, which was ratified on 10 July, 1997. The convention aims to promote cooperation among nations to protect all forms of natural and cultural heritage that are of such outstanding universal value that their conservation is of concern to all people. UNESCO adopted the convention in 1972. At present 144 countries are parties to it. The project corridors does not passes through any of the internationally recognized by UNESCO as World Heritage Site.

4.7. Summary of Applicable Clearance/Permission Required for BSRP

Summary of clearances / permissions required for the project Corridors is given below.

Table 4.2. Environmental Permits / Approvals Required for the BSRP Corridors

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
Pre-Construction Phase						
1.	Forest Clearance under Forest (Conservation) Act	Forest (Conservation) Act, 1980 and amendments	Diversion of forest land for Akkupete Depot	PIA/EMU	8-12 months	Forest Department & MoEFCC
2.	Permission for felling of trees and compensatory Afforestation	The Karnataka Preservation of Trees Act, 1976 and amendments	Felling of trees along proposed BSRP alignment & Stations	PIA/EMU	6-8 months	BBMP Forest wing/Forest Department
3.	Prior permission to be obtained under The Ancient Monuments and Archaeological Sites and Remains Act	The Ancient Monuments and Archaeological Sites and Remains Act, 1958 and it's Amendment, 2010	Construction of Station and Rail alignment at Devanahalli	PIA/EMU	4-6 months	National Monument Authority
4.	Construction Railway within buffer zone of Lakes	Karnataka Tank Conservation and Development Authority Act, 2018	Crossing/ abutting in buffer zone of Lakes	PIA/EMU	2-3 months	Karnataka Tank Conservation and Development Authority
5.	Consent to Establish & Operate under Air and Water Acts	Water(Prevention and Control of Pollution)Act, 1974 & Air(Prevention and Control of Pollution) Act,1981	Railway Locomotive Workshop	PIA/EMU	2-3 months	Karnataka Pollution Control Board
6.	Building Permissions for Depot, stations and property development	Respective Building bylaws	Before Construction	PIA/EMU	2-3 months	BBMP / Municipal Corporation
7.	Utility/traffic diversion	Respective Acts and Rules	Before Construction	PIA/EMU	2-3 months	Local Offices of respective Authorities such as RTO, BESCOM,

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
						BWSSB, Telecom Dept., etc.
8.	Consent to Establish construction yards, labour camps, stations and Depot (since non-residential)	Water(Prevention and Control of Pollution)Act, 1974 & Air(Prevention and Control of Pollution) Act,1981	Before Construction	Contractors/ PIA/EMU	2-3 months	Karnataka State Pollution Control Board (KSPCB) and Development Authority for land use clearance
9.	Sites to establish labour camps, pre-casting and material yards	Air(Prevention and Control of Pollution) Act,1981	Before Construction	Contractors/ PIA/EMU	2-3 months	BBMP / Municipal Corporation
		Land use Master Plan and DC&PR	Before Construction	Contractors/ PIA/EMU	2-3 months	
Construction Phase						
10.	Consent for Establishment and Operation of Hot Mix Plants (HMP), Crushers, Batching Plants, etc.	Water(Prevention and Control of Pollution)Act, 1974 & Air(Prevention and Control of Pollution) Act,1981	Construction	Contractors	2-3 months	Karnataka State Pollution Control Board (KSPCB)
11.	Consent for Establishment of labour camps		Construction	Contractors	2-3 months	BBMP / Municipal Corporation
12.	Permission for drawl of ground water for construction (not recommended)	Environment (Protection) Act, 1986	Construction	Contractors	2-3 months	Regional Director, Central Ground Water Board and Municipal Corporation
13.	Permission to store and Authorization for Disposal of Hazardous Waste	Hazardous Waste(Management and Handling and trans boundary movement) Rules, 2016	Construction	Contractors	2-3 months	Karnataka State Pollution Control Board (KSPCB)

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
14.	Consent for disposal of waste water from construction sites and sewage from labour camps	Water (Prevention and Control of Pollution) Act, 1974	Construction	Contractors	2-3 months	Karnataka State Pollution Control Board (KSPCB)
15.	PUC certificate for vehicles for construction	Environment (Protection) Act, 1986	Construction	Contractors	1-2 months	Transport Department of Karnataka
16.	Labour employment, safety, health/welfare measures and labour license	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Construction	Contractors	2-3 months	District Labour Commissioner
17.	Permission for management of C&D waste and muck	Construction and Demolition Waste Management Rules, 2016	Construction	Contractors	2-3 months	BBMP/Municipal Corporation and Karnataka State Pollution Control Board (KSPCB)
Operation Phase						
18.	Consent for Operation to Operate Depot	Environment Protection Act, 1986	After construction	PIA /EMU	2-3 months	Karnataka State Pollution Control Board (KSPCB)
19.	Installation and operation of DG sets at stations	Air (Prevention and Control of Pollution) Act, 1981	After construction	PIA /EMU	2-3 months	Karnataka State Pollution Control Board (KSPCB)

The project does not have any risks and impacts on Protected areas, MoEFCC notified Critically Polluted Area, UNESCO's World Heritage sites and Ramsar Wetlands. However, project requires forest land diversion, Archaeological clearance, CFE and CFO from KSPCB and tree felling prior to construction stage. Except Archaeological clearance, the remaining permissions are to be obtained from State agencies. At present, applications for Forest Clearance (for diversion of 18.6Ha of forest land for Akkupete Depot), Archaeological clearance and Tree felling permission (for Corridor 2) has been submitted.

Forest Clearance: As mentioned above, application for diversion of forest land has been submitted in online web-portal. The application was accepted by Nodal Officer (forest Conservation) for its completion and asked to submitted the hardcopy of the application to Deputy Conservator of Forest, Bengaluru Rural District for field verification and further process. Accordingly, hard copy of the Forest

Clearance application was submitted to Deputy Conservator of Forest, where verification of forest land & compensatory afforestation land and enumeration of trees are under progress. Further to obtain Stage-I Forest Clearance requires 6 to 8 months and Stage-II Forest Clearance requires 3-4 months.

Tree Felling Permission: For Corridor 2, Application for felling of 661 trees has been submitted. Out of which, permission for translocation of 58 trees and felling of 268 trees has been issued by the BBMP forest wing. Verification of remaining trees is under progress by the department. Further, tree felling application for 1,430 trees and 764 trees for Corridor 2 has been submitted.

Application for tree felling permission for remaining corridors will be submitted as and when the executive agency was appointed by K RIDE.

Archaeological clearance: An dully filled application form has been submitted to Archaeological department for obtaining clearance for ASI monuments located near Devanahalli Station on Corridor 1. A joint site visit has been completed and obtaining clearance is under progress.

Status on Permissions/approvals obtained by Contractor for Corridor 2: Status of clearances obtained by the Contractor prior to contruction is presented in Section 3.6.8.

Further , project will have potential risks & impacts on air, noise, vegetation, cultural heritage and health and safety issues to labours and community establishment during construction phase. Considering the above, project is categorised as “A Category - High Environmental and Social Risks” under KfW’s environmental and social safeguard policy. As per EIB’s Environmental and Social Standards, the project is categorized as “High Risk”. Hence, project requires detailed Environmental and Social Assessment.

4.8. Comparison of National Environmental Framework and WB’s Environmental & Social Framework, 2018

The following **Table 4.3** summarises a comparison between National statutes and legislation on Environmental and Social and World Bank’s ESF and identifies the gaps if any

Table 4.3. Comparison of National Environmental Policy and Regulations and Environmental & Social Framework, 2018

Sl. No.	WB's ESS,	EIB's ESS	Description	Equivalent National Environmental Policy and Regulations	Gaps	Addressal of Gaps
1.	ESS-1	ESS-1	Assessment and Management of Environmental and Social Risks and Impacts	Environmental Impact Assessment Notification 2006, and its subsequent amendments	The Sustainability Guidelines of KfW Development Bank stipulates that all the project seeking funding from KfW & EIB, EIA is required to be prepared in accordance with World Bank's ESS 1 & EIB's ESS 1.	EIA & EMP is prepared in accordance with ESS-1
2.	ESS-2	ESS-8	Labour and Working Conditions	• National Labour Act, 1970, • The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 • Contract Labour (Regulation and Abolition Act), 1970 • Minimum Wages Act, 1948 • Child Labour (Prohibition & Regulation) Act 1986 • Inter-state migrant worker 's (Regulation of Employment and Conditions of Services) Act, 1979	The national legal provisions broadly cover all the requirements as per ESS-2 & EIB's ESS 8 except related to community workers, forced Labours, third party or supply chain workers and function GRM for different types of workers.	To address the mentioned gap, procedures for labour management has been prepared in the EMP by referring IFC's Workers accommodation guidelines, IFC's Railway specific EHS, EIB's ESS 8 and Labour management procedures.
3.	ESS-3 and EHS Guidelines of IFC	ESS-3	Resource Efficiency and Pollution Prevention and Management	• Environmental protection Act, 1986 and subsequent amendments • Environmental Impact Assessment Notification- 2006, 14th Sep-2006 and amendments	Existing national regulations directly and indirectly covers all aspect of ESS3 including resource efficiency, pollution prevention, waste management and climate change. Further draft National	The Resource efficiency and pollution prevention have been covered during analysis of risks and impacts and the required mitigation measures has been formulated in accordance with ESS-3 & EHS guidelines of IFC & EIB for incorporating in EMP.

Sl. No.	WB's ESS,	EIB's ESS	Description	Equivalent National Environmental Policy and Regulations	Gaps	Addressal of Gaps
				• Air (Prevention and Control of Pollution) Act, 1981; • Water (Prevention and Control of Pollution) Act, 1974, • The Noise Pollution (Regulation & Control) Rules, 2000 • National Resource Efficiency Policy, 2019 (Draft) Notification for use of fly ash, 2003. • Solid Waste Management Rules, 2016 • Hazardous and other Wastes (Management and Trans-Boundary Movement) Rules, 2016. • Batteries (Management and Handling) Rules, 2001 • Central Motor Vehicle Act 1988 and Central Motor Vehicle Rules 1989 • The E-Waste (Management) Rules, 2016, • Plastic waste Management Rules, 2016 • Construction & Demolition, Waste Management Rules, 2016. • Karnataka Tank Conservation and Development Authority Act, 2018	Resource Efficiency Policy, 2019, will provide comprehensive policy to further fill the gap of ESS3, if any Gaps exist between National Air quality standards, Water pollution limits and respective interim targets and guideline values of EHS Guidelines.	
4.	ESS-4	ESS-9	Community Health and Safety	No Specific regulation for Community Health but safety regulations exists	Gaps exist in national statutes/ policies on Community Health and Safety.	To address the community health & safety issues of the project WB's ESS-4 and EIB's ESS 9 including EHS guidelines

Sl. No.	WB's ESS,	EIB's ESS	Description	Equivalent National Environmental Policy and Regulations	Gaps	Addressal of Gaps
				however these aspects have been covered through different regulations. • Air (Prevention and Control of Pollution) Act, 1981; • Water (Prevention and Control of Pollution) Act, 1974, • The Noise Pollution (Regulation and Control) Rules, 2000 • Guidelines on Traffic Management in Work Zones IRC: SP:55 – 2014, • Solid Waste Management Rules, 2016 • Hazardous and other Wastes (Management and Trans-Boundary Movement) Rules, 2016. • Construction & Demolition Waste Management Rules, 2016		of IFC has been followed and accordingly EMP has been formulated.
5.	ESS-5	ESS-6	Land Acquisition, Restrictions on Land Use and Involuntary Resettlement	• Right to Fair Compensation and Transparency in land Acquisition, Rehabilitation and Resettlement (RFCTLARR) Act, 2013 and its amendments • Karnataka Industrial Areas Development Act, 1966 (KIADA)	Cut-off dates for non-title holders and valuation of structure without depreciation.	A Project specific Resettlement Policy Framework has been developed to address the gap. The policy of BMRCL, which is being implemented may be considered for this project as well.
6.	ESS-6	ESS-4	Biodiversity Conservation and sustainable Management of	• Biological Diversity Act, 2002 • Wildlife Protection Act 1972, • The Forest (Conservation) Act, 1980	There is no Gap at policy level for World bank's, EIB's and Government of India. Broadly both cover all the aspects	-

Sl. No.	WB's ESS,	EIB's ESS	Description	Equivalent National Environmental Policy and Regulations	Gaps	Addressal of Gaps
			Living Natural Resources		related to biodiversity Conservation	
7.	ESS-7	ESS-7	Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities	Not applicable	Not applicable	-
8.	ESS-8	ESS-10	Cultural Heritage	• Ancient Monuments and Archaeological Sites and Remains Act, 1958 and Archaeological. Sites and Remains (Amendment and Validation) Act, 2010 • The Karnataka Ancient Monuments and Archaeological Sites and Remains Act, 1961	There is no Gap at policy level	Mitigation measures has been incorporated in EMP.
9.	ESS-9	ESS – 11	Financial-Intermediaries	Not applicable	Not applicable	-
10.	ESS-10	ESS-2	Stakeholder Engagement and Information Disclosure	• Environmental Impact Assessment Notification- 2006 and its subsequent amendments • Right to information Act 2005	None at policy level. Broadly both cover all aspects. EIA Notification provide provisions for conducting Public Hearing and disclosure of documents in projects requiring Environmental clearance. However, Environmental Impact	WB's ESS-10 and EIB's ESS2 have been followed for preparation of EIA report.

Sl. No.	WB's ESS,	EIB's ESS	Description	Equivalent National Environmental Policy and Regulations	Gaps	Addressal of Gaps
					Assessment Notification- 2006 is not applicable to the project	
11.		ESS-5	Climate Change	• National Action Plan for Climate Change	Gaps exist in national statutes/ policies on Climate Change	Under the national action plan, there is no defined method for estimating the Carbon foot print and GHGs. Hence proven methods laid out by KfW and EIB were adopted to estimate CO2 and GHGs.

4.9. Existing Institutional Arrangement

A brief analysis of the institutional framework for environmental management in India and Karnataka which is relevant for the project is done in this section. The objective of this analysis is to understand the role of various agencies in environmental management, with specific reference to the present project. A brief discussion on the various institutions involved and their level of responsibilities in project implementation is presented in the following sections.

4.9.1. Ministry of Environment, Forests and Climate Change (MoEF&CC)

The MoEF&CC is a nodal ministry at national level. It has set up offices within each region which is responsible for the collection and furnishing of information relating to EIA of projects, pollution control measures, methodology and status of legal and enforcement measures and environmental protection in special conservation areas such as wetlands, and other biological reserves. The proposed subproject falls under the jurisdiction of the Regional office of MoEF&CC, Bengaluru

4.9.2. Central Pollution Control Board (CPCB)

It is a statutory authority attached to the MoEF&CC located at New Delhi. The main responsibilities of CPCB include, planning and implementation of water and air pollution programmes; advising the Central Government on water and air pollution programmes; setting air and water standards and coordinating with the SPCBs.

4.9.3. Karnataka State Pollution Control Board (KSPCB)

The KSPCB is the government agency responsible for ensuring the compliance to relevant standards related to discharges to the environment. The following activities of the KSPCB include, planning and executing state level air and water quality initiatives; advising the state government on air, water and industry issues; establishing standards based on National Minimum standards; enforcing and monitoring of all activities within the state under the Air Act, the Water Act and the Cess Act.

4.9.4. K RIDE's Environmental Cell

K RIDE has taken extra mile efforts to protect and preserve the environment and to make the project environment and people friendly. In order to deliberate on green initiatives, identify best practices, explore green funding options and coordinate internal/external stakeholders on environment – related issues, it has established an environmental cell. The cell has headed by Executive Director, (Civil) and supported by three Assistant General Managers and one Senior Manager to address and to explore the green initiatives and resolve environmental issues raised from time to time. It will also undertaken the environmental and safety tasks assigned by the Competent Authority. The cell will also appraise key developments and initiatives to Director, BD/Finance & MD, K RIDE periodically. The present Environmental Cell is responsible for applying for Statutory clearances, monitoring of design activities w.r.to environment and safety aspects and handling the queries raised by competent authority/ statutory bodies, till K RIDE establishes EMU for the project.

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Chapter 5. Baseline Environmental Profile

5.1. Background

Collecting the baseline environmental status of the project study area helps to predict the magnitude of impacts that are likely to be caused due to the proposed improvements of the BSRP corridors on different environmental components of the project study area. In order to assess the baseline environmental status of the project study area, field visits were conducted by the Consultant. This involved field inspection at all the sensitive locations, collection of secondary data for all the environmental components & discussions with the officials of various depts, NGOs & local public.

Based on the existing environmental scenario, potential impacts of Suburban rail improvement will be identified and accordingly management plan will be proposed in forthcoming sections. The baseline environmental conditions will help in comparing and to monitor the predicted negative and positive impacts resulting from the project during pre-construction, construction and operation phases.

As part of reconnaissance study, a desktop review of the alignment was carried out to assess the presence of Environmental sensitive features in the project study area. Karnataka GIS web-portal, google earth & available departmental resources were used to outline the extent of study for the project. Accordingly, the study of environmental profile of the project was considered at three levels.

Environmental assessment includes baseline monitoring surveys, environmental investigations for sensitive receptors, public interactions were carried out within direct impact zone of the proposed project facilities (includes BSRP railway alignment, Stations, Depots). Further, in order to comply with State and National Ancient monument and Archaeological Sites Acts, studies were considered within 300m on either side from the proposed project facilities. Further, 5km buffer area was considered (indirect impact zone) for proposed project facilities to assess the major environmental sensitive features such as protected area, Ramsar notified wetlands, MoEFCC identified critically polluted sites, etc,.

A well-structured formats were used to gather baseline environmental data such as environmental and social sensitive features, tree enumerations, biodiversity, landuse and public opinion within direct impact zone (30m on either side of the railway alignment) of the project alignment. A walkthrough survey was conducted all along the proposed BSRP alignments to record the baseline environmental data. Details of forests, protected areas, notified wetlands, critically polluted areas were plotted within indirect impact zone (5Km on either side of the alignment) using GIS software.

As part of the study, baseline environmental monitoring was conducted for environmental attributes such as air, noise, vibration, water (surface & ground water) and soil. The sampling and monitoring locations were identified based on the land use type, topography and the sensitive receptors present along the BSRP corridors. Baseline environmental monitoring (air, noise, water (surface & ground water) and soil) was conducted through NABL accredited land M/s Enviro Solutions & Labs, Coimbatore in the month of March & April 2022. Ambient vibration study was conducted through M/s. Esperto Novero Inspection and Engineering Consultance (ENIECO) Pvt. Ltd. between 23rd March, 2022 to 5th April, 2022. Google earth map showing monitoring locations along the BSRP corridors are presented between **Figure 5.1** and **Figure 5.4.** Details of corridor wise sampling numbers of the above environmental indicators/attributes are tabulated in following table.

Table 5.1. Details of Baseline Environmental Monitoring Sampling for BSRP Corridors

Project Corridors	Environmental Monitoring Sampling for Four Suburban Rail Corridors					
	Air	Noise	Vibration	Surface Water	Ground Water	Soil
Corridor 1	12	20	3	7	5	4
Corridor 2	8	12	3	8	3	3
Corridor 3	12	16	3	10	6	4
Corridor 4	15	24	3	12	9	5
Total	**47**	**72**	**12**	**37**	**23**	**16**

In addition to the baseline environmental data gathering, secondary data were collected from various sources of government departments for physical environment (district gazette notification, ground water booklet, Industrial profile of the district, report on State's climate Action plan, meteorological reports, etc.,), biological environment (Forest management plan, notification on Protected Areas, reports on Flora & Fauna diversity, etc.,), socio-economic environment (district gazette notification, census data, district's statistical booklet, etc.,) were collected and studied.

Consultation was another source of information to explain local conditions like submergence, recent floods, noise exposure, cultural heritages, historical monuments etc. However, these consultation results were largely based on short term memories like information on floods, submergence but still it was helpful in comparing secondary information.

An interaction with Pollution control board officials, Ground water dept. Forest officials, Lake authority, Archaeological department, Tree officer at BBMP forest wing, southwestern railway officials etc., were undertaken to gather the information on existing environmental conditions of the project study area.

Baseline environmental profile of the project was studied for six environmental components to understand the sensitivity of the project corridors. These six environmental components are i) land environment, ii) water environment, iii) air environment, iv) noise environment, v) biological environment and vi) socio-economic environment. Under these six environmental components, various environmental parameters such as topography, climatic condition, soil characteristics, landuse, hydrology, air quality, noise level, water quality, flora & fauna and socio-economic condition were considered. A 5 km buffer map was prepared on Survey of India Toposheet to assess the major environmental features present along the BSRP Corridors is given as **Annexure 5.1.** This Chapter presents a detailed profile of the existing environment and social sensitivity in and around the project corridors. The project alignments spread across all parts of Bengaluru city of Karnataka State. Predominantly in central and northern part of the district. Detailed list of Environmental and social features present along BSRP corridors are presented in **Annexure 5.5.**

Strip plan for the project corridors were prepared on alignment plan comprising details of all the environmental features and sensitive receptors in the RoW such as trees, Reserve Forests, sanctuaries/ National Parks, rivers, lakes/ ponds, religious structures, archaeological monuments, Natural Habitats, schools, colleges, institutions, hospitals, Rajakaluve / irrigation canals, other sensitive structures along the four corridors of BSRP. The environmental features has been clearly recorded on the strip map indicating their distance from the centre line of the proposed alignment. Strip plan for the BSRP project corridors are presented as **Annexure 5.2.** Key Environmental Features present along BSRP project corridors are presented as **Annexure 5.3.**

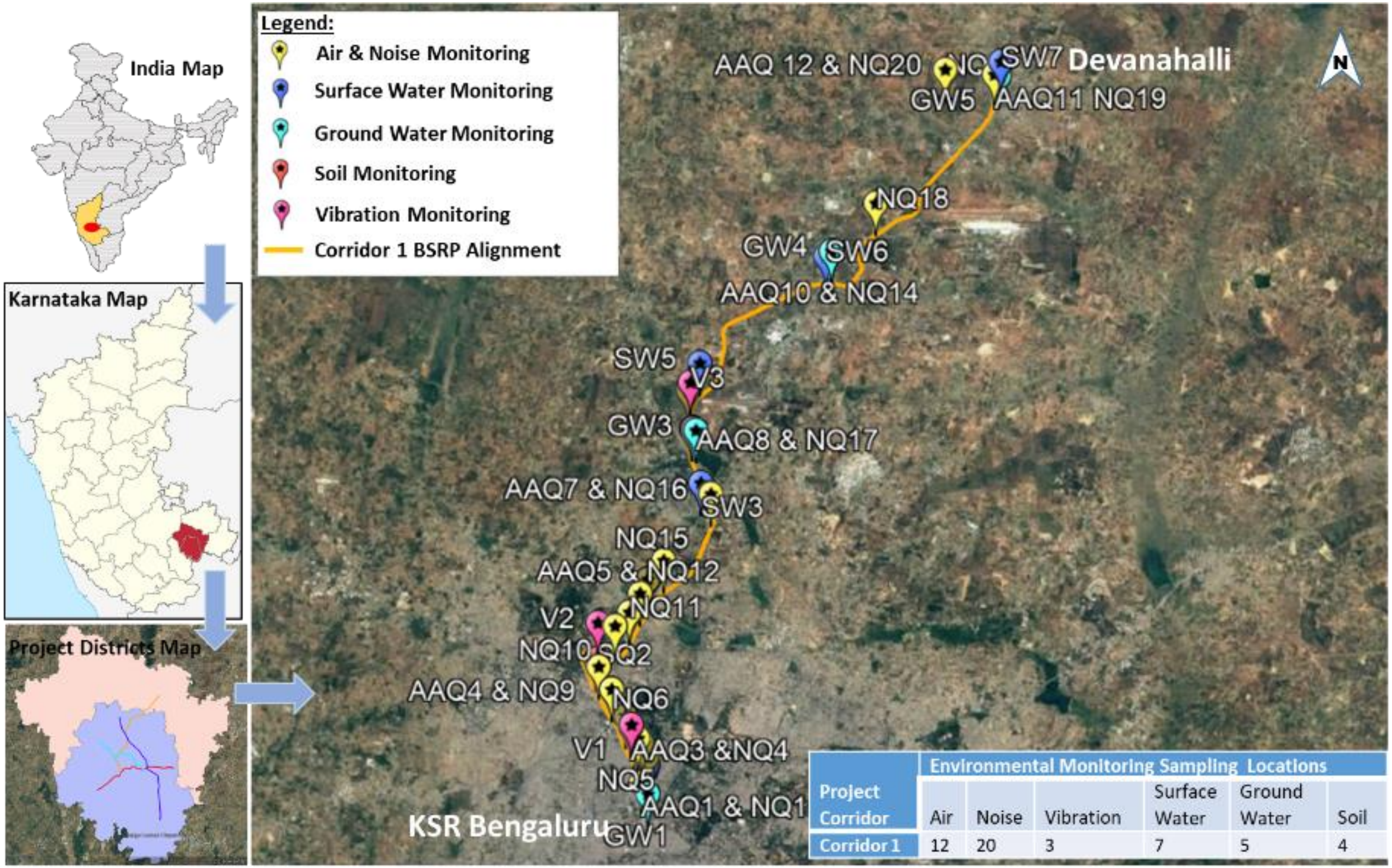
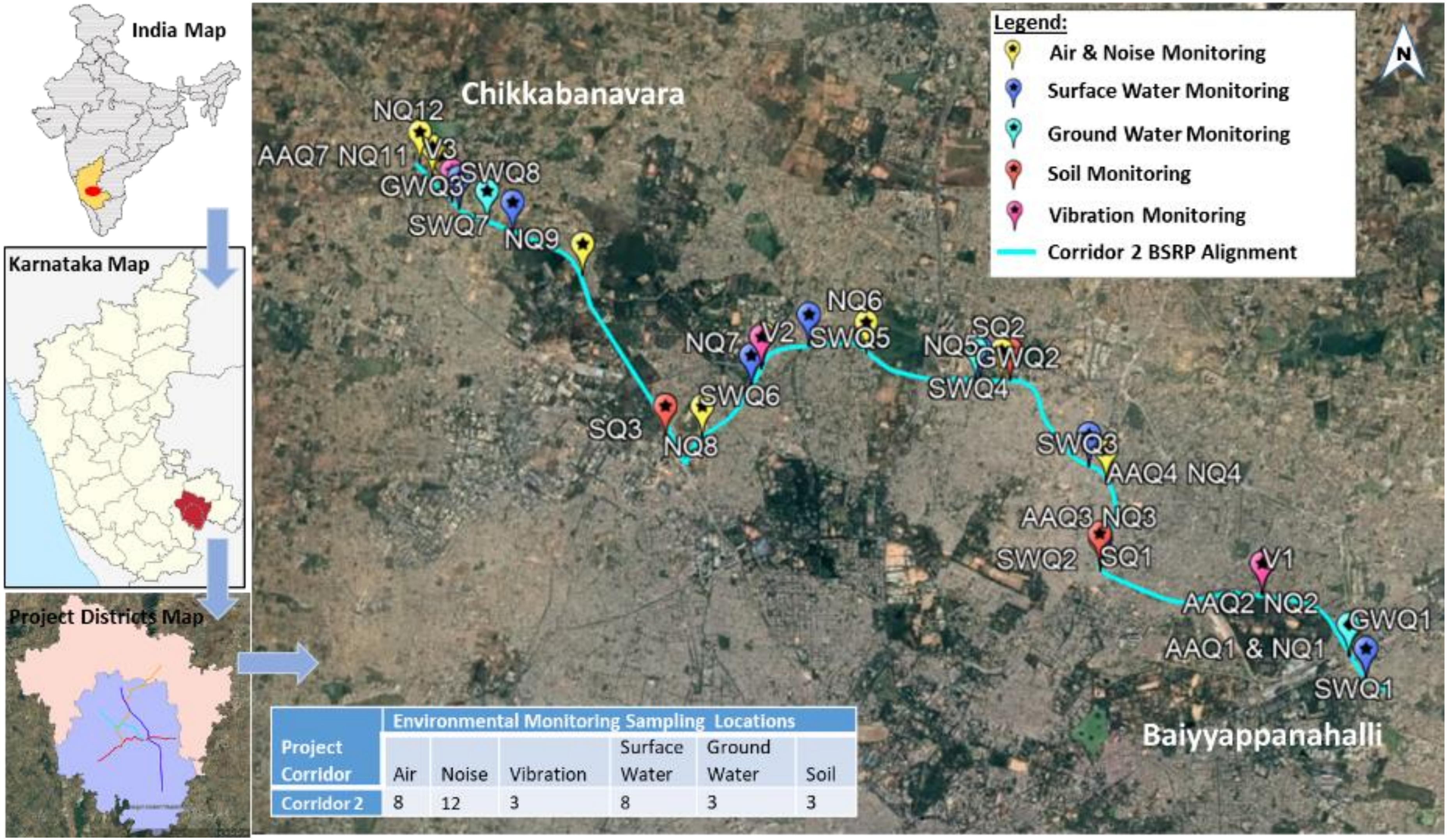


Figure 5.1. **Baseline Environmental Monitoring Locations for Corridor – 1: KSR Bengaluru City to Devanahalli**



Project Corridor	Environmental Monitoring Sampling Locations					
	Air	Noise	Vibration	Surface Water	Ground Water	Soil
Corridor 2	8	12	3	8	3	3

Figure 5.2. Baseline Environmental Monitoring Locations for Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara

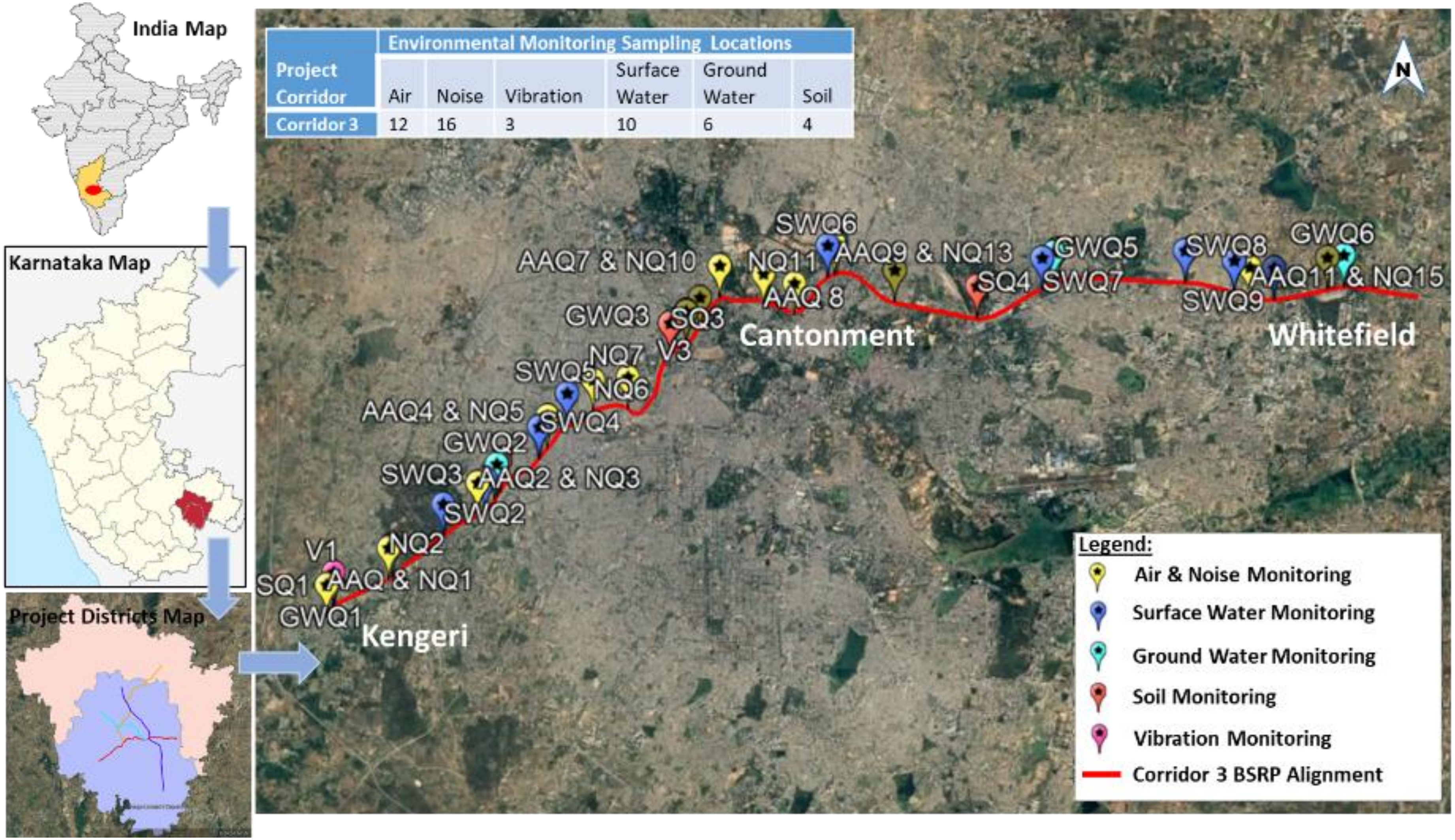


Figure 5.3. Baseline Environmental Monitoring Locations for Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)

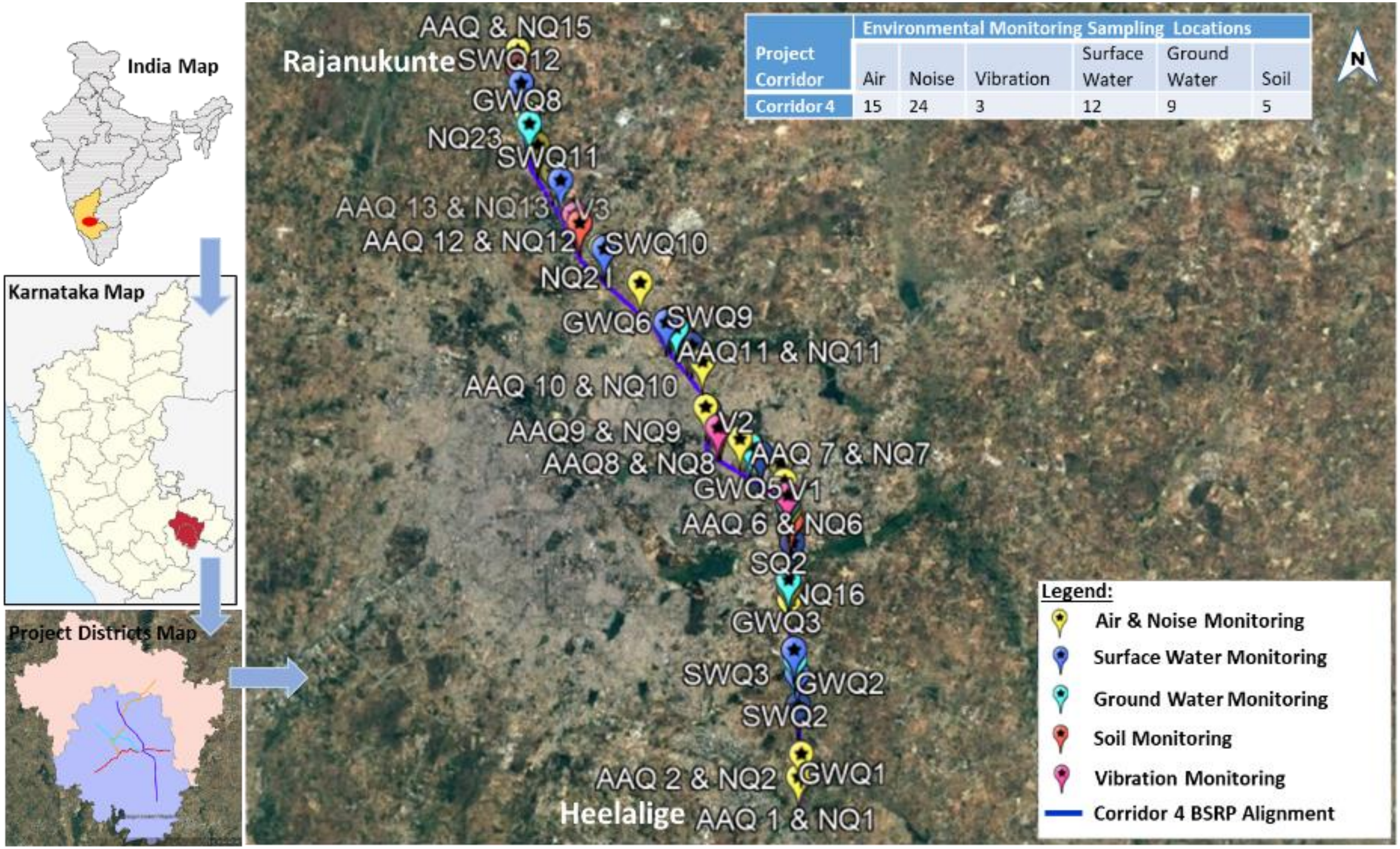


Figure 5.4. Baseline Environmental Monitoring Locations for Corridor – 4: Heelalige to Rajanukunte

5.2. 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 a strip of land on either side of the centre line of the proposed alignment. 30 m width on either side of the proposed suburban railway alignment, Stations and Depots has been adopted for detailed inventory of environmental features.
- **Indirect Impact Zone (IIZ):** This project study area consists of a strip of land of 5 km width on either sides of the proposed rail alignment. Here, the existence of sensitive features was identified and possible impacts on them due to the project corridors were assessed.
- **Cumulative Impact Zone (CIZ):** It is the incremental impact area, which is site/location specific, where the proposed project is overlapping with other reasonably foreseeable or underway projects which may occur in the proposed suburban railway project vicinity.

The project corridors fall in two districts namely Bengaluru Urban District and Bengaluru Rural District in the State of Karnataka.

5.3. Data Sources

Recent data on baseline environment component were collected from various sources of government departments, District and Taluk offices, literature and publications, websites etc. The general information of each district was collected from district handbook and their official websites. Details regarding the ground water were obtained from the reports of Central Ground Water Board. All meteorological data such as rainfall, temperature, relative humidity, wind speed and wind direction were collected from IMD websites and other research publications. Baseline environmental monitoring programme for various environmental attributes was conducted during February-March, 2014 and the details thereof is presented in subsequent sections. Baseline environmental monitoring was conducted as per the guidelines of CPCB and RDSO. Enviro Solutions & Labs, Coimbatore an NABL accredited laboratory was engaged to conduct the baseline environmental monitoring for the project.

5.4. Data Gaps/Constraints, Adequacy of Predicted Method and Assumptions and Uncertainties

In order to collect the forest land details from Bengaluru Urban forest division, a letter vide letter no. K RIDE/Civil/ESIA/2021-22/10 dated 02.12.2021 was written by K RIDE to Bengaluru Urban Forest Dept. requesting to provide the forest land details including forest map for their jurisdiction.

Against to the request, forest department provided the forest administrative map of the Bengaluru Forest division, which provides only the divisional and range boundaries. Environmental specialist and team visited forest department and requested Deputy Conservator of Forest (DCF) to provide Bengaluru Forest Department forest map. However, DCF informed that, they don't have any ready map available and suggested to refer topo-sheet prepared by Survey of India for forest land. Accordingly, consultant considered forest land present in SOI topo-sheet for the study.

As there was no data available in the Feasibility Report for water demand, number of labours engaged during construction and operation phase, waste water generation, locations of associated facility (construction/labour camps, batching mix plant, disposal sites, etc,) and waste generation, an projection/estimation was made for these items. All the Environmental issues shall be taken care including waste disposal arrangements as per EHS policy and guidelines.

Per capita water demand, generation of domestic wastewater, municipal solid waste from labour camp for labour engaged in project work was estimated as per the CPHEEO Manual and it is presented in Section 8.6.9 and 8.7.7.

Affected trees felling cost and compensatory afforestation cost was prepared from Common Forest Schedule of Rates 2022-23 and schedule of rates of Karnataka Public Work Department for year 2022-23.

As part of Baseline environmental profile, a detailed baseline environmental monitoring was conducted for the project corridors. Environmental Attributes such as Air, Noise, Surface water, Ground Water, Vibration, Soil quality monitoring was conducted to establish ambient pollution level/standard for the project. **Table 5.1** presents the number of monitoring locations undertaken to establish the baseline environmental conditions of the project.

Matrix method was adopted to assess the risks and impacts of the projects. Matrix method was adopted to assess the environmental risks and impacts for various environmental attributes including climate change assessment, social & economic issues, labour health and safety, cultural heritage, community health and safety, etc. Matrix method was used to evaluate the nature of impacts, extent of impacts, magnitude, variability/changeability, duration and localization of impacts. Subsequently, Environmental Management Action Plan and Environmental Monitoring Plan was prepared to comply with National, EIB and World Bank Standards.

As part of the risk and impact study, Noise modelling was undertaken to understand the potential noise level during project horizon period. Railway Noise Calculation Standards – FTA/FRA-HGST (2005) Standards were used to compute the rail noise with the help of SoundPLAN 8.2.

Vibration levels associated with project operations (i.e., train passing by) will be largely imperceptible. Further, during public interaction/FGDs and institutional consultation, there was no concerns raised from public/department officials on vibration issues due to running of existing railway alignment.

As per the study, there are no fragmentation of natural habitat and loss/impact on biodiversity of the natural habitat. Hence, risk and impact identification and mitigation measures of the biological environment is limited to loss of trees, impact of avifauna and micro biota, which are temporary and localised impact on fauna.

5.5. Land Environment

The components of land environment discussed in this section includes -

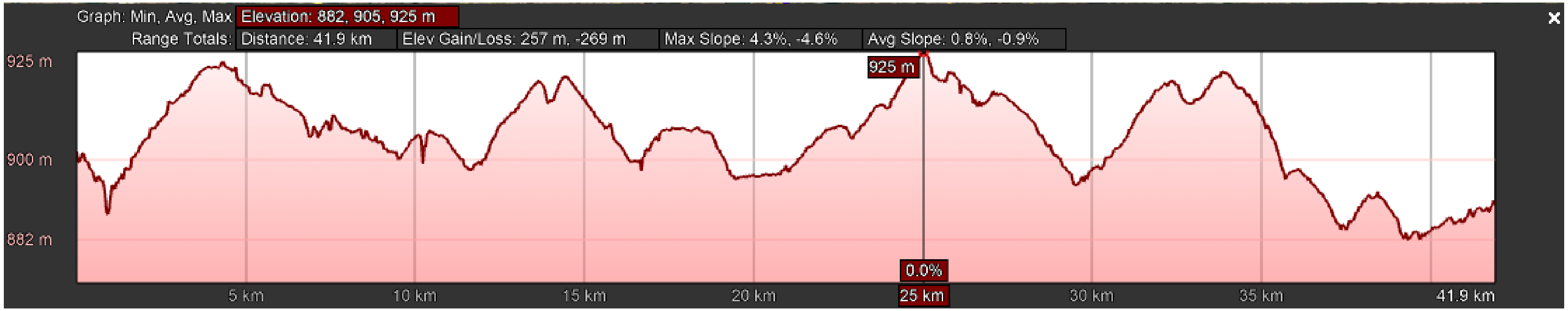
- Geography and Topography
- Geology and Minerals
- Land Use
- Soil characteristics

5.5.1. Geography and Topography

Bengaluru Urban district lies in the heart of Mysore Plateau of south Indian peninsula, which located at an elevation of 920m amsl. The district is geographically positioned at 12.97°N 77.56°E and covers an area of 2190 sq.km. The district is bounded by Bengaluru rural district in the East, West and North except in southeast, where the district is bounded by Krishnagiri district of Tamil Nadu.

The district is gradually sloping towards south to south-east part forming pediplains intercepted with hills all along the western part. Southern part of the district is more undulating coupled with small hillocks compared with others parts.

Bengaluru Rural district is located in the south-eastern corner of Karnataka State covering a geographical area of 2266 sq. km between the latitudinal parallels of 13° 29 .624' N and 13° 0.139' N and between the longitudinal meridians of 77° 55.151' E and 77°10.385'E. The district is bounded by Tumakuru district on the northwest, Chikkaballapura district on the north, Kolar district on the east, Bengaluru Urban district on the south, and Ramanagar district on the southwest touches Tamil Nadu state on south-east. Northern and eastern part of Bengaluru city is located in higher elevation compared with western and southern part. This is evident from the Elevation profile of the BSRP corridors presented in **Figure 5.5**. Slope and relief profile of the project region is presented in **Figure 5.6.** In general, proposed BSRP alignments are located in plain to undulating terrain condition.



Corridor – 1: KSR Bengaluru City to Devanahalli

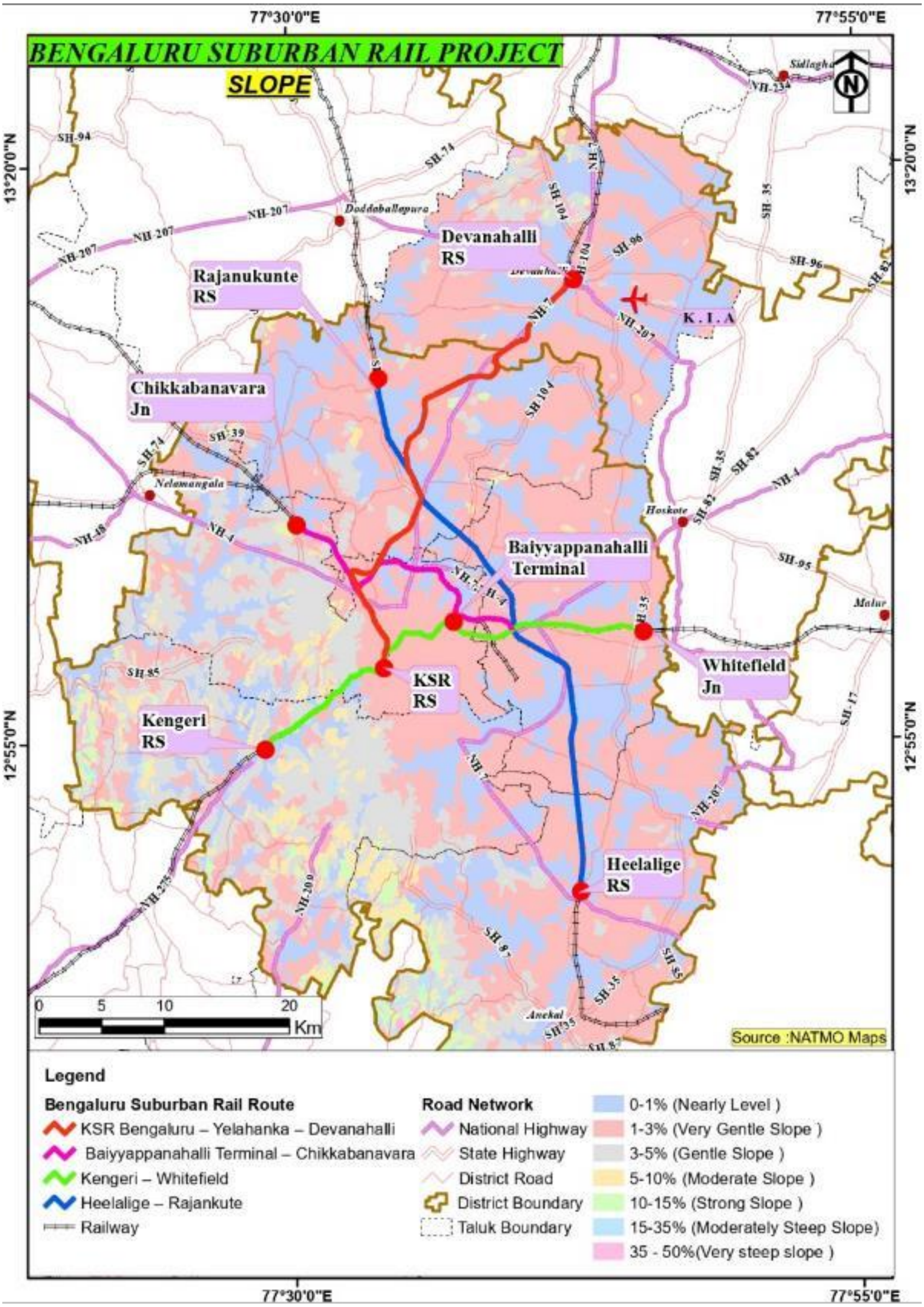
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara

Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)

Source: Google Earth

Corridor – 4: Heelalige to Rajanukunte

Figure 5.5. Elevation Profile the BSRP Corridors



Source: National Atlas and Thematic Mapping Organisation

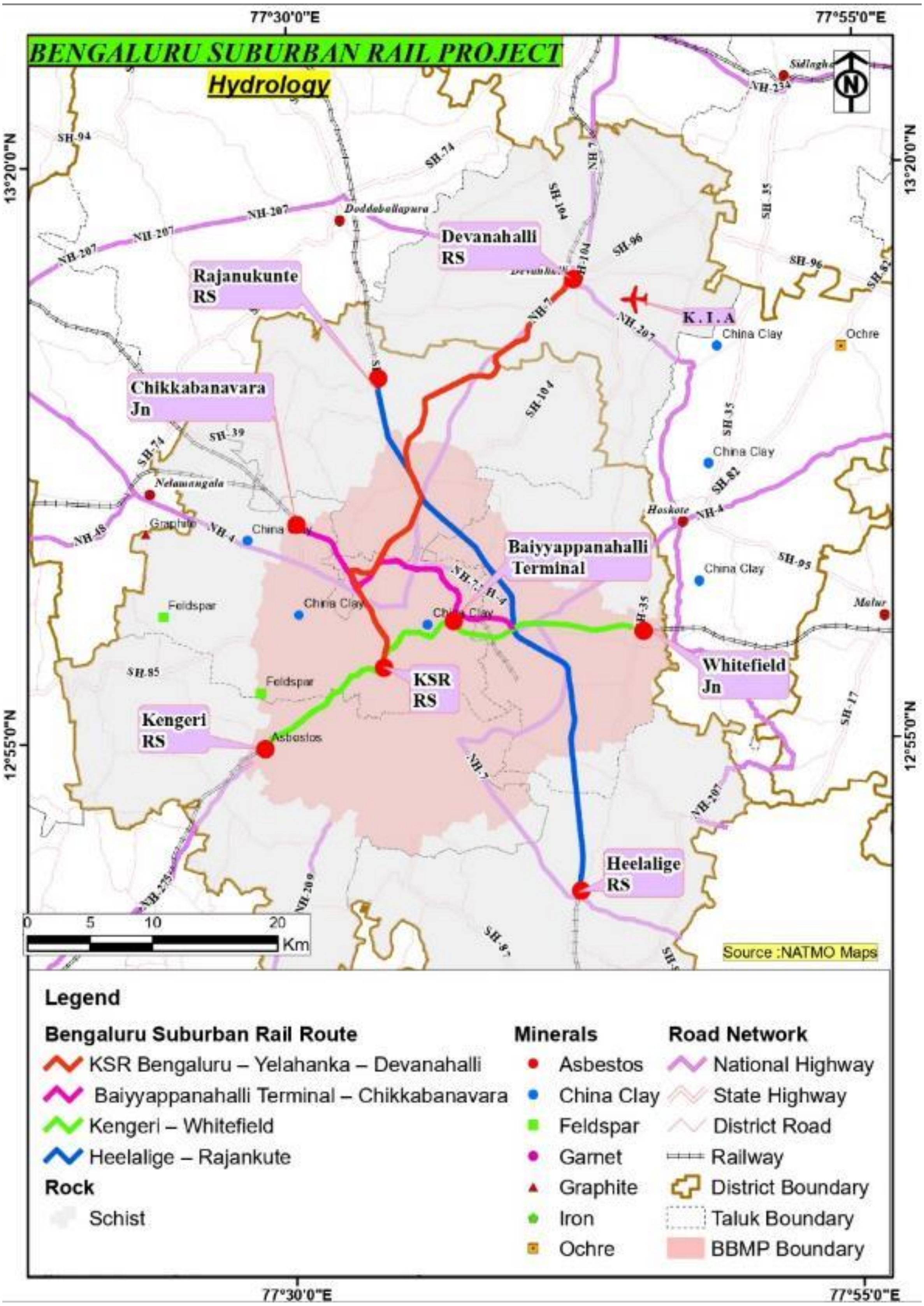
Figure 5.6. Map Showing Slope & Relief Profile of the Project Region

5.5.2. Geology and Mineralogy

Bengaluru Urban District: Granite and gneiss rock formations are predominantly covered in Bengaluru Urban district. China clay, Feldspar and Asbestos mineral deposits are found in few part of the district.

Bengaluru Rural District: The prevailing rock of the district is a light to dark-gray or whitish biotic granite gneiss, which varies considerably from place to place, in texture, structure and appearance, according to the fitness or coarseness of its constituent grains and the relative abundance or scarcity, and mode of deposition of the darker Ferro-minerals. These complex Gneissic masses have been styled as —Peninsular Gneiss.

The division does not contain minerals in any considerable quantity to be of sufficient commercial importance. Kaolin is found to some extent in Hosakote and Doddaballapura taluks. Nodular concretions of lime kankar are found as secondary products in many places in the gneissic regions. Graphite has been observed to occur in small quantities as crystalline flakes evenly disseminated in a quartzitic rock near Chikkabanavara and Gollahalli. The Gneissic exposures found in the division are yielding good ornamental slabs and size stones. Rocks and mineral map of the project study area are presented in **Figure 5.7**.

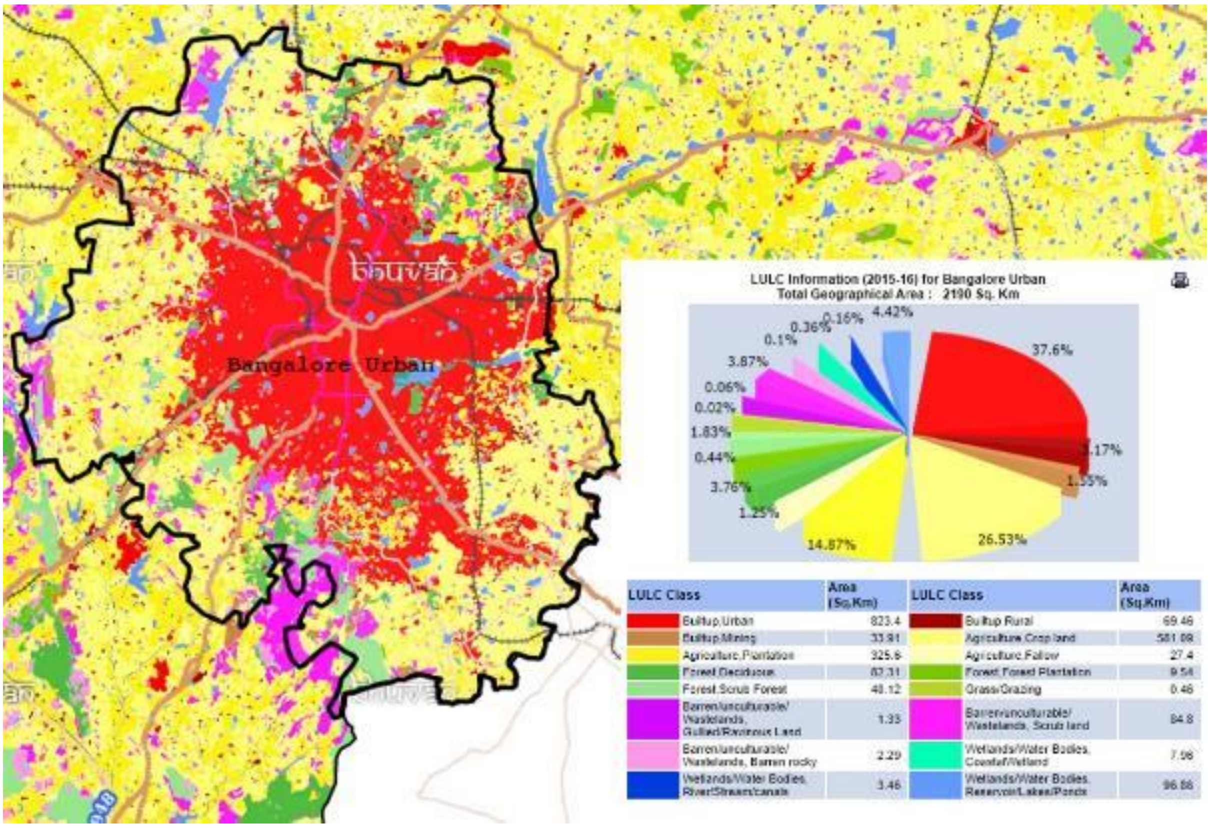


Source: National Atlas and Thematic Mapping Organisation

Figure 5.7. Map Showing Rocks and Minerals of Project Study Area

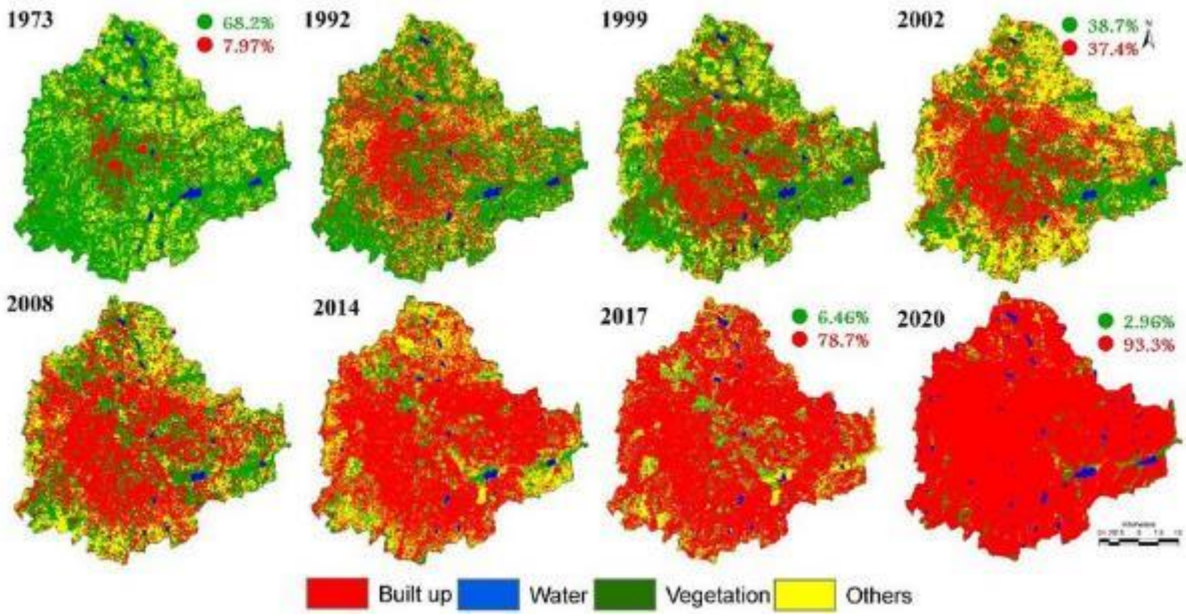
5.5.3. Land Use

Bengaluru Urban District: Land use characteristics of Bengaluru urban district broadly comprises of Built-up/settlements, Agricultural, Forests, Waterbodies, Barren land/uncultivated land etc. Bengaluru urban district is the smallest district compared to other districts in the State and it is a major information technology and industrial hub in the country. Also, the district is known for horticultural and agricultural activities. Hence, predominant part of the district is occupied with agricultural land (42.65%). As the district is well-known for its commercial and industrial activities, major share of land use constitutes built-up area (40.77%), followed by forest land (6.03%), etc. The urban built-up land use is increasing in rapid phase i.e., 1028% increase between 1973 and 2020. Land Use and Land Cover (LULC) map prepared by National Remote Sensing Center, (NRSC) for 2015-16 for Bengaluru Urban District is presented in **Figure 5.8**. Land use map showing changes in Bengaluru Urban limit from 1973 to 2020 is presented in **Figure 5.9**. Land Use and Land Cover (LULC) map prepared by National Remote Sensing Center, (NRSC) for 2015-16 for Bengaluru Rural District is presented in **Figure 5.10**.



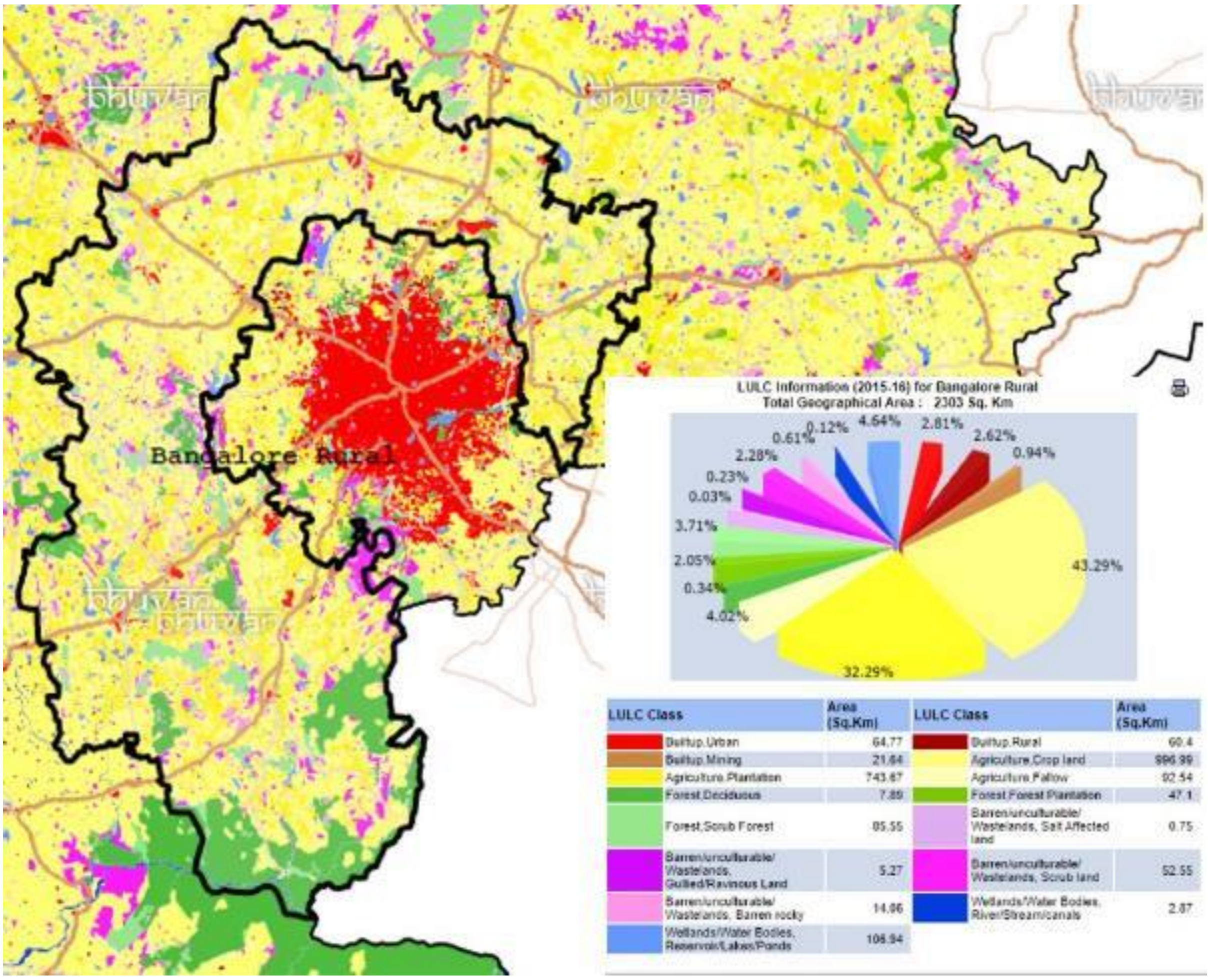
Source: National Remote Sensing Center

Figure 5.8. Land Use Land Cover Map Depicting Land use in Bengaluru Urban District



Source: Landuse Dynamics of Bengaluru, IISc

Figure 5.9. Land use Change in Bengaluru Urban Limit



Source: National Remote Sensing Center

Figure 5.10. Land Use Land Cover Map Depicting Land use in Bengaluru Rural District

Bengaluru Rural District: The district is comprised of various types of land uses from barren land to fertile agricultural and dense forest land. As per Land Use and Land Cover (LULC) map prepared by National Remote Sensing Center, (NRSC) for 2015-16, land use for Bengaluru Rural District is predominated by agricultural land (79.6%) followed by forest land (6.41%), built-up area (5.43%), etc.,

Land use of the proposed project study area is Built-ups, agriculture, water bodies, barren land etc., Corridor wise ward name and Built-up/settlements present is provided in **Table 5.2**. Landuse and land cover pattern including vegetation cover along the BSRP corridors are presented in **Table 5.3.** Map showing Land use along the BSRP Corridors is presented in **Figure 5.11**.

Table 5.2. Corridor wise Ward Name and Built-ups/Settlements

Sl. No.	BSRP Corridors	Ward /Settlement Name as per Revenue Records	Built-ups/Settlements
1.	Corridor 1: KSR Bengaluru City to Devanahalli	Subhash Nagar, Kadu Malleshwar, Malleswaram, Yeshwanthpura, Jaya Prakash Park, Dodda Bommasandra, Kodigehalli, Radhakrishna Nagar, Kodigehalli, Vidyaranyapura, Yelahanka Satellite Town, Kempegowda Nagar, Chowdeswari Nagar, Gantiganahalli, Nellukunte, Narayanapura, Bettahalasuru, Chikkajala, Meenakunte, Doddajala, Yarthiganahalli, Kannamangala, Bhuvanahalli, Doddasanne, Chikkasanne, Devanahalli	Subhash Nagar, Gandhi Nagar, M.G. Railway Colony, Seshadripuram, Dayananda Nagar, Srirampura, Kadu Malleshwar, Malleswaram, Gayatrinagar, Rajajinagar, Yeshwanthpura, B.Krishnamurthappa Nagar, Mohan kumar Nagar, Mattikere, Jaya Prakash Park, Jayaram sevabasathi, Aramane Nagara, Gokula, Dollars Colony , Tata Nagar, Dodda Bommasandra, Kodigehalli, Rajiv gandhi Nagar, Radhakrishna Nagar, Kodigehalli, Sahakar Nagar, Vidyaranyapura, Yelahanka Satellite Town, Amruthahalli, Jakkur Layout, Judicial Layout , Kempegowda Nagar, Kenchenahalli, Harohalli, Chowdeswari Nagar,Gantiganahalli, Nellukunte, Narayanapura, Bettahalasuru, Chikkajala, Meenakunte, Doddajala, Yarthiganahalli, Kannamangala, Bhuvanahalli, Doddasanne, Chikkasanne, Devanahalli
2.	Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara	Benniganahalli, C V Raman Nagar, Sarvagna Nagar, Maruthi Seva Nagar, Kammanahalli, Radhakrishna Nagar, Sanjaya Nagar, Ganga Nagar, Byatarayanapura, Vishwanath Nagenahalli, Nagavara, HBR Layout, Lingarajapura, Sagayarapuram, Kadugondanahalli, Kaval Bairasandra, HMT Ward, Sanjaya Nagar, Mattikere,	Pai layout, C V Raman Nagar, Narayanpura, Benniganahalli, Sadananda Nagar, Kasturi Nagar, OMBR Layout , Sarvagna Nagar, Chikka Banaswadi, Maruthi Seva Nagar, Naganyapalaya, Kammanahalli, Jai Bharath Nagar, Cooke Town, Radhakrishna Nagar, Sanjaya Nagar, Ganga Nagar,

Sl. No.	BSRP Corridors	Ward /Settlement Name as per Revenue Records	Built-ups/Settlements
		Yeshwanthpura, Jaya Prakash Park, Jalahalli, Shettihalli, Chikkabanavara	Byatarayanapura, Vishwanath Nagenahalli, Nagavara, HBR Layout, Lingarajapura, Sagayarapuram, Viekananda Nagar, RT Nagar, Kadugondanahalli, Guddadahalli, Hebbal, Kaval Bairasandra, Bhoopasandra, Nagashettyhalli, Dollars Colony, Mathikere, HMT Ward, Yeshwanthpura, Jaya Prakash Park, Jalahalli, Kamagondana Halli, Abbigere, mallasandra, Shettihalli, Chikkabanavara
3.	Corridor 3: Kengeri to Whitefield (via KSR and Cantonment)	Kengeri, Hemmigepura, Ullalu, Jnana Bharathi, Nayandahalli, Deepanjali Nagar, Hampi Nagar, Bapuji Nagar, Padarayanapura, Rayapuram, Binnipete, Cottonpete, Subhash Nagar, Gandhinagar, Vasanth Nagar, Aramane Nagara, Jayamahal, Pulikeshinagar, Pulikeshinagar, Shivaji Nagar, Pulikeshinagar, Jayamahal,	Kengeri, Kengeri Satellite Town, Hemmigepura, Ullalu, Jnana Bharathi, ITI Layout, Vinayaka layout, Pantharapalya, Nayandahalli, Attiguppe, K.H. Ranganatha Colony, Vijayanagar, Deepanjali Nagar, Hampi Nagar, Bapuji Nagar, Guddadahalli, Padarayanapura, Rayapuram, Binnipete, Cottonpete, Subhash Nagar, Gandhinagar, Vasanth Nagar, Madhava Nagar, Aramane Nagara, Jayamahal, Pulikeshinagar, Pulikeshinagar, Shivaji Nagar, Pulikeshinagar, Jayamahal.
4.	Corridor 4: Heelalige to Rajanukunte	Heelalige, Ramasagara, Singena Agrahara, Chintalamadivala, Huskur, Gattahalli, Kodathi, Doddakanneli, Chikkabellundur, Bellanduru, Varthuru, Dodda Nekkundi, Marathahalli, Vijnana Nagar, C V Raman Nagar, Narayanapura, Vijnanapura, Benniganahalli, Horamavu, Thanisandra, Jakkuru, Byatarayanapura, Kempegowda nagar, Chowdeswari nagar, Singanayakanahalli, Maddanahalli, Honnenahalli, Rajanukunte	Heelalige, Ramasagara, Singena Agrahara, Chintalamadivala, Huskur, Gattahalli, Kodathi, Doddakanneli, Chikkabellundur, Bellanduru, Panathur, Varthuru, Munekolala, Dodda Nekkundi, Marathahalli, Chinnappahalli, Karthik nagar, Vijnana Nagar, C V Raman Nagar, Kaggadasapura, Narayanapura, Vijnanapura, Benniganahalli, Kasturi Nagar, Sadanandanagar, Channasandra, Hoysala Nagar , Jyothi Nagara, Horamavu, Babusapalya, Hennuru, Geddalahalli, Narayanapura, Thanisandra, Rachenahalli, Hegde Nagar, Srirampura, Venkateshwara Nagar, Jakkuru, Byatarayanapura, Nehru Nagar, Yelahanka, Yelahanka New

Sl. No.	BSRP Corridors	Ward /Settlement Name as per Revenue Records	Built-ups/Settlements
			Town, Kempegowda nagar, Kenchanahalli, Chowdeswari nagar, Singanayakanahalli, Harohalli, Nagenahalli, Avalahalli, Maddanahalli, Honnenahalli, Rajanukunte

Table 5.3. Landuse and Land Cover Pattern with Vegetation cover along the BSRP Corridors

Existing Indian Railway Chainage in Km		Landuse & Land Cover Pattern		Remarks
From	To	LHS	RHS	
Corridor 1: KSR Bengaluru City to Devanahalli				
0/000	14/300	Built-up Residential/ commercial including Public amenities	Built-up Residential/ commercial including Public amenities	There are tree plantation seen along the proposed Railway alignment
14/300	14/800	Mango and other Plantation by Agricultural University	Mango and other Plantation by Agricultural University	
14/800	14/950	Built-up Residential/ commercial	Built-up Residential/ commercial	Trees seen on both side of the proposed Railway alignment
14/950	15/200	Plantation	Built-up commercial	Trees seen on both side of the proposed Railway alignment
15/200	15/400	Open land	Built-up commercial	Trees seen on both side of the proposed Railway alignment
15/400	16/800	Open land/agriculture land	National Highway NH48	Trees seen on both side of the proposed Railway alignment
16/800	18/200	Built-up Residential/ commercial	Built-up Residential/ commercial	Trees seen on both side of the proposed Railway alignment
18/200	1/300	Rail Wheel Factory	Built-up Residential/ commercial	
1/300	2/400	Built-up Residential/ commercial	Yelahanka Lake	
2/400	2/900	Open land/agriculture land	Open land/agriculture land	Trees seen on both side of the proposed Railway alignment
2/900	3/700	Built-up Residential/ Open /agriculture land	Nitte Minakshi Engineering college	Trees seen on both side of the proposed Railway alignment
3/700	4/800	Open land/agriculture land/ Gantiganahalli Lake	Defence land	Trees seen on LHS side of the proposed Railway alignment
4/800	6/900	Open land/agriculture land/ Nellukunte Lake	Open land/agriculture land/	Trees seen on both side of the proposed Railway alignment
6/900	7/500	Built-up Residential/ commercial	Built-up Residential/ commercial	Trees seen on both side of the proposed Railway alignment
7/500	12/100	Open land/agriculture land	Open land/agriculture land	Trees seen on both side of the proposed Railway alignment

Existing Indian Railway Chainage in Km		Landuse & Land Cover Pattern		Remarks
From	To	LHS	RHS	
12/100	12/800	Built-up Residential/ commercial	Built-up Residential/ commercial	
12/800	19/800	Open land/agriculture land	Open land/agriculture land	Trees seen on both side of the proposed Railway alignment
19/800	21/300	Built-up Residential	Open land/agriculture land	Trees seen on both side of the proposed Railway alignment
21/300	23/900	Open land/agriculture land	Open land/agriculture land	Trees seen on both side of the proposed Railway alignment
Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara				
204/400	205/900	Built-up Residential/ commercial	Built-up Residential/ commercial/ Benniganahalli Lake	Sparsely planted Trees seen on both side of the proposed Railway alignment
205/900	208/800	Madras Engineering Group Campus	Built-up Residential/ commercial	Trees seen on both side of the proposed Railway alignment
208/800	214/900	Built-up Residential/ commercial	Built-up Residential/ commercial	Sparsely planted Trees seen on both side of the proposed Railway alignment
214/900	215/600	Built-up Residential/ commercial	BWSSB Sewage Treatment Plant	Sparsely planted Trees seen on both side of the proposed Railway alignment
215/600	216/800	Built-up Residential/ commercial	Built-up commercial	
216/800	217/700	Mango and Coconut Plantation by Agricultural University	Outer Ring road	
217/700	219/900	Built-up Residential	Outer Ring road	Sparsely planted Trees seen on both side of the proposed Railway alignment
219/900	220/400	BEL Academy & Campus	Built-up Residential	
14/750	16/500	Built-up Residential/ commercial	Built-up Residential/ commercial	Realignment. Sparsely planted Trees seen on both side of the proposed Railway alignment
16/500	17/800	Yeshwanthapur Railway Station	Yeshwanthapur Railway Station	
17/800	11/600	Defence Land	Built-up Residential/ commercial	Trees seen on both side of the proposed Railway alignment
11/600	13/400	Built-up Residential/ commercial	Built-up Residential/ commercial	Sparsely planted Trees seen on both side of the proposed Railway alignment
Corridor 3: Kengeri to Whitefield (via KSR and Cantonment)				

Existing Indian Railway Chainage in Km		Landuse & Land Cover Pattern		Remarks
From	To	LHS	RHS	
12/700	10/600	Built-up Residential/ commercial	Built-up Residential/ commercial	Sparsely planted Trees seen on both side of the proposed Railway alignment
10/600	9/700	Coconut Tree plantation cum residential area	Built-up Residential/ commercial	Sparsely planted Trees seen on both side of the proposed Railway alignment
9/700	7/500	Indian Statistical Institute & University of Bengaluru	Built-up Residential/ commercial	Trees seen on both side of the proposed Railway alignment
7/500	1/300	Built-up Residential/ commercial	Built-up Residential/ commercial	Sparsely planted Trees seen on both side of the proposed Railway alignment
1/300	335/200	KSR Railway Station Campus	KSR Railway Station Campus	
335/200	352/600	Built-up Residential/ commercial	Built-up Residential/ commercial	Sparsely planted Trees seen on both side of the proposed Railway alignment
352/600	351/800	Bengaluru Place ground campus	Built-up Residential/ commercial	Sparsely planted Trees seen on both side of the proposed Railway alignment
351/800	349/700	Bengaluru Cantonment Railway Campus	Built-up Residential/ commercial	
Corridor 4: Heelalige to Rajanukunte				
182/400	183/600	Bengaluru Engineering college campus/residential area	Plantation	Trees seen on both side of the proposed Railway alignment
183/600	187/000	Open land/agriculture land	Open land/agriculture land	Trees seen on both side of the proposed Railway alignment
187/000	187/400	Open land/agriculture land	Built-up Residential	
187/400	191/500	Open land/agriculture land	Open land/agriculture land/ Huskur lake	Sparsely planted Trees seen on both side of the proposed Railway alignment
191/500	193/100	Built-up Residential/ commercial	Built-up Residential/ commercial/ open land	
193/100	193/900	Built-up Residential/ commercial	Open land/agriculture land	Sparsely planted Trees seen on both side of the proposed Railway alignment
193/900	195/800	Agricultural land/plantation	Agricultural land/plantation	Trees seen on both side of the proposed Railway alignment
195/800	196/000	Panathur Lake	Panathur Lake	
196/000	196/700	Built-up Residential/ plantation	Built-up Residential/ plantation	Trees seen on both side of the proposed Railway alignment

Existing Indian Railway Chainage in Km		Landuse & Land Cover Pattern		Remarks
From	To	LHS	RHS	
196/700	197/400	Open land/ Nala Crossing	Open land/ Nala Crossing	
197/400	201/500	Built-up Residential/ commercial	Built-up Residential/ commercial	Sparsely planted Trees seen on both side of the proposed Railway alignment
201/500	202/300	Doddanekundi Lake	Built-up Residential/ commercial/ open land	
202/300	203/800	Built-up Residential/ commercial	Defence land	
203/800	204/600	Defence land	Built-up Residential	
204/600	1/600	Built-up Residential/ commercial	Built-up Residential	
1/600	2/100	Built-up Residential/ commercial	Benniganahalli Lake	
2/100	2/500	Built-up Residential/ commercial	Built-up Residential/ commercial	Sparsely planted Trees seen on both side of the proposed Railway alignment
2/500	3/400	Built-up Residential/ commercial	Indian Railway land /Steel Authority of India	Sparsely planted Trees seen on both side of the proposed Railway alignment
3/400	7/200	Built-up Residential/ commercial	Built-up Residential/ commercial/open land	Sparsely planted Trees seen on both side of the proposed Railway alignment
7/200	7/700	Open land/nala crossing	BWSSB Sewage Treatment Plant	
7/700	12/800	Built-up Residential/ commercial/open land	Built-up Residential/ commercial/open land	
12/800	13/000	Built-up Residential	Open land/ Jakkur Lake	
13/000	14/100	Built-up Residential	Built-up Residential	
14/100	15/500	Built-up Residential/ commercial/agriculture land	Built-up Residential	Sparsely planted Trees seen on both side of the proposed Railway alignment
15/500	15/900	Built-up Residential/ commercial	Built-up Residential/ commercial	
15/900	17/500	Rail Wheel Factory	Built-up Residential/ commercial	
17/500	19/400	Built-up Residential/ commercial/ Nala Crossing	Built-up Residential/ Yelahanka lake	Sparsely planted Trees seen on both side of the proposed Railway alignment
19/400	19/900	Built-up Residential/plantation	Built-up Residential	Sparsely planted Trees seen on both side of the proposed Railway alignment

Existing Indian Railway Chainage in Km		Landuse & Land Cover Pattern		Remarks
From	To	LHS	RHS	
19/900	21/100	Built-up Residential	Open/Agriculture land	Trees seen on both side of the proposed Railway alignment
21/100	21/500	Open/Agriculture land	Open/Agriculture land	Trees seen on both side of the proposed Railway alignment
21/500	24/300	Built-up commercial	Open/Agriculture land	Trees seen on both side of the proposed Railway alignment
24/300	24/500	Built-up Residential	Built-up Residential	

Note: There are no forest, human-made forest or protected area present along BSRP Corridors.

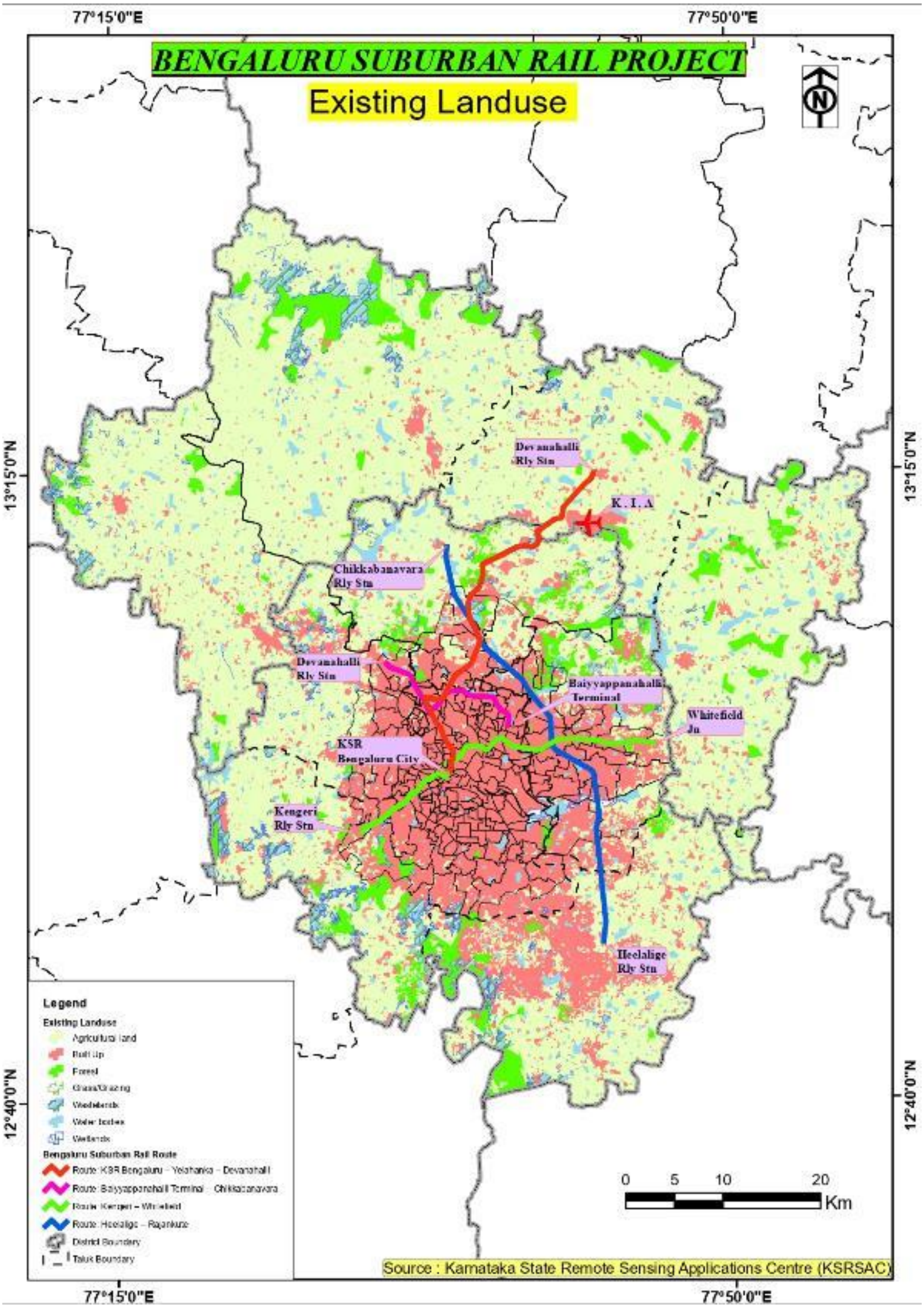
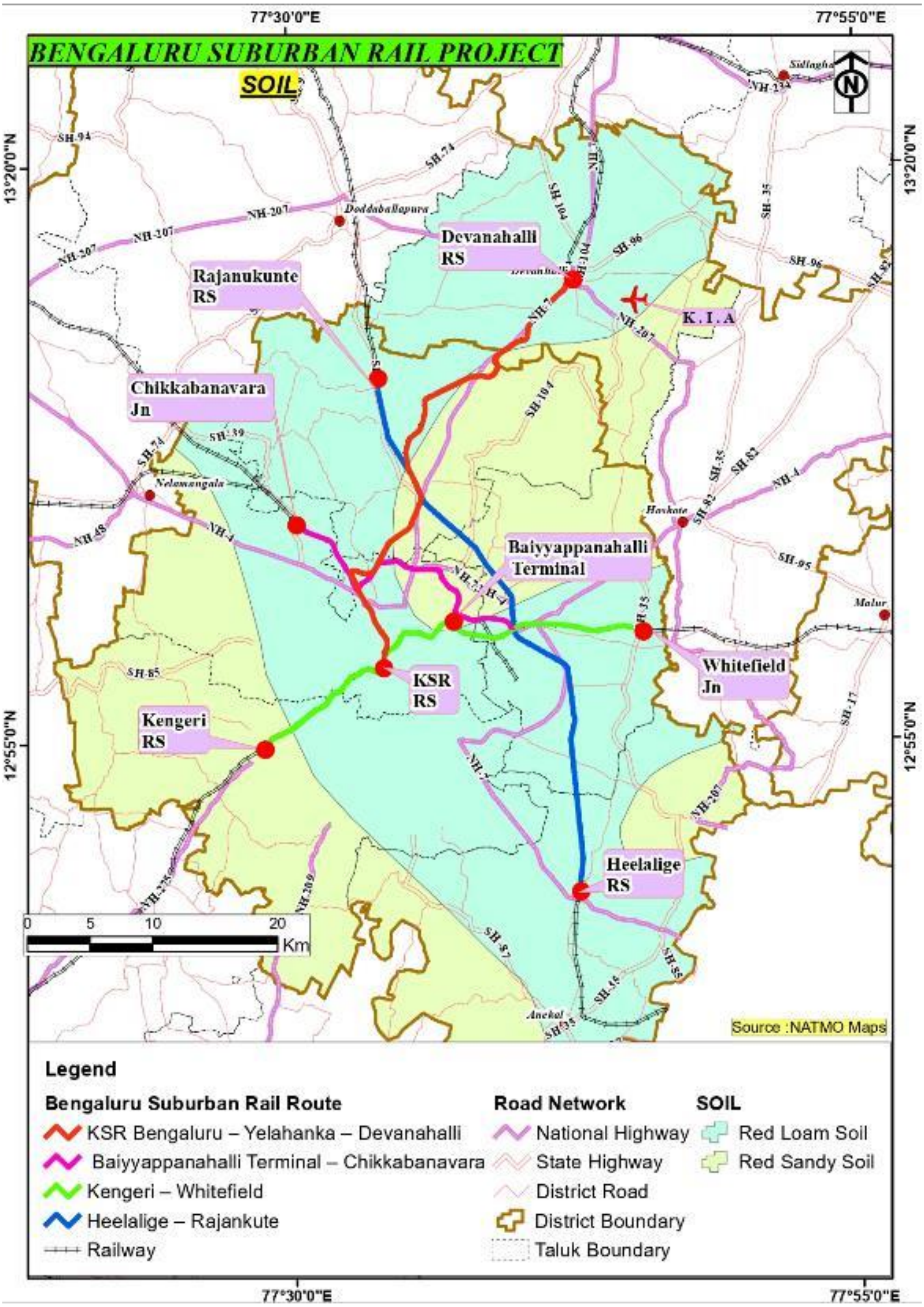


Figure 5.11. Map Showing Land Use along the BSRP Corridors

5.5.4. Soil Characteristics

Major part of the Bengaluru Urban district is broadly grouped into red loamy soil and lateritic soil. Red loamy soil generally occurs in hilly to undulating land slope on granite and gneissic terrain. It is mainly seen in the eastern and southern parts of Bengaluru north and south taluks. Lateritic soils occur in undulating terrain forming plain to gently sloping topography of peninsular gneissic region. It is mainly covered in Anekal taluk and western parts of Bengaluru north and south taluks.

The soils of Bengaluru Rural districts are broadly classified in to four categories viz (i). Loamy soil (ii) Lateritic soil (iii) Lateritic gravelly soil and (iv) Red sandy soil. Red loamy soils generally occur on hilly to undulating land slope on granite and granite gneisses. Lateritic soil occurs in undulating terrain forming plain to gently sloping topography of peninsular gneiss region. Lateritic gravelly soils occur in upland regions of lateritic soils, Red sandy soil occurs in undulating land slopes. These soils are derived from acidic rocks granites and granitic gneiss. Red loamy soil type is predominantly present in the project region. **Figure 5.12** shows the Soil distribution in the project region.



Source: National Atlas and Thematic Mapping Organisation

Figure 5.12. Map Showing Soil Distribution in the Project Region

In order to have a better understanding of soil characteristics of the project area, soil samples were taken and analyzed for all important parameters at pre-selected locations. Soil sampling locations for the BSRP Corridors are presented in **Table 5.4**. Results of the soil sample analysis for BSRP Corridors are presented in **Table 5.5** to **Table 5.8**. Photographs of the Soil sampling locations are presented in **Annexure 5.4**.

Table 5.4. Details of Soil Sampling Locations along the BSRP Corridors

Location Code	Name of the Location	Co-ordinates	Description of location
Corridor – 1: KSR Bengaluru City to Devanahalli			
SQ1	Srirampura	12°59'0.90"N 77°34'9.53"E	Urban settlement
SQ2	Yeswanthapur RS	13° 1'32.86"N 77°33'0.72"E	Urban settlement
SQ3	Yelahanka	13° 6'47.91"N 77°35'14.59"E	Urban settlement
SQ4	Proposed Akkupete Depot, Devanahalli	13°14'56.62"N 77°41'11.60"E	Agriculture land
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara			
SQ1	Baiyyappanahalli	13° 0'36.81"N 77°37'14.74"E	Rural Settlement
SQ2	Hebbala (behind STP)	13° 2'27.65"N 77°36'19.40"E	Urban settlement
SQ3	Yeswanthapura	13° 1'53.51"N 77°32'46.77"E	Urban settlement
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)			
SQ1	Near Kengeri Railway Station	12°55'8.66"N 77°29'6.83"E	Urban settlement
SQ2	Nayandananhalli	12°56'52.17"N 77°31'39.47"E	Urban settlement
SQ3	Near KSR Railway Station	12°58'54.41"N 77°34'15.14"E	Urban settlement
SQ4	Baiyyappanahalli	12°59'27.37"N 77°38'56.07"E	Urban settlement
Corridor – 4: Heelalige to Rajanukunte			
SQ1	Heelalige	12°48'44.04"N 77°42'38.85"E	Urban settlement
SQ2	Belandur	12°56'32.69"N 77°42'24.26"E	Urban settlement
SQ3	Geddalahalli	13° 2'36.47"N 77°38'40.59"E	Urban settlement
SQ4	Yelahanka	13° 5'31.92"N 77°35'51.65"E	Urban settlement
SQ5	Rajanukunte	13°10'16.07"N 77°33'55.69"E	Urban settlement

Table 5.5. Soil Sample Analysis Results for Corridor 1: KSR Bengaluru City to Devanahalli

S. No	Parameters	SQ1 Srirampura	SQ2 Yeswanthapur RS	SQ3 Yelahanka	SQ4 Akkupete Depot, Devanahalli
1	Texture				
	a) Sand	68.3	67.3	21.0	65.5
	b) Silt	26.6	24.6	56.3	28.3
	c) Clay	5.1	8.1	20.7	6.2
2	Soil Type	Sandy	Sandy	Silt Loam	Sandy Loam
3	Colour	Greyish	Greyish	Yellowish Brown	Redish brown
4	Moisture Content	2.3	2.46	1.71	4.28
5	Electrical Conductivity (1:5 Soil Extract)	0.036	0.041	0.014	0.030
6	pH	7.45	7.62	7.52	8.45
7	Organic Carbon	180	173	171	360
8	Nitrogen as N	58	62	21	41
9	Phosphorus as P	0.0003	0.0004	0.0002	0.0004
10	Potassium as K	4.86	5.12	9.7	7.3
11	Chlorides	0.0003	0.0005	0.0004	0.0008
12	Sodium	10	12.4	15.8	11.9
13	Sodium Absorption Ratio (SAR)	80.9	104	127	92.5
14	Bulk Density	1.09	1.09	1.01	1.18
15	Water Holding Capacity	5	6	9	6
16	Infiltration	11.3	11.7	10.4	12.6
17	Cation Exchange Capacity	12.6	12.2	9.8	14.7
18	Cadmium as Cd	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)
19	Chromium as Cr	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)
20	Copper as Cu	0.472	0.483	0.349	0.438
21	Iron as Fe	0.0052	0.0050	0.0039	0.0078
22	Manganese as Mn	5.23	5.38	3.84	4.86
23	Lead as Pb	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)
24	Zinc as Zn	1.36	1.24	1.08	1.12
25	Nickel as Ni	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Table 5.6. Soil Sample Analysis Results for Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara

S. No	Parameters	SQ 1 Baiyyappanahalli	SQ 2 Hebbala (behind STP)	SQ 3 Yeswanthapura
1	Texture			
	a) Sand	69.5	69.3	68.3
	b) Silt	24.3	25.6	24.0
	c) Clay	6.2	5.1	5.7

S. No	Parameters	SQ 1 Baiyyappanahalli	SQ 2 Hebbala (behind STP)	SQ 3 Yeswanthapura
2	Soil Type	Sandy	Sandy	Sandy
3	Colour	brown	Grey	Grey
4	Moisture Content	1.41	1.23	1.28
5	Electrical Conductivity (1:5 Soil Extract)	0.279	0.07	0.014
6	pH	8.46	8.54	8.02
7	Organic Carbon	420	220	169
8	Nitrogen as N	89	72	26
9	Phosphorus as P	0.0009	0.0004	0.0002
10	Potassium as K	11.3	5.63	9.3
11	Chlorides	0.0012	0.0005	0.0004
12	Sodium	25.8	14.3	15.6
13	Sodium Absorption Ratio (SAR)	208	116	114
14	Bulk Density	1.35	1.22	1.08
15	Water Holding Capacity	7	6	7
16	Infiltration	13.4	11.8	10.9
17	Cation Exchange Capacity	16.7	12.8	10.2
18	Cadmium as Cd	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)
19	Chromium as Cr	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)
20	Copper as Cu	0.447	0.475	0.386
21	Iron as Fe	0.0066	0.0053	0.0035
22	Manganese as Mn	4.72	5.37	3.87
23	Lead as Pb	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)
24	Zinc as Zn	1.18	1.22	1.11
25	Nickel as Ni	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Table 5.7. Soil Sample Analysis Results for Corridor 3: Kengeri to Whitefield (via KSR and Cantonment)

S. No	Parameters	SQ 1 Near Kengeri Railway Station	SQ 2 Nayandananhalli	SQ 3 Near KSR Railway Station	SQ 4 Baiyyappanahalli
1	Texture				
	a) Sand	67.5	68.3	68.3	69.3
	b) Silt	26.3	26.6	23.5	23.6
	c) Clay	6.2	5.1	8.2	7.1
2	Soil Type	Sandy	Sandy	Sandy	Sandy
3	Colour	Grey	Greyish	Yellowish Brown	Brown
4	Moisture Content	1.58	3.62	1.32	1.48

S. No	Parameters	SQ 1 Near Kengeri Railway Station	SQ 2 Nayandananhalli	SQ 3 Near KSR Railway Station	SQ 4 Baiyyappanahalli
5	Electrical Conductivity (1:5 Soil Extract)	0.052	0.039	0.031	0.041
6	pH	7.86	8.09	8.39	8.17
7	Organic Carbon	186	180	210	189
8	Nitrogen as N	75	60	46	64
9	Phosphorus as P	0.0004	0.0005	0.0004	0.0005
10	Potassium as K	7.6	5.2	7.3	5.27
11	Chlorides	0.0008	0.0004	0.0008	0.0005
12	Sodium	17.2	15.8	11.9	12.4
13	Sodium Absorption Ratio (SAR)	124	114	92.5	104
14	Bulk Density	1.23	1.11	1.18	1.13
15	Water Holding Capacity	8	6	7	8
16	Infiltration	11.4	11.8	12.6	11.8
17	Cation Exchange Capacity	15.2	12.9	14.9	12.6
18	Cadmium as Cd	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)
19	Chromium as Cr	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)
20	Copper as Cu	0.438	0.479	0.349	0.491
21	Iron as Fe	0.0067	0.0047	0.0042	0.0055
22	Manganese as Mn	4.86	5.18	3.64	5.11
23	Lead as Pb	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)
24	Zinc as Zn	1.27	1.43	1.14	1.28
25	Nickel as Ni	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Table 5.8. Soil Sample Analysis Results for Corridor 4: Heelalige to Rajanukunte

S. No	Parameters	SQ 1 Heelalige	SQ 2 Belandur	SQ 3 Geddalahalli	SQ 4 Yelahanka	SQ 5 Rajanukunte
1	Texture					
	a) Sand	69.2	68.7	69.4	21.4	69.8
	b) Silt	20.5	25.1	19.3	58.1	20.0
	c) Clay	10.3	6.2	11.3	20.5	10.2
2	Soil Type	Sandy Loam	Sandy	Sandy Loam	Silt Loam	Sandy Loam
3	Colour	Brownish	Yellowish	Brownish	Yellowish Brown	Greyish
4	Moisture Content	1.98	2.07	1.86	1.76	2.11
5	Electrical Conductivity (1:5 Soil Extract)	0.041	0.042	0.193	0.019	0.034

S. No	Parameters	SQ 1 Heelalige	SQ 2 Belandur	SQ 3 Geddalahalli	SQ 4 Yelahanka	SQ 5 Rajanukunte
6	pH	7.54	7.32	7.48	7.58	7.89
7	Organic Carbon	161	179	171	132	386
8	Nitrogen as N	54	65	78	25	46
9	Phosphorus as P	0.0004	0.0004	0.0009	0.0002	0.0003
10	Potassium as K	4.97	5.25	9.4	3.72	4.29
11	Chlorides	0.0004	0.0006	0.0008	0.0003	0.0003
12	Sodium	11.5	12.9	17.2	9.74	10.3
13	Sodium Absorption Ratio (SAR)	83	105	139	72.8	77.5
14	Bulk Density	1.13	1.24	1.32	1.01	1.05
15	Water Holding Capacity	6	9	5	8	6
16	Infiltration	10.9	11.8	12.3	10.4	10.1
17	Cation Exchange Capacity	11.5	12.8	13.9	9.5	10.7
18	Cadmium as Cd	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)
19	Chromium as Cr	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)
20	Copper as Cu	0.387	0.396	0.497	0.301	0.318
21	Iron as Fe	0.0048	0.0053	0.0076	0.0032	0.0038
22	Manganese as Mn	4.83	5.08	5.84	3.76	4.14
23	Lead as Pb	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)	BQL(LOQ:0.5)
24	Zinc as Zn	1.13	1.27	1.49	0.96	1.01
25	Nickel as Ni	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)	BQL(LOQ:1.0)

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Results and Observation

Corridor 1: It has been observed that the pH of the soil is ranging from 7.45 to 8.45. Moisture found in the range from 1.71% to 4.28%. Conductivity of the soil ranges from 0.014 to 0.041 mS/cm. Texture of the soil in the selected locations of study area were found to be Sandy, Sandy Loam & Silt Loam in nature. The potassium content varies from 4.86 to 9.7 mg/100g. Sodium content varies from 10.0 to 15.8 mg/100g.

Corridor 2: It has been observed that the pH of the soil is ranging from 8.02 to 8.54. Moisture found in the range from 1.23% to 1.41%. Conductivity of the soil ranges from 0.014 to 0.279 mS/cm. Texture of the soil in the selected locations of study area were found to be Sandy, in nature. The potassium content varies from 5.63 to 11.3 mg/100g. Sodium content varies from 14.3 to 25.8 mg/100g.

Corridor 3: It has been observed that the pH of the soil is ranging from 7.86 to 8.39. Moisture found in the range from 1.32% to 3.62%. Conductivity of the soil ranges from 0.031 to 0.052mS/cm. Texture of the soil in the selected locations of study area were found to be Sandy, in nature. The potassium content varies from 5.2 to 7.6 mg/100g. Sodium content varies from 11.9 to 17.2 mg/100g.

Corridor 4: It has been observed that the pH of the soil is ranging from 7.32 to 7.89. Moisture found in the range from 1.76% to 2.11%. Conductivity of the soil ranges from 0.019 to 0.193mS/cm. Texture of the soil in the selected locations of study area were found to be Sandy, Sandy Loam & Silt Loam in nature. The potassium content varies from 3.72 to 9.4 mg/100g. Sodium content varies from 9.74 to 17.2 mg/100g.

5.5.5. Natural Hazards and Vulnerability of the Project Area

5.5.5.1. Earthquake

As per the seismic zone classification of India IS1893 (Part I):2002, the project region falls in Zone II, i.e. Low Damage Risk Zone to earthquakes (MSK VI). The Vulnerability Atlas for Karnataka prepared by Building Material and Technology Promotion Council (BMTPC) shows that, Bengaluru Urban and Rural Districts are situated in relatively safe zone from earthquake. Historically, there has been no incident of major earthquake during last one hundred years. Earthquake Hazard map showing Project Districts is presented in **Figure 5.13.**

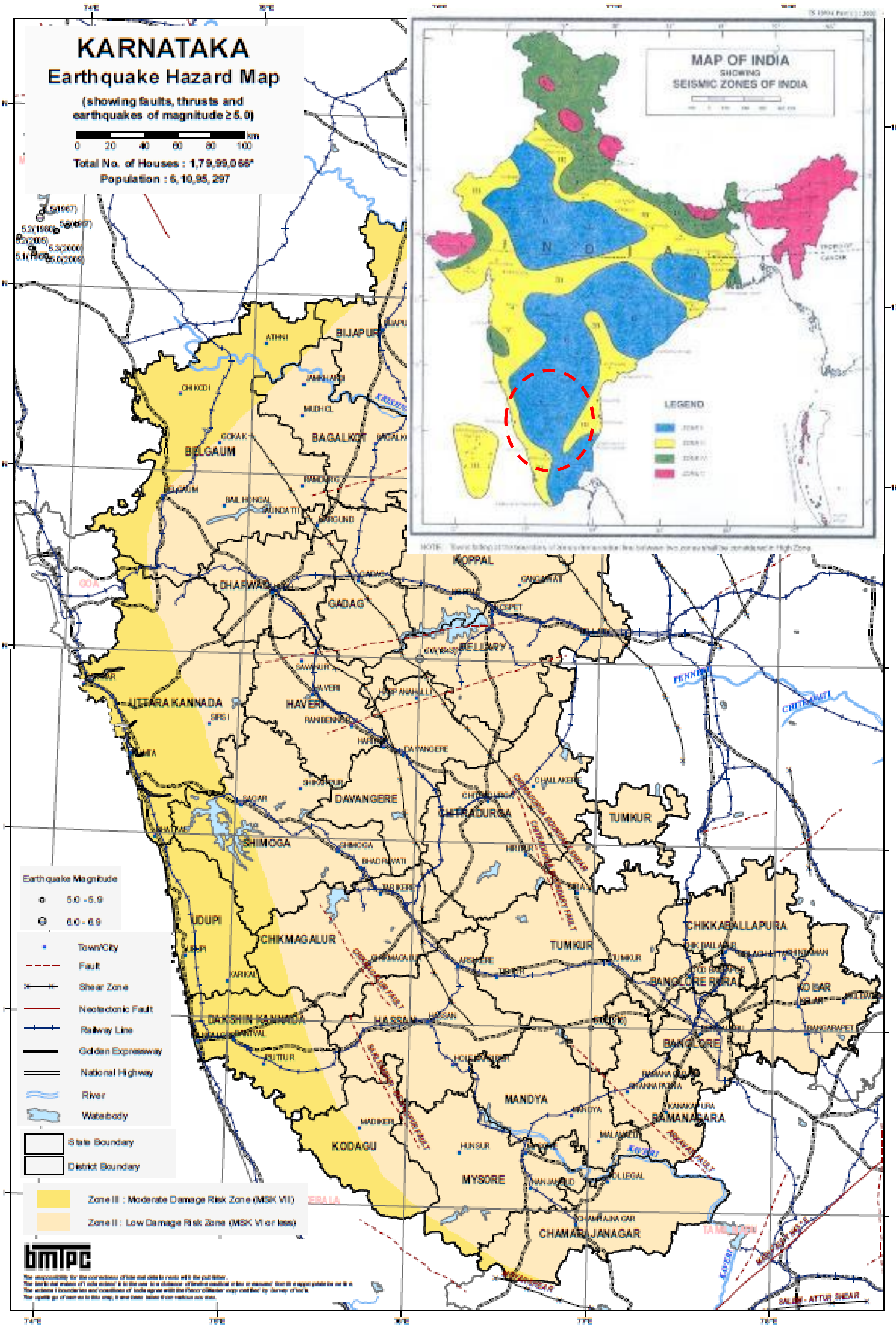
5.5.5.2. Wind Hazard

There are no serious threats of wind hazards in the project region. As per Vulnerability Atlas for Karnataka prepared by Building Material and Technology Promotion Council (BMTPC), Bengaluru Urban and Rural Districts are situated in Low Damage Risks Zone. There is low intensity wind flow recorded during pre-monsoon season i.e., between April to June, which is accompanied by rain causing damages to trees. Wind Hazard map showing Project Districts is presented in **Figure 5.14**.

5.5.5.3. Landslide Incidents

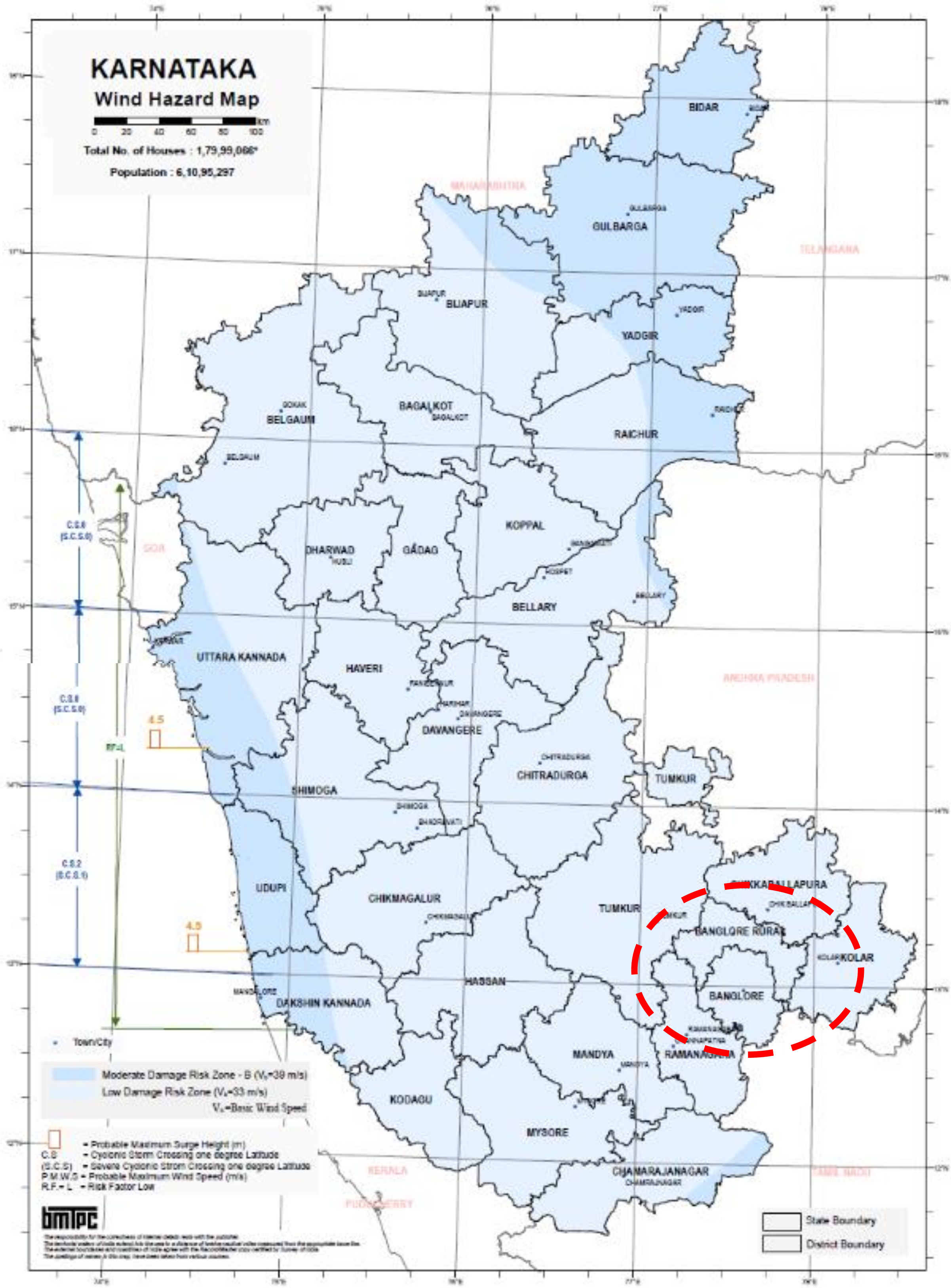
The project districts are located in Archaean crystalline formation comprising peninsular gneissic complex, which mainly comprises of igneous and metamorphic rock formations. Landforms in the project region is mainly covered with lateritic soil, red loam and red sandy soils which has high binding characteristics. There are no landslide or landslip problems reported from any part of the project area, since major parts of the project corridor are passing through plain terrain. Since, railway alignments have to be developed by maintaining elevation, cutting and filling may be envisaged. Appropriate measures should be incorporated in strengthening of embankments and cutting sections to avoid slipping and erosions.

As per Vulnerability Atlas for Karnataka prepared by Building Material and Technology Promotion Council (BMTPC), Bengaluru Urban and Rural Districts are situated in Low Risks Zone. Landslide Incidence map showing Project Districts is presented in **Figure 5.15**.



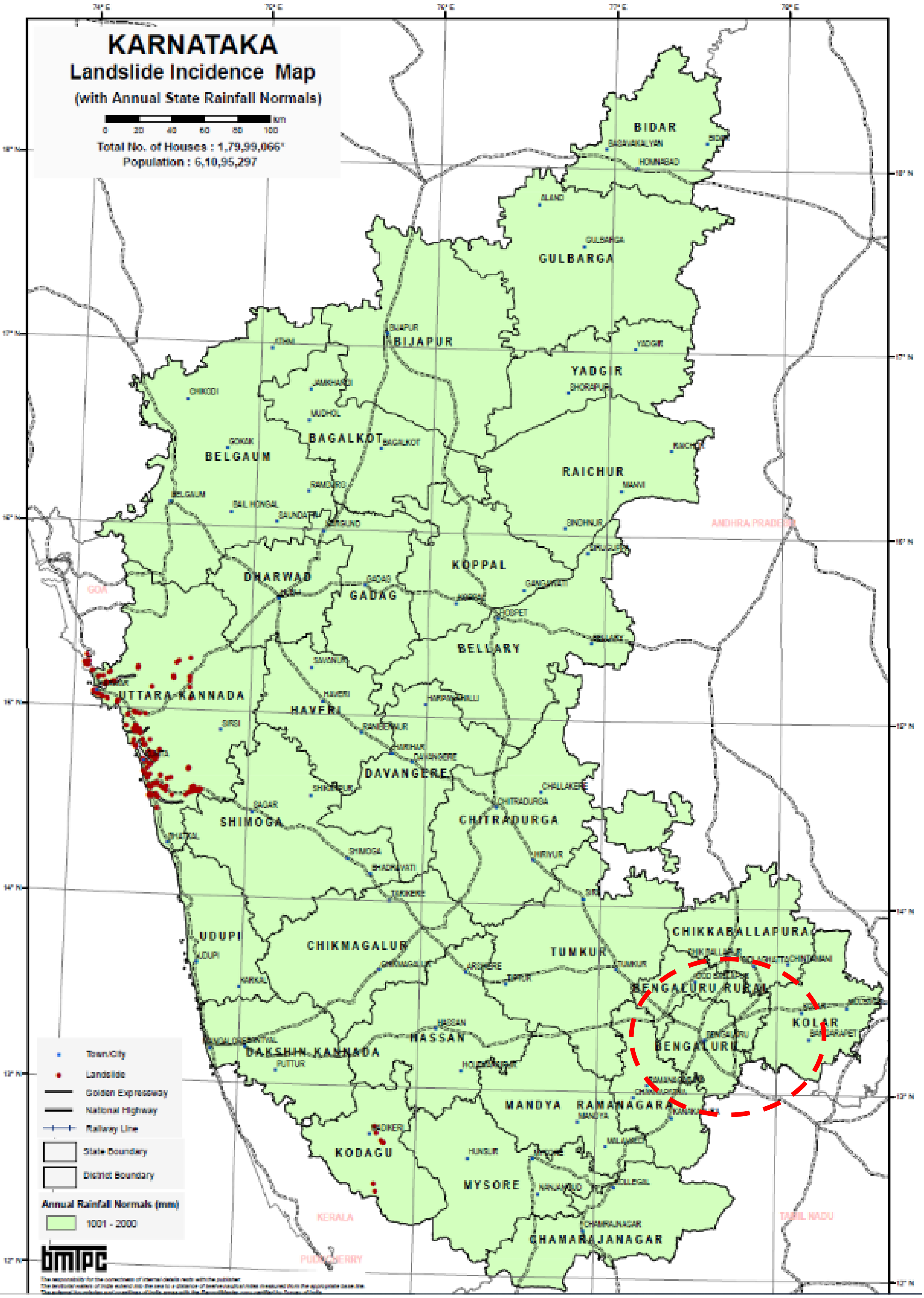
Source: Building Material and Technology Promotion Council

Figure 5.13. Earthquake Hazard Map Showing Bengaluru Urban & Rural Districts



Source: Building Material and Technology Promotion Council

Figure 5.14. Wind Hazard Map Showing Bengaluru Urban & Rural Districts



Source: Building Material and Technology Promotion Council

Figure 5.15. Landslide Incidence Map Showing Bengaluru Urban & Rural Districts

Further, in the last consecutive years, Bengaluru town has reported of inundation at a few locations in the project region in monsoon and post-monsoon seasons. This was observed mainly at ROB and RUB locations near railway alignments. This lasts for a few days and till the end of the monsoon at few locations. However, no loss of lives or property was reported due to flooding near the railway underpass.

5.6. Water Environment

5.6.1. Hydrology

5.6.1.1. Surface Water Resources

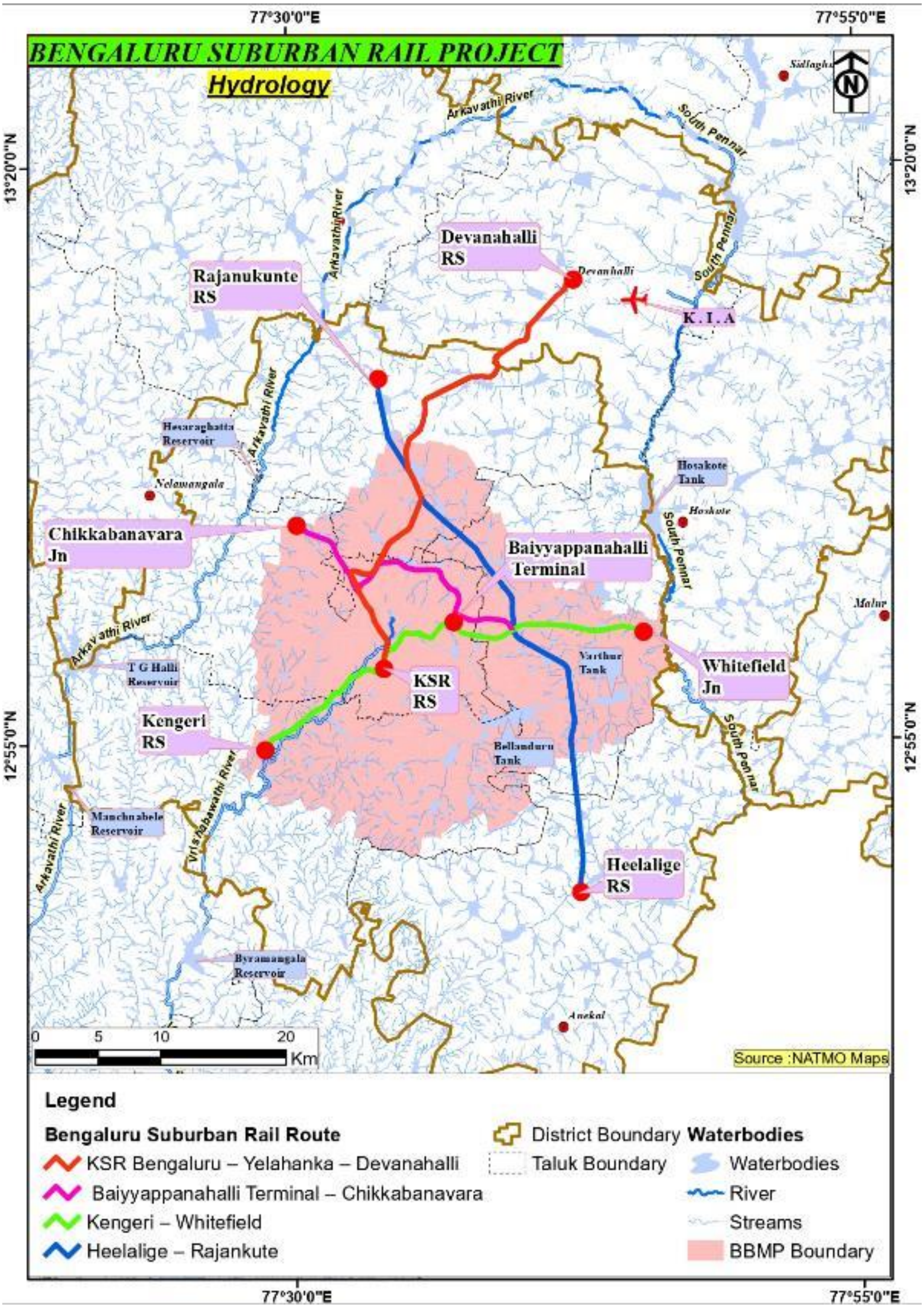
Bengaluru Urban District: The Arkavati river flows in the district for a small distance in Bengaluru North taluk. The South Pinakini touches the borders of the district to the northeast of the Anekal taluk. The Vrishabhavathi, a tributary of the Arkavati, flows in the district before joining the Arkavati near Muduvadidurga. The tributary takes its birth in the Bengaluru city at Basavanagudi and the Suvarnamukhi from Anekal taluk joins the tributary before joining the Arkavati. The Basavanahole originating beyond and Muthyalamadu falls passes through Anekal taluk and join the Arkavati near Kanakapura. Apart from these, the district has many seasonal and perennial waterbodies.

Bengaluru Rural District: There are two prominent rivers and many other rivulets present in the Bengaluru Suburban district. River Arkavathi and Dakshina Pinakini are the two seasonal rivers which flows from north to south direction.

Arkavathi river is a tributary of the Cauvery river, rises in Nandi hills flowing through the division form north to south entering the division in Doddaballapura taluk. It forms several large tanks, Doddaballapura tank is one of them, and passes through the east of the Nelamangala taluk. It then flows through Ramanagara District.

Dakshina Pinakini river flows in the eastern parts of the district. It rises like Arkavathi in Nandi hills and flows southwards through Devanahalli and Hosakote taluks where it forms the Hosakote tank, which is a big tank.

There are no river crossings observed in the BSRP corridors. Map of BSRP alignment with Drainage pattern of project region is shown in **Figure 5.16**.



Source: National Atlas and Thematic Mapping Organisation

Figure 5.16. Hydrologic Profile of the Project Region

Corridor 1 & Corridor4 abuts number of lakes as its passes along existing railway alignment. However, there are no lakes/ponds present along proposed Corridor 2 & Corridor 3 railway alignments. Some of the waterbodies are perineal in nature such as Yelahanka lake, Jakkur lake, Panathur lake, etc. Major source of water for these lakes are surface runoff through storm water drainages during monsoon season. It is also noticed that, these storm water drains are severely contaminated with sewage and industrial effluents. Google earth imagery showing BSRP alignment abutting the lakes are presented in **Figure 5.17.** Detailed list of waterbodies present along BSRP corridors are also presented in **Annexure 5.5.**

Huskur Lake: Huskur Lake is located near Huskur village, which was used for irrigation purpose in the past. However, in recent days, agriculture land located around Huskur lake were converted to residential and commercial space due to rapid urban growth. The lake is spreads over 102 arces and is under the influence of sewage intrusion. The lake is located at 35m from the proposed RoW of the Corridor 4 railway alignment, after the existing India railway alignment. Hence, there is no direct impact to lake due to proposed project.

Panathur Lake: Panathur lake is located near Kadubeesanahalli village, which spreads for 23 acres. The existing Indian railway alignment is intersects lake and divide in to two parts. As per the records, Indian Railway has approx. 56m Right of Way at this location, out of which only 10m is utilized for the existing a railway alignment. Bruhat Bengaluru Mahanagara Palike (BBMP) has taken up rejuvenation of lake by de-weeding, desilting work, bund formation and public amenity works in the year 2018. Now, its open for public to walking and recreational activities. After the rejuvenation works, fishery department introduced fishes in to the lake to restore the biodiversity of the lake. However, still the lake receives sewage water from nearby house and apartments. The lake is situated at 20m away from the proposed ROW of the Corridor 4 railway alignment. Hence, there is no direct impact to lake due to proposed project.

Doodanekundi Lake: Doddanekundi lake is spread across an area of 137 acres of land which is located near Doddanekundi and Kagadapura villages. It is one of the largest lake in west Bengaluru. The lake was rejuvenated by BDA in the year 2017. Even BBMP has undertaken de-weeding of lake from time to time. However, lake is severely contaminated with influx of sewage water. Due to the intrusion of sewage, water quality is deteriorating day by day. The lake is located at 50m from the proposed RoW of the Corridor 4 railway alignment, after existing India railway alignment. Hence, there is no direct impact to lake due to proposed project.

Benniganahalli Lake: The lake was developed by the Bengaluru Development Authority (BDA) two decades ago and handed over the lake to BBMP in 2016. Benniganahalli lake was a favorite destination for morning and evening walkers. The developed portion of the lake has good water quality whereas the undeveloped portion is polluted with sewage from nearby layouts. In January 2018 BBMP took up the task of cleaning the lake by dredging, desilting and weed removal and constructed a channel to divert the sewage flow. In recent years, the inflow of the lake has been increase due to good monsoon. The lake is spread over around 45 acres. Benniganahalli lake is located at 100m away from the proposed RoW of the Corridor 4 railway alignment. Hence, there is no direct impact to lake due to proposed project.

Jakkur Lake: Jakkur Lake is one of the largest lakes in the grid of man-made lakes in the city and is located in the north eastern part of Bengaluru. Unplanned development in the area surrounding the lake had led to solid waste filling its feeder channels. This choked the natural watershed so much that the lake resembled a dumping yard. Jakkur lake covers 160 acres, out of which water carrying capacity is only 139 acres. In 2005, the BDA took up a project to rejuvenate a Jakkur lake. They worked on it for from 2008 till about 2010-11. As part of the project, BDA carried out desilting, fencing and sewage treatment and completed the revival of the lake. After completing the work, Lake was handed over to BBMP by BDA in the year 2012. Now, the lake is known for its beautiful ambience, which attracts number of birds. The lake is open for public for walking and recreational activities. Also fishery department has introduced fishes in the lake to improve the biodiversity of the lake. The lake is located at 25m from the proposed RoW of the Corridor 4 railway alignment, after existing India railway alignment. Hence, there is no direct impact to lake due to proposed project.

Yelahanka Lake: Yelahanka Lake is located near Yelahanka new town. It is spreads over 300 acres. Yelahanka lake is one of the largest lake in the Bangalore North zone. The lake was highly polluted and emanated foul smell because of discharge of industrial effluents and sewerage water & garbage. It had even contaminated the groundwater table. People living in the low-lying areas were forced to clear the drain water that had entered their house during continuous downpour in Yelahanka. However, recently BBMP has planned for development of lake with water fountain and bird watching island in the centre of the lake, toy train around the lake, musical fountain, gym facilities and sculptures in the lake premises. Also, it is proposed to increasing the water holding capacity by desilting the lake. The lake is located at 40m from the proposed RoW of the Corridor 4 railway alignment. Hence, there is no direct impact to lake due to proposed project.

Gantiganahalli Lake: Gantiganahalli Lake is located adjacent to Gantiganahalli village. On southwestern side of the lake is abutted by existing Indian railway alignment. The lake spreads over approx. 60 acres. The lake is filled with silt and has many naturally grown trees inside it. Due to siltation, carrying capacity of the lake has been drastically reduced. It is observed that, lake water is still utilized for agricultural purpose. The lake is located at 30m from the proposed RoW of the Corridor 1 railway alignment. Hence, there is no direct impact to lake due to proposed project.

Nellukunte Lake: Nellukunte Lake is a lake formed for agricultural purpose located adjacent to Nellukunte village. On southern side of the lake was abutted by existing Indian railway alignment. The lake spreads over approx. 21 acres. The lake is perennial and filled with silt. Due to siltation, carrying capacity of the lake has been drastically reduced. It is observed that, lake water is still utilized for agricultural purpose. The lake is located at 40m from the proposed RoW of the Corridor 1 railway alignment, after the existing Indian Railway alignment. Hence, there is no direct impact to lake due to proposed project.

	
Huskur Lake with Corridor 4 Alignment	**Panathur Lake with Corridor 4 Alignment**
	
Doodanekundi Lake with Corridor 4 Alignment	**Benniganahalli Lake with Corridor 4 Alignment**
	
Jakkur Lake with Corridor 4 Alignment	**Yelahanka Lake with Corridor 1 & 4 Alignment**

Gantiganahalli Lake Lake with Corridor 1 Alignment	Nellukunte Lake with Corridor 1 Alignment

Figure 5.17. Google Earth Imagery showing BSRP alignment abutting the Lakes in the Project

Chainage wise list of water bodies identified along the BSRP Corridors are presented in **Table 5.9.**

Table 5.9. Chainage –Wise List of Waterbodies Present along BSRP Corridors

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
Corridor – 1: KSR Bengaluru City to Devanahalli						
LHS						
1	0/550	Over Head Tank	80	90	50	-
2	11/650	Stream	-	-	-	Along with 25m
3	1/510	Yelahanka Lake	-	-	-	Along with 450m
4	2/610	Stream	-	-	-	Along with 107m
5	4/200	Gantiganahalli Lake	-	15	-	Along with 100m
6	6/300	Nellukunte Lake	-	40	-	Along with 30m
7	9/500	Over Head Tank	-	30	20	No Compound Wall
8	10/650	Over Head Tank	-	30	20	No Compound Wall
9	11/750	Over Head Tank	-	30	18	No Compound Wall
10	11/850	Stream	-	-	-	Along with 2m
11	12/00	Open well	-	10	-	along with 4m
RHS						
1	0/850	Vrishabhavathi River	-	-	-	No Compound Wall
2	7/740	Drain	-	-	-	No Compound Wall
3	9/510	Drain	-	-	-	No Compound Wall
4	11/650	Drain	-	-	-	Along with 120m
5	1/350	Yelahanka Lake	-	-	-	Along with 700m
6	2/300	Drain	-	-	-	Along with 120m
7	2/650	Drain	-	-	-	No Compound Wall

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
8	11/220	Chikkajala Lake	-	40	-	No Compound Wall
9	11/880	Drain, Chennahalli.	-	-	-	No Compound Wall
10	13/600	Over Head Tank	-	35	16	No Compound Wall
11	23/060	Drain	-	-	-	Along with 300m
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara						
LHS						
1	204/700	Canal, Benniganahalli	-	-	-	No Compound Wall
2	208/580	Over Head Tank	10	13	-	Military
3	208/588	Over Head Tank	7	10	-	Military
4	211/230	Drain	-	-	-	-
5	212/150	Public Drinking Water Unit, Kadugondanahalli	-	20	5	No Compound Wall
6	212/780	Drain	-	-	-	-
7	215/630	Drain	-	-	-	-
8	217/100	Irrigation canal	-	-	-	-
9	217/550	Open well	-	5	-	No Compound Wall
10	219/00	Drain	-	-	-	-
11	220/420	Drain	-	-	-	-
12	15/350	BBMP Drinking water Unit, Mathikere	-	-	4	Realignment
13	17/620	Drain	-	-	-	No Compound Wall
14	18/080	Drain	-	-	-	No Compound Wall
15	23/550	Drain	-	-	-	No Compound Wall
16	23/660	Drain	-	-	-	No Compound Wall
RHS						
1	206/450	Over Head Tank	-	50	15	No compound wall
2	209/300	Drain	-	-	-	100m parallel to railways
3	210/650	Drain	-	-	-	No compound wall
4	211/240	Drain	-	-	-	10m parallel to railways
5	212/700	Drain	-	-	-	No compound wall
6	213/250	Drain	-	-	-	500 m parallel to railway
7	215/000	BWSSB Water Treatment Plant, Jogappa Layout, Nagavara	15	20	-	-

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
8	215/625	Drain	-	-	-	-
9	216/625	Bore well with motor	15	20	-	-
10	216/830	Open well	-	15	3	No compound wall
11	217/450	Open well	-	9	-	No compound wall
12	217/600	Open well	-	9	-	No compound wall
13	218/100	Open well	-	9	-	No compound wall
14	219/050	Drain	-	-	-	No compound wall
15	219/600	Drain	-	-	-	No compound wall
16	15/330	Public water tap	-	-	-	Realignment
17	15/350	Public water tap	-	-	-	Realignment
18	15/400	Public water tap	-	-	-	Realignment
19	21/900	Bore well	-	-	-	No compound wall
20	23/650	Drain	-	-	-	-
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)						
LHS						
1	11/310	Drain	-	-	-	Along with 50m
2	10/200	Drain	-	-	-	Along with 90m
3	8/400	Drain	-	-	-	Along with 150m
4	6/000	Drain	-	-	-	-
5	5/625	Drain	-	-	-	Along with 500m
6	5/390	Drain	-	-	-	No Compound Wall
7	4/740	Drinking Water Unit, Hampinagar	-	18	8	No Compound Wall
8	4/590	Drinking Water, Unit, Hampinagar	-	10	8	No Compound Wall
9	3/715	Drain	-	-	-	No Compound Wall
10	3/825	Public Water Tap, Hosahalli	-	7	7	No Compound Wall
11	1/650	Drain	-	-	-	No Compound Wall
12	0/720	Drain	-	-	-	No Compound Wall
13	0/250	Over Head Tank	-	-	-	Along with 80m
14	355/450	Drain	-	-	-	Along with 60m
15	355/40	Drain	-	-	-	No Compound Wall
16	354/480	Drain	-	-	-	Along with 550m
17	350/860	Drain	-	-	-	No Compound Wall
18	353/730	Drain	-	-	-	No Compound Wall
19	400/000	Drain	-	-	-	No Compound Wall
20	347/400	Drain	15	17	-	-
21	343/350	Irrigation Canal	-	-	-	No Compound Wall

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
22	340/100	Drain	-	-	-	No Compound Wall
23	339/300	Drain	-	-	-	Along with 50m
24	338/450	Over Head Tank	30	35	35	-
25	336/750	Drain	-	-	-	No Compound Wall
26	334/180	Drain	-	7	-	No Compound Wall
RHS						
1	11/900	Drain	-	-	-	Along with 90m
2	9/360	Drain	-	-	-	Along with 110m
3	8/400	Drain	-	-	-	Along with 200m
4	8/180	Open Well	-	10	-	No Compound Wall
5	7/030	Drain	-	-	-	Along with 350m
6	6/820	Bore well	-	16	-	No Compound Wall
7	5/450	Public Water Tap, Deepanjali Nagar	-	15	-	No Compound Wall
8	4/930	Drain	-	-	-	Along with 150m
9	4/350	Drain	-	-	-	Along with 80m
10	2/750	Drain	-	-	-	Along with 130m
11	1/660	Drain	-	-	-	Along with 250m
12	353/520	Drain	-	-	-	Along with 120m
13	353/600	Drain	-	-	-	No Compound Wall
14	349/860	Open well	7	-	-	-
15	349/700	Drain	-	-	-	Along with 200m
16	347/400	Drain	-	-	-	Along with 50m
17	344/400	Drain	-	-	-	Along with 40m
18	344/050	Drain	-	-	-	Along with 100m
19	343/230	Drain, Baiyyappanahalli	-	-	-	Along with 160m
20	339/450	Pond	-	15	-	Along with 60m
21	338/870	Drain	-	-	-	Along with 35m
22	338/840	Drain	-	-	-	Along with 60m
23	338/350	Drain	-	-	-	Along with 50m
24	337/900	Drain	-	-	-	Along with 60m
25	337/180	Drain	-	-	-	Along with 110m
26	335/600	Drain	-	5	-	Along with 120m
Corridor – 4: Heelalige to Rajanukunte						
LHS						
1	181/300	Drain	-	-	-	Along with pound wall
2	188/600	Huskur Lake	-	-	-	Along with 10m

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
3	188/750	Drain	-	-	-	Along With 250m
4	195/800	Panathur Lake	-	-	-	Along with 150m
5	196/200	Drain	-	-	-	Along with 50m
6	197/100	Drain	-	-	-	Along with 50m
7	201/450	Drain	-	-	-	No compound wall
8	202/050	Doddanekundi Lake	-	-	-	Along with 100m
9	204/450	Drain	-	-	-	Along with 120m
10	5/360	Drain	-	-	-	No compound wall
11	7/320	Drain	-	-	-	No compound wall
12	12/550	Drain	-	-	-	No compound wall
13	12/950	Drain	-	-	-	No compound wall
RHS						
1	180/680	Drain	-	-	-	-
2	181/650	Drain	-	-	-	No Compound Wall
3	182/100	Drain	-	-	-	No Compound Wall
4	195/890	Panathur Lake	-	-	-	No Compound Wall
5	197/100	Drain	-	-	-	-
6	201/450	Drain	-	-	-	No Compound Wall
7	202/050	Drain	-	-	-	No Compound Wall
8	7/150	Drain	-	-	-	No Compound Wall
9	12/500	Pond	-	3	-	No Compound Wall
10	12/880	Jakkur Lake	7	8	-	-
11	16/100	Over Head tank	-	30	35	No Compound Wall
12	16/150	Over Head tank	-	35	30	CW Parallel for 330 m
13	17/600	Yalahanka Lake	-	5	-	No Compound Wall
14	18/620	Over Head tank	-	20	-	No Compound Wall
15	22/050	Drain	-	-	-	No Compound Wall

Note: Rows in Red colour represents Elevated Sections

Photographs of few Waterbodies present along BSRP Corridors are presented in **Figure 5.18.**

Figure 5.18. Photographs of Waterbodies Present along BSRP Corridors

It is evident from the site visits and photos that, all the storm water drains in the city carries considerable amount of sewage water, resulting these waterbodies are contaminated and polluted and provides less chance for existence of aquatic life.

5.6.1.2. Ground Water Resources

Ground water resource of the project districts have been assessed by Central Ground Water Board keeping in view the sustainable and optimum development of the resource. The estimation has been done based Ground Water Estimation methodology - 1997. Assessment is done taking into consideration of various hydrologic units viz. command, non-command hilly area with more than 20 % slope and poor quality area.

Bengaluru Urban District: Net annual groundwater availability of the district is 11,723 ham, total ground water draft for irrigation, domestic and industrial uses is 3,794 ham and existing gross ground water draft for all uses is 16,703 ham. Thus, draft exceeding the total available ground water resources leaving absolutely nil ground water resources for future use. The stage of ground water development in all the four taluks of the district is above 100% and are in the over exploited category. Therefore, Central Ground Water Authority has notified these taluks for registration of ground water abstraction structures.

Bengaluru Rural District: Net annual groundwater availability of the district is 19,394 ham, total ground water draft for irrigation is 23,202 ham, and total ground water draft for domestic and industrial uses is 2,450 ham and existing gross ground water draft for all uses is 25,653 ham. Thus, draft exceeding the total available ground water resources leaving almost nil ground water resources for future use. The stage of ground water development in all the four taluks of the district is above 100% and are in the over exploited category. Therefore, both Central Ground Water Authority and Karnataka Ground Water Authority have notified these taluks for regulation and development of ground water resources.

5.6.2. Drainage Conditions / Issues

In Urban limit, at few sections along existing railway alignment near the stations, there is concrete section of rectangular channel drains on either sides of the tracks, which are either open or covered. Along the alignment, it is mostly earthen drain or without drainages, where water is either stagnated or flows towards lower gradient areas. In most cases, these drains are open and connected to nearby culverts or cross drainage structures.

At peri-urban areas, runoff water flows towards either sides of the railway track and stagnate in the nearby low lying areas. This stagnated water gradually evaporates or percolates into the ground over a period of time.

The most common drainage defects observed are:

- Absence of side drains and ponding of water at the railway side – in both urban and peri-urban areas;
- In some instances, there is inadequate width between neighbouring property and the Railway edge to construct effective side drainage;
- Poor grading of the shoulder and side-slopes, allowing water to channel and scour along the railway edge and stagnate along the edges instead of running off into the side drains;
- In urban areas, blocked or broken drainage channels and various obstructions to run-off.

5.6.3. Surface & Ground Water Quality

Water samples were collected from various surface & ground water sources along the project corridors and were examined for selected Physico-chemical, Heavy Metal and Bacteriological parameters in order to assess the pollution /contamination level of the waterbodies due to existing railway, industrial, sewage intrusion and other activities. This helped in establishing the baseline water quality of the project area, which can be used for comparison with water quality during construction and operation phases of the project.

5.6.3.1. Surface Water Quality

To assess the surface water quality in the project region, lakes and surface water drainages abutting/crossing the project corridors were identified by conducting detailed environmental survey using structured format and secondary data sources. Water sampling locations were selected based on the survey outcome after confirming the presence of water in the waterbodies at site, land use and understanding the significance of it for the local community. Based on the study, a comprehensive monitoring network was designed to understand the baseline water quality levels in the region. About 37 Surface water samples were collected for four BSRP corridors to establish baseline water quality of the study area. Sampling for water quality monitoring was conducted at all the locations once during March & April 2022. The surface water samples were collected and tested as per the procedures specified by CPCB. Results was compared with IS: 2296 Class C – “Drinking Water with Conventional Treatment followed by disinfection”. Surface water monitoring locations identified for the project corridors are tabulated in **Table 5.10**. Photographs of the Surface Water sampling sites are presented as **Annexure 5.4**.

Table 5.10. Details of Surface Water Sampling Locations along the BSRP Corridors

Location Code	Source/ Location	Co-ordinates	Direction & Distance from the Corridor
Corridor – 1: KSR Bengaluru City to Devanahalli			
SW1	Drain near KSR Rly. station	12°59'8.47"N 77°34'12.94"E	Drainage water which is located 5m distance from right side of the track
SW2	Drain near Malleswaram	13° 3'21.86"N 77°34'13.14"E	Drainage water which is located 82m distance from right side of the track
SW3	Lake near Hebbal	13° 5'33.50"N 77°35'27.51"E	Lake water which was located in 560m distance Left side of the track
SW4	Yelahanka Lake	13° 6'46.51"N 77°35'19.89"E	Lake water which was located in 53m distance right side of the track
SW5	Stream, Yelahanka	13° 8'17.09"N 77°35'26.12"E	Stream water which was located in 05m distance right side of the track
SW6	Doddajala Lake	13°10'43.20"N 77°38'22.96"E	Lake water which was located in 205m distance right side of the track
SW7	Devanahalli Lake	13°15'8.39"N 77°42'28.44"E	Pond water which was located in 137m distance right side of the track
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara			
SW1	Canal near Nagawarpalya	12°59'27.45"N 77°39'59.10"E	Canal contains drainage water which is located 90m distance from right side of the track
SW2	Drain at Lingarajapura	13° 0'35.22"N 77°37'15.32"E	Drainage water which is located 25m distance from left side of the track
SW3	Drain at Kadugondanahalli	13° 1'36.23"N 77°37'8.15"E	Drainage water which is located 23m distance from right side of the track
SW4	Drain at Kanakanagar, Hebbal	13° 2'28.20"N 77°36'1.01"E	Drainage water which is located 44m distance from right side of the track
SW5	Drain at Devinagar	13° 2'48.66"N 77°34'15.23"E	Drainage water which is located 105m distance from left side of the track
SW6	Drain at MSR Nagar	13° 2'23.82"N 77°33'39.72"E	Drainage water which is located 41m distance from left side of the track
SW7	Drain at Shettyhalli	13° 3'56.00"N 77°31'12.50"E	Drainage water which is located 90m distance from right side of the track
SW8	Drain at Myadarahalli	13° 4'10.76"N 77°30'39.48"E	Drainage water which is located 33m distance from left side of the track
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)			
SW1	Drain at Dubasipalya	12°55'36.05"N 77°30'0.22"E	Drainage water which is located 5m distance from right side of the track
SW2	Stream near Jnanabharathi Metro Station	12°56'12.81"N 77°30'47.53"E	Stream contains drainage water is located 103m distance from right side of the track
SW3	Canal at Nayandahalli	12°56'35.15"N 77°31'26.19"E	Canal contains drainage water which is located 116m distance from right side of the track
SW4	Drain near Bapuji Nagar	12°57'21.64"N 77°32'15.28"E	Drainage water which is located 76m distance from left side of the track

Location Code	Source/ Location	Co-ordinates	Direction & Distance from the Corridor
SW5	Vrishabavathi River	12°57'51.01"N 77°32'40.97"E	River contains drainage water which is located 45m distance from right side of the track
SW6	Drain near Padarayanapura	13° 0'3.78"N 77°36'39.40"E	drainage water which is located 35m distance from left side of the track
SW7	Benniganahalli Lake	12°59'52.68"N 77°39'55.74"E	Lake water which was located in 53m distance right side of the track
SW8	Drain at Chikkadabasandra	13° 0'1.09"N 77°42'7.68"E	Drainage water which is located 68m distance from left side of the track
SW9	Drain near Ayyappanagar	12°59'50.55"N 77°42'51.87"E	Drainage water which is located 82m distance from left side of the track
SW10	Drain near Whitefield	12°59'43.26"N 77°43'28.12"E	Drainage water which is located 46m distance from left side of the track
Corridor – 4: Heelalige to Rajanukunte			
SW1	Gottamaranahalli Lake	12°50'57.41"N 77°42'38.19"E	Lake water which was located in 89m distance left side of the track
SW2	Huskur Lake	12°51'55.45"N 77°42'36.29"E	Lake water which was located in 28m distance right side of the track
SW3	Avalahalli Lake	12°52'39.62"N 77°42'28.72"E	Lake water which was located in 30m distance right side of the track
SW4	Panathur lake	12°56'0.82"N 77°42'22.34"E	Lake water which was located in 49m distance left side of the track
SW5	Canal near Panathur	12°56'31.06"N 77°42'23.91"E	Canal water which is located 10m distance from right side of the track
SW6	Canal near Doddanekundi	12°58'33.52"N 77°41'35.63"E	Canal contains drainage water which is located 90m distance from right side of the track
SW7	Benniganahalli Lake	12°59'53.60"N 77°39'51.77"E	Lake water which was located in 113m distance left side of the track
SW8	Canal at Horamavu	13° 1'50.22"N 77°39'20.34"E	Canal contains drainage water which is located 58m distance from right side of the track
SW9	Canal near Geddalahalli	13° 2'34.45"N 77°38'41.16"E	Canal contains drainage water which is located 270m distance from right side of the track
SW10	Jakkur Lake	13° 4'48.74"N 77°36'40.71"E	Lake water which was located in 3m distance right side of the track
SW11	Yelahanka Lake	13° 6'46.51"N 77°35'19.89"E	Lake water which was located in 53m distance right side of the track
SW12	Rajanukunte Lake	13° 9'55.74"N 77°34'4.75"E	Lake water which was located in 94m distance right side of the track

The monitoring results for surface water quality for BSRP corridors are presented in **Table 5.11.** to **Table 5.14.**

Table 5.11. Surface Water Analysis Results for Corridor – 1: KSR Bengaluru City to Devanahalli

S. No	Parameters	Unit	SW-1 Stream	SW-2 Stream	SW-3 Lake	SW-4 Lake	SW-5 Stream	SW-6 Lake	SW-7 Lake	Limit as per IS 2296: 1982
1	PH	-	7.17	7.62	8.21	8.28	7.78	7.82	7.98	6.5 – 8.5
2	Colour	Hazen	12	14	12	58	10	12	10	300
3	Temperature	^0C	28.1	28.5	27.9	28.5	27.8	28.1	27.8	Not specified
4	Electrical Conductivity	µS/cm	968	1020	1780	1840	964	992	764	Not specified
5	Turbidity	NTU	28	24	4	22	13.2	14.4	12.9	Not specified
6	Total Solids	mg/l	530	560	930	1378	515	536	415	Not specified
7	Suspended Solids	mg/l	46	46	32	38	28	34	26	Not specified
8	Total Dissolved Solids	mg/l	480	510	890	920	482	496	382	1500
9	Dissolved Oxygen	mg/l	6.8	6.9	6.9	6.9	6.8	6.9	6.8	4 (Minimum)
10	Biological Oxygen Demand	mg/l	660	543	210	190	687	664	14	3
11	Chemical Oxygen Demand	mg/l	2640	2172	840	760	2748	2656	56	Not specified
12	Alkalinity as $CaCO_3$	mg/l	182	198	245	282	135	144	168	Not specified
13	Total Hardness as $CaCO_3$	mg/l	201	228	580	608	165	178	170	Not specified

S. No	Parameters	Unit	SW-1 Stream	SW-2 Stream	SW-3 Lake	SW-4 Lake	SW-5 Stream	SW-6 Lake	SW-7 Lake	Limit as per IS 2296: 1982
14	Chlorides	mg/l	82.6	101	98.4	156	138	112	48.1	600
15	Fluorides	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	1.5
16	Sodium	mg/l	72	95	98	110	95	102	55	Not specified
17	Potassium	mg/l	15	16	16	34	20	23	13	Not specified
18	Calcium	mg/l	56.1	68.3	72.6	110	48.1	56.3	48.1	Not specified
19	Magnesium	mg/l	16.2	19.8	14.5	28.2	12.2	15.8	12.2	Not specified
20	Sulphates	mg/l	36.2	44.1	33.8	89	44.7	49.4	27.8	400
21	Nitrates	mg/l	4.6	9.2	8.6	9.6	5.8	6.1	1.98	50
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	Not specified
23	Total Nitrogen, N	mg/l	9.8	19.2	16.4	20.1	12.6	14.2	5.6	Not specified
24	Phosphates	mg/l	0.3	0.24	0.28	0.58	0.36	0.39	0.25	Not specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.005
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	0.72	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	50
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	Not specified
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	1.5
30	Nickel	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	Not specified
31	Cadmium	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.01

S. No	Parameters	Unit	SW-1 Stream	SW-2 Stream	SW-3 Lake	SW-4 Lake	SW-5 Stream	SW-6 Lake	SW-7 Lake	Limit as per IS 2296: 1982
32	Chromium	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	0.05
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	Not specified
34	Lead	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.1
35	Oil and Grease	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	6	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	10
36	Total Coliforms	MPN/100 ml	$1.2X10^4$	$1.2X10^4$	$2.3X10^4$	$2.1X10^4$	$1.5X10^4$	$1.3X10^4$	$1.1X10^4$	5000
37	Faecal Coliforms	MPN/100 ml	>1600	>1600	>1600	>1600	>1600	>1600	>1600	Not specified

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Table 5.12. Surface Water Analysis Results for Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara

S.No	Parameters	Unit	SW-1 Canal	SW-2 Drain	SW-3 Drain	SW-4 Drain	Limit as per IS 2296:1982
1	PH	-	8.38	7.86	8.25	7.75	6.5 – 8.5
2	Colour	Hazen	80	75	72	76	300
3	Temperature	^0C	28.6	27.2	27.5	27.2	Not specified
4	Electrical Conductivity	µS/cm	3312	3320	3270	3160	Not specified
5	Turbidity	NTU	247	138	208	166	Not specified
6	Total Solids	mg/l	1858	1815	1800	1752	Not specified
7	Suspended Solids	mg/l	186	150	158	152	Not specified
8	Total Dissolved Solids	mg/l	1656	1660	1635	1580	1500
9	Dissolved Oxygen	mg/l	7.2	6.9	6.9	6.7	4 (Minimum)
10	Biological Oxygen Demand	mg/l	960	320	300	360	3
11	Chemical Oxygen Demand	mg/l	3840	1280	1200	1440	Not specified
12	Alkalinity as $CaCO_3$	mg/l	513	496	492	486	Not specified

S.No	Parameters	Unit	SW-1 Canal	SW-2 Drain	SW-3 Drain	SW-4 Drain	Limit as per IS 2296:1982
13	Total Hardness as $CaCO_3$	mg/l	752	662	642	610	Not specified
14	Chlorides	mg/l	392	469	493	474	600
15	Fluorides	mg/l	0.6	0.2	0.1	0.3	1.5
16	Sodium	mg/l	220	210	215	205	Not specified
17	Potassium	mg/l	46	44	46	40	Not specified
18	Calcium	mg/l	262	212	218	204	Not specified
19	Magnesium	mg/l	46.3	32.5	42.6	40.6	Not specified
20	Sulphates	mg/l	132	158	162	158	400
21	Nitrates	mg/l	62.5	58.2	60.4	58.8	50
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	Not specified
23	Total Nitrogen, N	mg/l	126	117	121	118	Not specified
24	Phosphates	mg/l	1.5	0.7	0.6	0.58	Not specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.005
26	Iron as Fe	mg/l	0.2	0.2	0.1	BQL(LOQ:0.1)	50
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	Not specified
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	1.5
30	Nickel	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	Not specified
31	Cadmium	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.01
32	Chromium	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	0.05
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	Not specified
34	Lead	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.1
35	Oil and Grease	mg/l	8.2	6.2	6.5	6.8	10
36	Total Coliforms	MPN/100ml	$5.6X10^4$	$1.4X10^4$	$1.5X10^4$	$1.1X10^4$	5000
37	Faecal Coliforms	MPN/100ml	>1600	>1600	>1600	>1600	Not specified

S.No	Parameters	Unit	SW-5 Drain	SW-6 Drain	SW-7 Drain	SW-8 Drain	Limit as per IS 2296:1982
1	PH	-	7.91	7.95	7.81	8.24	6.5 – 8.5
2	Colour	Hazen	74	68	66	68	300
3	Temperature	^0C	27.8	28.1	27.9	27.4	Not specified

S.No	Parameters	Unit	SW-5 Drain	SW-6 Drain	SW-7 Drain	SW-8 Drain	Limit as per IS 2296:1982
4	Electrical Conductivity	µS/cm	3162	3192	2760	2704	Not specified
5	Turbidity	NTU	126	179	138	231	Not specified
6	Total Solids	mg/l	1735	1751	1514	1428	Not specified
7	Suspended Solids	mg/l	142	148	134	138	Not specified
8	Total Dissolved Solids	mg/l	1582	1596	1380	1280	1500
9	Dissolved Oxygen	mg/l	6.9	6.8	6.9	6.8	4 (Minimum)
10	Biological Oxygen Demand	mg/l	340	320	280	340	3
11	Chemical Oxygen Demand	mg/l	1360	1280	1120	1360	Not specified
12	Alkalinity as $CaCO_3$	mg/l	498	436	448	484	Not specified
13	Total Hardness as $CaCO_3$	mg/l	616	622	496	468	Not specified
14	Chlorides	mg/l	475	477	436	411	600
15	Fluorides	mg/l	0.2	0.2	0.1	0.2	1.5
16	Sodium	mg/l	212	218	182	142	Not specified
17	Potassium	mg/l	44	46	40	38	Not specified
18	Calcium	mg/l	210	216	198	218	Not specified
19	Magnesium	mg/l	38.8	41.2	40.8	52.2	Not specified
20	Sulphates	mg/l	162	156	140	135	400
21	Nitrates	mg/l	59.5	60.2	52.6	49.6	50
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	Not specified
23	Total Nitrogen, N	mg/l	122	124	114	105	Not specified
24	Phosphates	mg/l	0.52	0.56	0.62	0.68	Not specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.005
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	0.1	50
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	Not specified
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	1.5
30	Nickel	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	Not specified

S.No	Parameters	Unit	SW-5 Drain	SW-6 Drain	SW-7 Drain	SW-8 Drain	Limit as per IS 2296:1982
31	Cadmium	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.01
32	Chromium	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	0.05
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	Not specified
34	Lead	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.1
35	Oil and Grease	mg/l	6.4	6.2	5.8	5.6	10
36	Total Coliforms	MPN/100ml	$1.7X10^4$	$1.8X10^4$	$1.6X10^4$	$1.1X10^4$	5000
37	Faecal Coliforms	MPN/100ml	>1600	>1600	>1600	>1600	Not specified

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Table 5.13. Surface Water Analysis Results for Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)

S.No	Parameters	Unit	SW-1 Drain	SW-2 Stream	SW-3 Canal	SW-4 Drain	SW-5 Vrishabavathi River	Limit as per IS 2296:1982
1	PH	-	7.76	7.57	7.53	7.68	7.43	6.5 – 8.5
2	Colour	Hazen	72	16	76	68	22	300
3	Temperature	^0C	28.1	28.1	28.3	27.4	28.1	Not specified
4	Electrical Conductivity	µS/cm	2704	884	2402	2504	918	Not specified
5	Turbidity	NTU	181	28	183	166	36	Not specified
6	Total Solids	mg/l	1501	480	1342	1395	501	Not specified
7	Suspended Solids	mg/l	142	36	132	128	38	Not specified
8	Total Dissolved Solids	mg/l	1352	442	1201	1252	459	1500
9	Dissolved Oxygen	mg/l	6.7	6.8	6.9	6.9	6.7	4 (Minimum)
10	Biological Oxygen Demand	mg/l	300	547	945	340	152	3
11	Chemical Oxygen Demand	mg/l	1200	2186	3780	1360	631	Not specified
12	Alkalinity as $CaCO_3$	mg/l	492	176	496	478	181	Not specified
13	Total Hardness as $CaCO_3$	mg/l	482	188	440	458	210	Not specified

S.No	Parameters	Unit	SW-1 Drain	SW-2 Stream	SW-3 Canal	SW-4 Drain	SW-5 Vrishabavathi River	Limit as per IS 2296:1982
14	Chlorides	mg/l	458	78.6	392	405	88.1	600
15	Fluorides	mg/l	0.3	BQL(LOQ:0.1)	0.3	0.1	BQL(LOQ:0.1)	1.5
16	Sodium	mg/l	208	62	125	122	65	Not specified
17	Potassium	mg/l	42	11	34	32	9	Not specified
18	Calcium	mg/l	216	48.3	172	216	51.2	Not specified
19	Magnesium	mg/l	48.2	12.2	44.2	38.4	14.6	Not specified
20	Sulphates	mg/l	154	28	132	135	32.6	400
21	Nitrates	mg/l	51.2	3.8	45.5	48.2	4.2	50
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	Not specified
23	Total Nitrogen, N	mg/l	108	8.2	92.5	98.4	8.8	Not specified
24	Phosphates	mg/l	0.72	0.3	0.68	0.52	0.18	Not specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.005
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	50
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	Not specified
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	1.5
30	Nickel	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	Not specified
31	Cadmium	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.01
32	Chromium	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	0.05
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	Not specified
34	Lead	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.1
35	Oil and Grease	mg/l	5.4	BQL(LOQ:4)	6.2	5.4		10
36	Total Coliforms	MPN/100ml	$1.5X10^4$	$1.1X10^4$	$6.1X10^4$	$1.8X10^4$	$1.5X10^4$	5000
37	Faecal Coliforms	MPN/100ml	>1600	>1600	>1600	>1600	>1600	Not specified

S.No	Parameters	Unit	SW-6 Drain	SW-7 Beneganahalli Lake	SW-8 Drain	SW-9 Drain	SW-10 Drain	Limit as per IS 2296:1982
1	PH	-	8.08	7.82	7.86	8.21	8.24	6.5 – 8.5
2	Colour	Hazen	70	68	74	72	68	300

S.No	Parameters	Unit	SW-6 Drain	SW-7 Beneganahalli Lake	SW-8 Drain	SW-9 Drain	SW-10 Drain	Limit as per IS 2296:1982
3	Temperature	^0C	28.1	28.7	28.3	27.8	27.6	Not specified
4	Electrical Conductivity	µS/cm	2568	1772	3220	2922	2804	Not specified
5	Turbidity	NTU	198	118	133	135	212	Not specified
6	Total Solids	mg/l	1442	138	1751	1595	1534	Not specified
7	Suspended Solids	mg/l	138	48	124	128	122	Not specified
8	Total Dissolved Solids	mg/l	1284	886	1610	1461	1402	1500
9	Dissolved Oxygen	mg/l	6.8	7.3	6.8	6.9	6.9	4 (Minimum)
10	Biological Oxygen Demand	mg/l	340	104	320	240	260	3
11	Chemical Oxygen Demand	mg/l	1360	416	1280	960	1040	Not specified
12	Alkalinity as $CaCO_3$	mg/l	494	340	488	496	498	Not specified
13	Total Hardness as $CaCO_3$	mg/l	462	433	612	488	482	Not specified
14	Chlorides	mg/l	409	172	480	460	457	600
15	Fluorides	mg/l	0.2	BQL(LOQ:0.1)	0.1	0.2	0.1	1.5
16	Sodium	mg/l	130	95	215	210	198	Not specified
17	Potassium	mg/l	36	15	48	42	40	Not specified
18	Calcium	mg/l	212	98.6	146	156	162	Not specified
19	Magnesium	mg/l	36.5	15.8	52.4	52.2	48.8	Not specified
20	Sulphates	mg/l	138	54.6	160	158	156	400
21	Nitrates	mg/l	48.6	9.3	60.8	50.8	50.8	50
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	Not specified
23	Total Nitrogen, N	mg/l	98.8	11.5	125	110	112	Not specified
24	Phosphates	mg/l	0.58	0.35	0.72	0.6	0.52	Not specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.005
26	Iron as Fe	mg/l	0.2	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	50
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	Not specified
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15

S.No	Parameters	Unit	SW-6 Drain	SW-7 Beneganahalli Lake	SW-8 Drain	SW-9 Drain	SW-10 Drain	Limit as per IS 2296:1982
29	Copper	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	1.5
30	Nickel	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	Not specified
31	Cadmium	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.01
32	Chromium	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	0.05
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	Not specified
34	Lead	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.1
35	Oil and Grease	mg/l	6		5.8	6.2	5.8	10
36	Total Coliforms	MPN/100ml	$1.5X10^4$	$3.1X10^4$	$1.4X10^4$	$1.7X10^4$	$1.6X10^4$	5000
37	Faecal Coliforms	MPN/100ml	>1600	>1600	>1600	>1600	>1600	Not specified

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Table 5.14. Surface Water Analysis Results for Corridor – 4: Heelalige to Rajanukunte

S. No	Parameters	Unit	SW-1 Gottamaranahalli Lake	SW-2 Huskur Lake	SW-3 Avalahalli Lake	SW-4 Panathur lake	SW-5 Canal	SW-6 Canal	Limit as per IS 2296:1982
1	PH	-	7.51	7.82	8.18	7.54	7.24	7.11	6.5 – 8.5
2	Colour	Hazen	80	20	150	30	60	300	300
3	Temperature	^0C	29.5	28.8	28.9	28.5	28.6	28.5	Not specified
4	Electrical Conductivity	µS/cm	3790	1131	1668	1047	3370	1754	Not specified
5	Turbidity	NTU	42	8	46	15	22	50	Not specified
6	Total Solids	mg/l	1940	580	855	542	1721	1142	Not specified
7	Suspended Solids	mg/l	46	8	18	12	38	262	Not specified
8	Total Dissolved Solids	mg/l	1890	566	834	523	1680	877	1500

S. No	Parameters	Unit	SW-1 Gottamaranahalli Lake	SW-2 Huskur Lake	SW-3 Avalahalli Lake	SW-4 Panathur lake	SW-5 Canal	SW-6 Canal	Limit as per IS 2296:1982
9	Dissolved Oxygen	mg/l	6.9	6.8	6.9	6.9	6.9	6.8	4 (Minimum)
10	Biological Oxygen Demand	mg/l	62	10	15	4	114	120	3
11	Chemical Oxygen Demand	mg/l	248	40	60	16	456	480	Not specified
12	Alkalinity as $CaCO_3$	mg/l	474	198	248	124	463	328	Not specified
13	Total Hardness as $CaCO_3$	mg/l	870	200	350	180	660	410	Not specified
14	Chlorides	mg/l	612	153	248	176	478	242	600
15	Fluorides	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	1.5
16	Sodium	mg/l	112	54	58	52	72	61	Not specified
17	Potassium	mg/l	18	10	12	12	16	14	Not specified
18	Calcium	mg/l	180	72.6	82.8	68.5	168	92.6	Not specified
19	Magnesium	mg/l	42.5	18.6	19.2	16.4	38.3	19.8	Not specified
20	Sulphates	mg/l	192	52.6	81.3	51.8	162	82.6	400
21	Nitrates	mg/l	64.4	38.2	41.6	36.5	58.5	43.6	50
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	Not specified
23	Total Nitrogen, N	mg/l	68.2	43.5	45.8	40.1	63.2	41.6	Not specified
24	Phosphates	mg/l	0.38	0.24	0.28	0.29	0.42	0.38	Not specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.005
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	0.72	BQL(LOQ:0.1)	BQL(LOQ:0.1)	50

S. No	Parameters	Unit	SW-1 Gottamaranahalli Lake	SW-2 Huskur Lake	SW-3 Avalahalli Lake	SW-4 Panathur lake	SW-5 Canal	SW-6 Canal	Limit as per IS 2296:1982
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	Not specified
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	1.5
30	Nickel	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	Not specified
31	Cadmium	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.01
32	Chromium	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	0.05
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	Not specified
34	Lead	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.1
35	Oil and Grease	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	6	BQL(LOQ:4)	BQL(LOQ:4)	10
36	Total Coliforms	MPN/100ml	$1.3X10^4$	$1.3X10^2$	$2.5X10^4$	$2.3X10^4$	$1.7X10^4$	$1.5X10^4$	5000
37	Faecal Coliforms	MPN/100ml	>1600	60	>1600	>1600	>1600	>1600	Not specified

S. No	Parameters	Unit	SW-7 Benniganahalli Lake	SW-8 Canal	SW-9 Canal	SW-10 Jakkur Lake	SW -11 Yelahanka Lake	SW-12 Rajanukunte Lake	Limit as per IS 2296: 1982
1	PH	-	7.82	7.25	7.4	8.23	8.28	7.9	6.5 – 8.5
2	Colour	Hazen	68	250	190	120	58	100	300
3	Temperature	^{0}C	28.7	29.1	28.8	29.1	28.5	29.3	Not specified
4	Electrical Conductivity	µS/cm	1772	1915	3010	1728	1840	762	Not specified
5	Turbidity	NTU	118	187	202	87	22	15	Not specified

S. No	Parameters	Unit	SW-7 Benniganahalli Lake	SW-8 Canal	SW-9 Canal	SW-10 Jakkur Lake	SW -11 Yelahanka Lake	SW-12 Rajanukunte Lake	Limit as per IS 2296: 1982
6	Total Solids	mg/l	138	1212	1621	912	1378	431	Not specified
7	Suspended Solids	mg/l	48	253	112	42	38	44	Not specified
8	Total Dissolved Solids	mg/l	886	956	1500	860	920	381	1500
9	Dissolved Oxygen	mg/l	7.3	6.9	6.8	6.9	6.9	6.8	4 (Minimum)
10	Biological Oxygen Demand	mg/l	104	140	160	14	90	22	3
11	Chemical Oxygen Demand	mg/l	416	560	640	56	360	88	Not specified
12	Alkalinity as $CaCO_3$	mg/l	340	382	468	356	282	148	Not specified
13	Total Hardness as $CaCO_3$	mg/l	433	426	550	350	508	155	Not specified
14	Chlorides	mg/l	172	292	363	237	156	98.1	600
15	Fluorides	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	1.5
16	Sodium	mg/l	95	52	54	58	110	36	Not specified
17	Potassium	mg/l	15	12	12	10	34	8	Not specified
18	Calcium	mg/l	98.6	98.4	148	64.6	110	36.5	Not specified
19	Magnesium	mg/l	15.8	21.5	36.5	12.5	28.2	8.6	Not specified
20	Sulphates	mg/l	74.6	94.8	138	78.6	89	34.5	400
21	Nitrates	mg/l	9.3	42.8	56.2	38.3	9.6	12.6	50
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	Not specified

S. No	Parameters	Unit	SW-7 Benniganahalli Lake	SW-8 Canal	SW-9 Canal	SW-10 Jakkur Lake	SW -11 Yelahanka Lake	SW-12 Rajanukunte Lake	Limit as per IS 2296: 1982
23	Total Nitrogen, N	mg/l	42.5	45.4	60.1	42.1	20.1	15.3	Not specified
24	Phosphates	mg/l	0.35	0.4	0.34	0.21	0.58	0.22	Not specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.005
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	0.72	BQL(LOQ:0.1)	50
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	Not specified
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	1.5
30	Nickel	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	Not specified
31	Cadmium	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.01
32	Chromium	mg/l	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	BQL (LOQ:0.05)	0.05
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	Not specified
34	Lead	mg/l	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	BQL (LOQ:0.01)	0.1
35	Oil and Grease	mg/l		BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	6	BQL(LOQ:4)	10
36	Total Coliforms	MPN/ 100ml	$3.4X10^4$	$1.4X10^4$	$1.3X10^4$	$1.8X10^2$	$2.7X10^4$	$1.8X10^4$	5000
37	Faecal Coliforms	MPN/ 100ml	>1600	>1600	>1600	92	>1600	>1600	Not specified

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Results and Observation:

Corridor 1: The pH value of the collected surface water in the study area found to be in the range from 7.17 to 8.28 and conductivity observed in the range 764 µS/cm to 1840 µS/cm. TDS values were observed to be in range from 382 mg/L to 920 mg/ L. Total alkalinity is found to be the range from 135 mg/L to 282 mg/L and Total Hardness ranges from 165 to 608 mg/L. The chloride values of the samples were observed from 48.1 mg/L to 156 mg/L and Sulphate values were observed from 27.8 mg/L to 89 mg/L. The Calcium and magnesium values were ranged from 48.1 mg/L to 110 mg/L and 12.2 mg/L to 28.2mg/L respectively. Iron content found in the range from 0.10 mg/L to 0.72 mg/l. COD values observed in the range from 16 mg/l to 400 mg/l. Most of the heavy metals are observed to be within the detection limit. Total Coliforms were observed from 110 MPN/100ml to 230 MPN/100ml and Fecal Coliforms were observed from >1600 MPN/100ml at all locations.

For Corridor 1, the baseline environmental monitoring for surface water quality results reveals that, all the surface water quality parameters falls within permissible limits of IS:9926 Standards except for Biological Oxygen Demand and Total Coliform.

Corridor 2: The pH value of the collected surface water in the study area found to be in the range from 7.75 to 8.38 and conductivity observed in the range 2704 µS/cm to 3320 µS/cm. TDS values were observed to be in range from 1280 mg/L to 1660 mg/ L. Total alkalinity is found to be the range from 436 mg/L to 513 mg/L and Total Hardness ranges from 468 to 752 mg/L. The chloride values of the samples were observed from 392 mg/L to 493 mg/L and Sulphate values were observed from 132 mg/L to 162 mg/L. The Calcium and magnesium values were ranged from 198 mg/L to 262 mg/L and 32.5 mg/L to 52.2 mg/L respectively. Iron content found in the range from 0.10 mg/L to 0.2 mg/l. COD values observed in the range from 1120 mg/l to 1440 mg/l. Most of the metals are observed to be within the detection limit. Total Coliforms were observed from 110 MPN/100ml to 560 MPN/100ml and Fecal Coliforms were observed from >1600 MPN/100ml at all locations.

For Corridor 2, the baseline environmental monitoring for surface water quality results reveals that, TDS values exceeds permissible limits of IS:9926 Standards in the locations from SW1 to SW6 and Nitrate values are exceeding in the locations from SW1 to SW7. Further, Biological Oxygen Demand and Total Coliform values exceed the permissible limits of IS:9926 Standards in all the monitoring locations. However, remaining parameters for all the monitoring locations are falling within the permissible limits of IS:9926 Standards.

Corridor 3: The pH value of the collected surface water in the study area found to be in the range from 7.43 to 8.24 and conductivity observed in the range 884 µS/cm to 3220 µS/cm. TDS values were observed to be in range from 442 mg/L to 1610 mg/ L. Total alkalinity is found to be the range from 176 mg/L to 498 mg/L and Total Hardness ranges from 188 to 612 mg/L. The chloride values of the samples were observed from 78.6 mg/L to 480 mg/L and Sulphate values were observed from 28 mg/L to 160 mg/L. The Calcium and magnesium values were ranged from 48.3 mg/L to 216 mg/L and 12.2 mg/L to 52.4 mg/L respectively. Iron content found in the range from 0.10 mg/L to 0.2 mg/l. COD values observed in the range from 416 mg/l to 1360 mg/l. Most of the metals are observed to be within the detection limit. Total Coliforms were observed from 110 MPN/100ml to 610 MPN/100ml and Fecal Coliforms were observed from >1600 MPN/100ml at all locations.

For Corridor 3, the baseline environmental monitoring for surface water quality results reveals that, TDS values exceeds permissible limits of IS:9926 Standards in SW8 and Nitrate values are exceeding in the locations from SW1, SW8, SW9 and SW10. Further, Biological Oxygen Demand and Total Coliform values exceeds the permissible limits of IS:9926 Standards in all the monitoring locations. However, remaining parameters for all the monitoring locations are falling within the permissible limits of IS:9926 Standards.

Corridor 4: The pH value of the collected surface water in the study area found to be in the range from 7.11 to 8.28 and conductivity observed in the range 762 µS/cm to 3790 µS/cm. TDS values were observed to be in range from 381 mg/L to 1890 mg/ L. Total alkalinity is found to be the range from 124 mg/L to 474 mg/L and Total Hardness ranges from 155 to 870 mg/L. The chloride values of the samples were observed from 98.1 mg/L to 612 mg/L and Sulphate values were observed from 34.5 mg/L to 192 mg/L. The Calcium and magnesium values were ranged from 36.5 mg/L to 180 mg/L and 8.6 mg/L to 42.5 mg/L respectively. Iron content found in the range from 0.10 mg/L to 0.72 mg/l. COD values observed in the range from 16 mg/l to 640 mg/l. Most of the metals are observed to be within the detection limit. Total Coliforms were observed from 130 MPN/100ml to 17000 MPN/100ml and Fecal Coliforms were observed from 60 MPN/100ml to >1600 MPN/100ml.

For Corridor 4, the baseline environmental monitoring for surface water quality results reveals that, TDS values exceeds permissible limits of IS:9926 Standards in SW1 and SW5, chloride value exceeds in SW1 and Nitrate values are exceeding in the locations from SW1, SW5 and SW9. Further, Biological Oxygen Demand and Total Coliform values exceeds the permissible limits of IS:9926 Standards in all the monitoring locations. However, remaining parameters for all the monitoring locations are falling within the permissible limits of IS:9926 Standards.

5.6.3.2. Ground Water Quality

In order to assess the ground water quality in the project region, ground water samples were collected all along the BSRP corridors. Samples were drawn from open well and bore wells near the project corridors. Residential, commercial and agricultural sources were selected to collect the water samples. Water samples were examined for Physico-chemical, Heavy metals and Bacteriological parameters in order to assess the effect of industrial, vehicular and other activities on ground water. 23 Ground Water samples were collected to establish baseline water quality of the study area. Sampling for water quality monitoring was conducted at all the locations once during March & April 2022. The ground water samples were collected and tested as per the procedures specified by CPCB. Results are compared with IS: 10500 – “Drinking Water specifications”. Details of Ground water sampling sites are presented in **Table 5.15**. Photographs of water collection locations are presented as **Annexure 5.4**.

Table 5.15. Details of Ground Water Sampling Locations along the BSRP Corridors

Location Code	Name of the Location	Co-ordinates	Direction & Distance from the Track
Corridor – 1: KSR Bengaluru City to Devanahalli			
GW1	KSR Bengalur	12°58'28.57"N 77°34'13.15"E	Residential Bore Well 30m Right Side of the Track
GW2	Lottegollanhalli	13° 2'36.57"N 77°33'47.15"E	Bore well water within the railway station
GW3	Yelahanka	13° 6'45.31"N 77°35'20.49"E	Bore well is located within 170m from the right side of the track
GW4	Doddajalla	13°10'49.91"N 77°38'30.82"E	Agriculture bore well is located within 60m from the right side of the track

Location Code	Name of the Location	Co-ordinates	Direction & Distance from the Track
GW5	Devanahalli	13°14'48.99"N 77°42'25.74"E	Bore well is located within 200m from the right side of the track
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara			
GW1	Benniganahalli	12°59'42.03"N 77°39'48.53"E	Residential Bore Well 50m Left Side of the Track
GW2	Guddadahalli	13° 2'28.08"N 77°35'58.15"E	Residential Bore Well 65m Right Side of the Track
GW3	Shettyhalli	13° 4'2.74"N 77°30'56.68"E	Residential Bore Well 90m Right Side of the Track
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)			
GW1	Near Kengeri Railway Station	12°55'8.11"N 77°29'6.20"E	Residential Bore Well 87m Right Side of the Track
GW2	Nayandananhalli	12°56'48.53"N 77°31'36.46"E	Bore well water within the railway station
GW3	Near KSR Railway Station	12°58'56.91"N 77°34'17.55"E	Residential Bore Well 70m right Side of the Track
GW4	Sarvangnya Nagar	13° 0'7.20"N 77°36'47.39"E	Residential Bore Well 120m right Side of the Track
GW5	Near Food Corporation of India	12°59'57.77"N 77°40'6.32"E	Residential Bore Well 85m right Side of the Track
GW6	Near Whitefield Station	12°59'55.09"N 77°44'31.96"E	Residential Bore Well 130m Left Side of the Track
Corridor – 4: Heelalige to Rajanukunte			
GW1	Heelalige	12°48'44.60"N 77°42'37.93"E	Residential Bore Well 190m Left Side of the Track
GW2	Open Well at Gattahalli	12°52'22.45"N 77°42'32.24"E	Agriculture Open well water is 280m distance of left side of the track
GW3	Doddkanelli	12°54'45.61"N 77°42'20.12"E	Residential Bore Well 45m right Side of the Track
GW4	Marathahalli	12°57'4.48"N 77°42'18.84"E	Residential Bore Well 76m Left Side of the Track
GW5	Doddanekundi	12°58'47.88"N 77°41'8.66"E	Residential Bore Well 125m Left Side of the Track
GW6	Hennur	13° 2'21.79"N 77°38'51.08"E	Residential Bore Well 55m Left Side of the Track
GW7	Yelahanka New Town	13° 5'50.90"N 77°35'40.57"E	Residential Bore Well 160m right Side of the Track
GW8	Naganahalli	13° 8'31.81"N 77°34'17.60"E	Residential Bore Well 210m Left Side of the Track
GW9	Rajanukunte	13°10'47.94"N 77°33'56.75"E	Residential Bore Well 140m Left Side of the Track

The monitoring results for ground water quality for BSRP corridors are presented in **Table 5.16.** to **Table 5.19.**

Table 5.16. Ground Water Analysis Results for Corridor – 1: KSR Bengaluru City to Devanahalli

S.No	Parameters	Unit	GW 1 KSR Bengaluru	GW 2 Lottegollanhalli	GW 3 Yelahanka	GW 4 Doddajalla	GW 5 Devanahalli	Limit as per IS 10500:2012
1	PH	-	7.98	7.81	8.01	7.85	7.78	6.5-8.5
2	Colour	Hazen	2	2	2	3	2	15
3	Temperature	^{0}C	28.3	29.1	29.1	29.3	28.8	Not Specified
4	Electrical Conductivity	µS/cm	2360	576	2280	1522	1029	Not Specified
5	Turbidity	NTU	1	1	1.4	2	1.2	5
6	Total Solids	mg/l	1302	312	1162	788	546	Not Specified
7	Suspended Solids	mg/l	4	4	2	4	2	Not Specified
8	Total Dissolved Solids	mg/l	1180	288	1140	761	514	2000
9	Dissolved Oxygen	mg/l	6.6	6.8	6.9	6.9	6.8	Not Specified
10	Biological Oxygen Demand	mg/l	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	Not Specified
11	Chemical Oxygen Demand	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
12	Alkalinity as $CaCO_3$	mg/l	415	118	178	262	138	600
13	Total Hardness as $CaCO_3$	mg/l	590	115	430	380	225	600
14	Chlorides	mg/l	267	55.4	352	196	138	1000
15	Fluorides	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	1.5
16	Sodium	mg/l	117	29	149	99	66	Not Specified
17	Potassium	mg/l	6	2	11	6	6	Not Specified
18	Calcium	mg/l	192	38.1	108	110	70.1	200
19	Magnesium	mg/l	26.8	4.9	39	25.6	12.2	100
20	Sulphates	mg/l	96	20.7	99	70.1	45.7	400
21	Nitrates	mg/l	47	6	29	5.3	4.97	21
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	22
23	Total Nitrogen, N	mg/l	65.3	10.2	42.5	9.8	8.2	23
24	Phosphates	mg/l	0.24	0.35	0.28	0.31	0.25	Not Specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.002

S.No	Parameters	Unit	GW 1 KSR Bengaluru	GW 2 Lottegollanhalli	GW 3 Yelahanka	GW 4 Doddajalla	GW 5 Devanahalli	Limit as per IS 10500:2012
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	0.3
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.001
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	1.5
30	Nickel	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.02
31	Cadmium	mg/l	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	0.003
32	Chromium	mg/l	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	Not Specified
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	0.3
34	Lead	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.01
35	Oil and Grease	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
36	Total Coliforms	MPN/100ml	Absent	Absent	Absent	Absent	Absent	Absent/100ml
37	Faecal Coliforms*	MPN/100ml	<2	<2	<2	<2	<2	Not Specified

*Note: * - Value of <2 can be considered as absent.*

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Table 5.17. Ground Water Analysis Results for Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara

S.No	Parameters	Unit	GW 1 Benniganahalli	GW 2 Guddadahalli	GW 3 Shettyhalli	Limit as per IS 10500:2012
1	PH	-	7.22	7.82	8.05	6.5-8.5
2	Colour	Hazen	2	4	2	15
3	Temperature	^0C	28.9	28.6	29.3	Not Specified
4	Electrical Conductivity	µS/cm	913	1120	2380	Not Specified
5	Turbidity	NTU	BQL(LOQ:0.1)	BQL(LOQ:0.1)	2	5
6	Total Solids	mg/l	460	550	1226	Not Specified
7	Suspended Solids	mg/l	2	4	6	Not Specified
8	Total Dissolved Solids	mg/l	457	540	1190	2000
9	Dissolved Oxygen	mg/l	6.9	6.8	6.8	Not Specified
10	Biological Oxygen Demand	mg/l	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	Not Specified
11	Chemical Oxygen Demand	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
12	Alkalinity as $CaCO_3$	mg/l	128	135	465	600
13	Total Hardness as $CaCO_3$	mg/l	195	252	600	600

S.No	Parameters	Unit	GW 1 Benniganahalli	GW 2 Guddadahalli	GW 3 Shettyhalli	Limit as per IS 10500:2012
14	Chlorides	mg/l	116	145	282	1000
15	Fluorides	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	1.5
16	Sodium	mg/l	58	72	112	Not Specified
17	Potassium	mg/l	8	10	12	Not Specified
18	Calcium	mg/l	62	76.2	180	200
19	Magnesium	mg/l	10.5	14.6	36.5	100
20	Sulphates	mg/l	39	49.2	97	400
21	Nitrates	mg/l	3.6	6.8	27	21
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	22
23	Total Nitrogen, N	mg/l	7.5	14	40.6	23
24	Phosphates	mg/l	0.37	0.28	0.30	Not Specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.002
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	0.3
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.001
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	1.5
30	Nickel	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.02
31	Cadmium	mg/l	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	0.003
32	Chromium	mg/l	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	Not Specified
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	0.3
34	Lead	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.01
35	Oil and Grease	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
36	Total Coliforms	MPN/100ml	Absent	Absent	Absent	Absent/100ml
37	Faecal Coliforms*	MPN/100ml	<2	<2	<2	Not Specified

*Note: * - Value of <2 can be considered as absent.*

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Table 5.18. Ground Water Analysis Results for Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)

S. No	Parameters	Unit	GW 1 Near Kengeri Railway Station	GW 2 Nayandananhalli	GW 3 Near KSR Railway Station	GW 4 Sarvangnya Nagar	GW 5 Near Food Corporation of India	GW 6 Near Whitefield Station	Limit as per IS 10500:2012
1	PH	-	7.5	7.69	7.52	7.38	7.04	7.34	6.5-8.5
2	Colour	Hazen	2	2	4	3	20	2	15
3	Temperature	^{0}C	28.7	28.7	28.4	28.5	28.7	28.9	Not Specified
4	Electrical Conductivity	µS/cm	1260	748	960	2360	2740	1723	Not Specified
5	Turbidity	NTU	3	BQL(LOQ:0.1)	2	2	21	BQL(LOQ:0.1)	5
6	Total Solids	mg/l	650	376	496	1203	1460	966	Not Specified
7	Suspended Solids	mg/l	12	2	8	10	12	10	Not Specified
8	Total Dissolved Solids	mg/l	630	372	480	1190	1350	861	2000
9	Dissolved Oxygen	mg/l	6.8	6.7	6.9	6.8	6.9	6.8	Not Specified
10	Biological Oxygen Demand	mg/l	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	Not Specified
11	Chemical Oxygen Demand	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
12	Alkalinity as $CaCO_3$	mg/l	162	125	132	112	158	282	600
13	Total Hardness as $CaCO_3$	mg/l	310	182	201	585	650	410	600
14	Chlorides	mg/l	152	88	123	296	301	208	1000
15	Fluorides	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	1.5
16	Sodium	mg/l	82	51	63	110	126	108	Not Specified
17	Potassium	mg/l	12	6	8	11	15	12	Not Specified
18	Calcium	mg/l	81.5	56	64.2	172	186	119	200
19	Magnesium	mg/l	16.2	8	9.8	34.5	38.2	28.2	100
20	Sulphates	mg/l	55	35	41	96.4	101	72.5	400
21	Nitrates	mg/l	7.2	3.2	4.8	25.6	30.5	8.1	21
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	22

S. No	Parameters	Unit	GW 1 Near Kengeri Railway Station	GW 2 Nayandananhalli	GW 3 Near KSR Railway Station	GW 4 Sarvangnya Nagar	GW 5 Near Food Corporation of India	GW 6 Near Whitefield Station	Limit as per IS 10500:2012
23	Total Nitrogen, N	mg/l	15	8	10.2	54.6	62	17	23
24	Phosphates	mg/l	0.25	0.29	0.18	0.3	0.24	0.31	Not Specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.002
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	0.3
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.001
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	1.5
30	Nickel	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.02
31	Cadmium	mg/l	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	0.003
32	Chromium	mg/l	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	Not Specified
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	0.3
34	Lead	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.01
35	Oil and Grease	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
36	Total Coliforms	MPN/100ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent/100ml
37	Faecal Coliforms*	MPN/100ml	<2	<2	<2	<2	<2	<2	Not Specified

*Note: * - Value of <2 can be considered as absent.*

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Table 5.19. Ground Water Analysis Results for Corridor – 4: Heelalige to Rajanukunte

S. No	Parameters	Unit	GW 1 Heelalige	GW 2 Gattahalli	GW 3 Doddkanelli	GW 4 Marathahalli	GW 5 Doddanekundi	Limit as per IS 10500:2012
1	PH	-	7.82	7.69	7.64	7.49	7.81	6.5-8.5
2	Colour	Hazen	2	2	2	3	3	15

S. No	Parameters	Unit	GW 1 Heelalige	GW 2 Gattahalli	GW 3 Doddkanelli	GW 4 Marathahalli	GW 5 Doddanekundi	Limit as per IS 10500:2012
3	Temperature	^0C	28.3	29.1	29.1	29.3	28.8	Not Specified
4	Electrical Conductivity	µS/cm	2440	1727	1293	1960	916	Not Specified
5	Turbidity	NTU	1.1	1.2	1.4	1.2	1.2	5
6	Total Solids	mg/l	1230	871	658	991	465	Not Specified
7	Suspended Solids	mg/l	2	2	2	4	2	Not Specified
8	Total Dissolved Solids	mg/l	1220	864	647	980	458	2000
9	Dissolved Oxygen	mg/l	6.6	6.8	6.9	6.9	6.8	Not Specified
10	Biological Oxygen Demand	mg/l	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	Not Specified
11	Chemical Oxygen Demand	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
12	Alkalinity as $CaCO_3$	mg/l	277	216	182	226	152	600
13	Total Hardness as $CaCO_3$	mg/l	585	350	318	418	236	600
14	Chlorides	mg/l	341	282	132	294	98.6	1000
15	Fluorides	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	1.5
16	Sodium	mg/l	106	92	80	96	36	Not Specified
17	Potassium	mg/l	16	12	8	14	8	Not Specified
18	Calcium	mg/l	180	84.1	72.1	128	54	200
19	Magnesium	mg/l	38.8	12.2	10.8	25.6	9.6	100
20	Sulphates	mg/l	118	81	66	101	42.5	400
21	Nitrates	mg/l	36	22	18	25	12	21
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	22
23	Total Nitrogen, N	mg/l	41.5	26.8	22.5	30.2	21.5	23
24	Phosphates	mg/l	0.28	0.23	0.24	0.21	0.18	Not Specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.002
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	0.3
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.001
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	1.5
30	Nickel	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.02
31	Cadmium	mg/l	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	0.003

S. No	Parameters	Unit	GW 1 Heelalige	GW 2 Gattahalli	GW 3 Doddkanelli	GW 4 Marathahalli	GW 5 Doddanekundi	Limit as per IS 10500:2012
32	Chromium	mg/l	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	Not Specified
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	0.3
34	Lead	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.01
35	Oil and Grease	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
36	Total Coliforms	MPN/100ml	Absent	Absent	Absent	Absent	Absent	Absent/100ml
37	Faecal Coliforms*	MPN/100ml	<2	<2	<2	<2	<2	Not Specified

S.No	Parameters	Unit	GW 6 Hennur	GW 7 Yelahanka New Town	GW 8 Naganahalli	GW 9 Rajanukunte	Limit as per IS 10500:2012
1	PH	-	7.9	7.51	7.52	7.47	6.5-8.5
2	Colour	Hazen	2	3	2	2	15
3	Temperature	^0C	28.3	28.7	28.9	28.5	Not Specified
4	Electrical Conductivity	µS/cm	2490	1184	1642	690	Not Specified
5	Turbidity	NTU	1.4	1.3	1.2	0.9	5
6	Total Solids	mg/l	1261	601	831	351	Not Specified
7	Suspended Solids	mg/l	4	4	2	2	Not Specified
8	Total Dissolved Solids	mg/l	1250	590	821	344	2000
9	Dissolved Oxygen	mg/l	6.8	6.9	6.8	6.7	Not Specified
10	Biological Oxygen Demand	mg/l	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	BQL(LOQ:2)	Not Specified
11	Chemical Oxygen Demand	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
12	Alkalinity as $CaCO_3$	mg/l	280	172	208	138	600
13	Total Hardness as $CaCO_3$	mg/l	592	265	342	135	600
14	Chlorides	mg/l	348	142	268	92.2	1000
15	Fluorides	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	1.5
16	Sodium	mg/l	108	73	86	38	Not Specified
17	Potassium	mg/l	18	8	8	8	Not Specified
18	Calcium	mg/l	184	68	72.5	41	200
19	Magnesium	mg/l	40.2	10.2	9.8	8.2	100

S.No	Parameters	Unit	GW 6 Hennur	GW 7 Yelahanka New Town	GW 8 Naganahalli	GW 9 Rajanukunte	Limit as per IS 10500:2012
20	Sulphates	mg/l	125	52.6	78.5	32.3	400
21	Nitrates	mg/l	38	18	18	12	21
22	Nitrites	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	22
23	Total Nitrogen, N	mg/l	42.2	22.8	23.5	15.8	23
24	Phosphates	mg/l	0.26	0.22	0.21	0.12	Not Specified
25	Phenols	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.002
26	Iron as Fe	mg/l	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	BQL(LOQ:0.1)	0.3
27	Mercury	mg/l	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	BQL(LOQ:0.001)	0.001
28	Zinc	mg/l	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	BQL(LOQ:0.02)	15
29	Copper	mg/l	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	BQL(LOQ:0.05)	1.5
30	Nickel	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.02
31	Cadmium	mg/l	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	BQL(LOQ:0.003)	0.003
32	Chromium	mg/l	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	BQL (LOQ:0.2)	Not Specified
33	Manganese	mg/l	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	BQL (LOQ:0.1)	0.3
34	Lead	mg/l	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	BQL(LOQ:0.01)	0.01
35	Oil and Grease	mg/l	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	BQL(LOQ:4)	Not Specified
36	Total Coliforms	MPN/100ml	Absent	Absent	Absent	Absent	Absent/100ml
37	Faecal Coliforms*	MPN/100ml	<2	<2	<2	<2	Not Specified

*Note: * - Value of <2 can be considered as absent.*

Source: Baseline Environmental Monitoring done by Enviro Solutions & Labs, Coimbatore

Results and Observation:

Corridor 1: The pH value of the collected ground water in the study area is found to be in the range from 7.78 to 8.01 and conductivity observed in the range 576 µS/cm to 2360 µS/cm. TDS values were observed to be in range from 288 mg/L to 1180 mg/ L. Total alkalinity is found to be the range from 118 mg/L to 415 mg/L and Total Hardness ranges from 115 to 590 mg/L. The chloride values of the samples were observed from 55.4 mg/L to 352 mg/L and Sulphate values were observed from 20.7 mg/L to 99 mg/L. The Calcium and magnesium values were ranged from 38.1 mg/L to 192 mg/L and 4.9 mg/L to 39 mg/L respectively. Most of the metals are observed as below the detection limit. Total Coliforms were observed as Absent/100ml and Fecal Coliforms were observed <2 MPN/100ml at all locations.

For Corridor 1, Ground water is neutral in nature where pH value varies from 7.78 to 8.01. Nitrates value in GW1 and GW3 is exceeding the Permissible limits of IS:10500 Standards and Total Nitrogen is exceeding the permissible limits of IS:10500 Standards in GW1. Ground water parameters of remaining locations are falling within the permissible limits of IS: 10500 standards.

Corridor 2: The pH value of the collected ground water in the study area is found to be in the range from 7.22 to 8.05 and conductivity observed in the range 913 µS/cm to 2380 µS/cm. TDS values were observed to be in range from 457 mg/L to 1190 mg/ L. Total alkalinity is found to be the range from 128 mg/L to 465 mg/L and Total Hardness ranges from 195 to 600 mg/L. The chloride values of the samples were observed from 116mg/L to 282 mg/L and Sulphate values were observed from 39 mg/L to 97 mg/L. The Calcium and magnesium values were ranged from 62 mg/L to 180 mg/L and 10.5 mg/L to 36.5 mg/L respectively. Most of the metals are observed as below the detection limit. Total Coliforms were observed as Absent/100ml and Fecal Coliforms were observed <2 MPN/100ml at all locations.

For Corridor 2, Ground water is neutral in nature where pH value varies from 7.22 to 8.02. Nitrates and Total Nitrogen are found slightly on higher side in GW3 which is exceeding the permissible limits of IS:10500 Standards. Ground water parameters of remaining locations are falling within the permissible limits of IS: 10500 Standards.

Corridor 3: The pH value of the collected ground water in the study area is found to be in the range from 7.04 to 7.69 and conductivity observed in the range 748 µS/cm to 2740 µS/cm. TDS values were observed to be in range from 372 mg/L to 1350 mg/ L. Total alkalinity is found to be the range from 112 mg/L to 282 mg/L and Total Hardness ranges from 182 to 650 mg/L. The chloride values of the samples were observed from 88 mg/L to 301 mg/L and Sulphate values were observed from 35 mg/L to 101 mg/L. The Calcium and magnesium values were ranged from 56 mg/L to 186 mg/L and 8.0 mg/L to 38.2 mg/L respectively. Most of the metals are observed as below the detection limit. Total Coliforms were observed as Absent/100ml and Fecal Coliforms were observed <2 MPN/100ml at all locations.

For Corridor 3, Ground water is slightly alkaline where pH value varies from 7.04 to 7.69. Colour, Turbidity, Nitrates and Total Nitrogen are exceeding the permissible limits of IS:10500 Standards. Nitrates and Total Nitrogen is exceeding the permissible limits of IS:10500 Standards in GW4. Ground water parameters of remaining locations are falling within the permissible limits of IS: 10500 Standards.

Corridor 4: The pH value of the collected ground water in the study area is found to be in the range from 7.35 to 7.9 and conductivity observed in the range 690 µS/cm to 2490 µS/cm. TDS values were observed to be in range from 344 mg/L to 1250 mg/ L. Total alkalinity is found to be the range from 138 mg/L to 280 mg/L and Total Hardness ranges from 135 to 592 mg/L. The chloride values of the samples were observed from 92.2 mg/L to 348 mg/L and Sulphate values were observed from 32.3 mg/L to 125 mg/L. The Calcium and magnesium values were ranged from 41 mg/L to 184 mg/L and 8.2 mg/L to 40.2 mg/L respectively. Most of the metals are observed as below the detection limit. Total Coliforms were observed as Absent/100ml and Fecal Coliforms were observed <2 MPN/100ml at all locations.

For Corridor 4, Ground water is slightly alkaline where pH value varies from 7.35 to 7.9. Nitrates value is exceeding the permissible limit of IS:10500 in GW1, GW2,GW4 and GW6 and Total Nitrogen is exceeding the permissible limits of IS:10500 Standards in GW1, GW2,GW4, GW6 and GW8. Ground water parameters of remaining locations are falling within the permissible limits of IS: 10500 Standards.

5.7. Air Environment

5.7.1. Ambient Air Quality

Ambient air quality refers to the background air quality levels in a region, characterized by concentrations of various pollutants in the atmosphere. The presence of air pollutants and their concentrations depends on the type of polluting sources and other factors that influence their flow and dispersion. In most cases, vehicular emissions are the predominant source of air pollution compared to other sources. Existing ambient air quality data on various sections of the project corridors was collected to establish a baseline database. The aim was to identify areas that already have high pollution levels or are expected to experience so, on account of the suburban rail project, and to design adequate mitigation measures, as applicable.

The activities, which modify atmospheric air quality are transportation (i.e., emissions from existing rail movement and motor vehicle emissions, which are addressed in this study); industry; domestic and construction. The major pollutants of significance to railways air quality, on account of vehicular emissions, are Fine Particulate Matter ($PM_{2.5}$), Respirable Particulate Matter (PM_{10}), Sulphur dioxide (SO_2), Nitrogen oxides (NO_x), Carbon monoxide (CO) and Hydrocarbon (HC).

Ambient Air quality monitoring was conducted along the BSRP Corridors as part of baseline environmental monitoring. Ambient Air Quality monitoring was conducted at all the locations during March & April 2022. 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 ambient air quality during construction and operation phases.

Monitoring Locations: Air quality monitoring locations were selected based on the type of sensitive features present along the project corridors. The other criteria are density and type of land use, type and nature of vulnerable groups, meteorological parameters etc. Corridor wise Ambient Air Quality monitoring locations are presented in **Table 5.20**. Photographs of the ambient air quality monitoring locations are presented in **Annexure 5.4**.

Table 5.20. Details of Ambient Air Quality Monitoring Locations along the BSRP Corridors

Code	Location	Coordinates	Description of the Station
Corridor – 1: KSR Bengaluru City to Devanahalli			
AAQ1	KSR Bengaluru RQ	12°58'44.07"N 77°34'3.29"E	Residential Building left side of the corridor which was 15m from the Railway track
AAQ2	Apartment	12°59'36.8"N 77°34'05.7"E	Residential Building left side of the corridor which was 20m from the Railway track
AAQ3	Malleswaram RS	13° 0'1.52"N 77°33'48.90"E	Commercial area which was located at railway station 10 m distance from the track
AAQ4	Yeswanthapur RS	13° 1'22.77"N 77°33'4.41"E	Commercial area which was located at railway station 10 m distance from the track
AAQ5	Secondary school	13° 3'2.69"N 77°34'2.17"E	Educational Institution Building Right side of the corridor which was adjacent to the Railway track
AAQ6	Apartment	13° 3'21.86"N 77°34'13.14"E	Residential Building left side of the corridor which was adjacent to the Railway track
AAQ7	Apartment of the irish house	13° 5'18.57"N 77°35'41.57"E	Residential Building left side of the corridor which was 40m from the Railway track
AAQ8	Gnanabaharathi School Yellahanka	13° 6'45.31"N 77°35'20.49"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ9	Nitte Globale Instute	13° 7'39.64"N 77°35'9.61"E	Residential Building left side of the corridor which was adjacent to the Railway track
AAQ10	Apartment cum Clinic	13°10'49.91"N 77°38'30.82"E	Residential Building left side of the corridor which was 13m from the Railway track
AAQ11	Devanahalli RS	13°14'51.04"N 77°42'19.50"E	Commercial area which was located at railway station 10 m distance from the track
AAQ12	Nirmithi Kendra Near Akkupete Depot	13°14'56.80"N 77°41'10.05"E	A Rural Settlement
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara			
AAQ1	Govt. School, Bennaganahalli	12°59'41.37"N 77°39'48.86"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ2	Mother Mary English School	13° 0'18.95"N 77°38'55.08"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ3	Eunice English school	13° 0'33.34"N 77°37'15.20"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ4	Mosque	13° 1'26.98"N 77°37'18.77"E	Residential Building left side of the corridor which was 13m from the Railway track
AAQ5	Lottegollanahalli RS	13° 2'37.06"N 77°33'47.25"E	Commercial area which was located at railway station 10 m distance from the track
AAQ6	P.R Public School	13° 1'53.30"N 77°33'9.50"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ7	National Public School, Shetty Halli	13° 4'16.19"N 77°30'36.60"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ8	Residential House, Chikkabanavara	13° 4'29.83"N 77°30'23.22"E	Residential Building left side of the corridor which was 13m from the Railway track

Code	Location	Coordinates	Description of the Station
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)			
AAQ1	Bengaluru Institute of Management Studies	12°55'33.57"N 77°29'57.41"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ2	Residential near Nayandanahalli RS	12°56'32.46"N 77°31'20.57"E	Residential Building left side of the corridor which was 13m from the Railway track
AAQ3	Sreekant Industrial Unit	12°56'45.08"N 77°31'34.07"E	Industrial area which was located at railway station 10 m distance from the track
AAQ4	Shiva & Ganesh temple	12°57'31.56"N 77°32'22.84"E	Residential Building left side of the corridor which was 13m from the Railway track
AAQ5	Karnataka Welfare Association for the Blind	12°58'5.55"N 77°33'38.79"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ6	Gandhinagar School	12°59'4.80"N 77°34'29.84"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ7	Mount Carmel college	12°59'17.16"N 77°34'42.44"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ8	Mount Carmel Stadium	12°59'45.61"N 77°35'0.15"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ9	City Hospital	13° 0'5.47"N 77°36'45.19"E	Commercial area which was located at railway station 20 m distance from the track
AAQ10	Central Library, Jeevanahalli	12°59'41.78"N 77°37'40.83"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ11	Sappalamma temple, Hoodi	12°59'47.19"N 77°43'7.99"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ12	Residential at Sadarmangala	12°59'53.04"N 77°44'16.93"E	Commercial area which was located at railway station 10 m distance from the track
Corridor – 4: Heelalige to Rajanukunte			
AAQ1	Bengaluru College of Engineering	12°48'48.35"N 77°42'37.20"	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ2	Norwich High School, Electronic City Phase II	12°49'29.97"N 77°42'43.75"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ3	Masjid	12°54'34.00"N 77°42'19.80"E	Residential Building left side of the corridor which was 13m from the Railway track
AAQ4	iSmile Dental Care, Sapthagiri Layout	12°56'53.27"N 77°42'21.77"E	Commercial area which was located at railway station 10 m distance from the track
AAQ5	Lions Airport City Hospital	12°57'18.31"N 77°42'18.45"E	Commercial area which was located at railway station 10 m distance from the track
AAQ6	Kies mansion School	12°57'44.03"N 77°42'12.93"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ7	Geethanjali Vidyalaya	12°58'51.16"N 77°41'8.76"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ8	Ayappaswamy Temple	12°59'0.76"N 77°40'49.76"E	Commercial area which was located at railway station 10 m distance from the track
AAQ9	Sai Specialty Hospital	12°59'58.55"N 77°39'46.14"E	Commercial area which was located at railway station 10 m distance from the track

Code	Location	Coordinates	Description of the Station
AAQ10	Residential at Horamavu	13° 1'20.83"N 77°39'40.25"E	Residential Building left side of the corridor which was 13m from the Railway track
AAQ11	Grace Methodist Church	13° 2'17.04"N 77°38'54.38"E	Residential Building left side of the corridor which was 13m from the Railway track
AAQ12	Residential at Jakkur	13° 4'49.08"N 77°36'31.25"E	Residential Building left side of the corridor which was 13m from the Railway track
AAQ13	Govt. PU College	13° 5'50.08"N 77°35'41.26"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ14	Masjid	13° 7'3.87"N 77°35'2.25"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track
AAQ15	Industry	13°10'44.89"N 77°33'55.82"E	Educational Institution Building Right side of the corridor which was 80m to the Railway track

Analysis techniques used for different air quality parameters are presented in **Table 5.21**

Table 5.21. Techniques Used for Ambient Air Quality Monitoring

Sl. No.	Parameter	Technique	Technical Protocol	Detectable Limit
1	Particulate Matter of size less than 10 µm (PM_{10})	Gravimetric method	IS 5182 Pt.23 : 2006 (Reaff. 2017)	5 µg/m^3
2	Particulate Matter of size less than 2.5 µm ($PM_{2.5}$)	Gravimetric method	EPA- 40 Appendix L To CFR PART 50	5 µg/m^3
3	Sulphur dioxide (SO_2)	Improved West and Gaeke	IS 5182: Part 2:2001 (Reaff. 2017)	5 µg/m^3
4	Oxides of Nitrogen (NO_x)	Modified Jacob & Hochheiser	IS 5182: Part 6:2006 (Reaff. 2017)	5 µg/m^3
5	Carbon monoxide (CO)	Non Dispersive Infra-Red (NDIR) Spectroscopy	IS 5182:Part 10 :1999 (Reaff. 2014)	0.1 mg/m^3
6	Hydro Carbon (HC)	GC FID	ESL/INS/SOP/027	0.1 µg/m^3

The Air Quality Monitoring results of four corridors are presented in below **Table 5.22.** The results are compared with the standards prescribed by Central Pollution Control Board (CPCB) for "Industrial, Residential, Rural and Other areas".

Table 5.22. Ambient Air Quality Monitoring Results

AAQ Locations	PM10 µg/ m3			PM2.5 µg/m3			SO2 µg/ m3			NOx µg/m3			CO mg/m3			HC µg/m3
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Corridor – 1: KSR Bengaluru City to Devanahalli																
KSR Bengaluru RQ	71.4	80.6	76.0	30.6	36.3	33.5	7.8	9.3	8.6	17.0	20.1	18.7	0.65	0.82	0.73	<0.1
Residential Building Srirampura	68.9	83.6	76.3	28.6	35.2	31.9	7.8	13.6	10.2	20.2	27.6	24.4	0.71	0.88	0.78	<0.1
Malleshwaram RS	68.3	75.9	72.1	27.5	33.1	30.3	7.9	10.5	9.2	20.6	23.8	22.3	0.63	0.77	0.69	<0.1
Yeswanthpur RS	80.8	91.7	86.3	36.3	43.8	40.1	10.1	13.5	12.1	22.9	28.7	25.8	0.89	1.22	1.10	<0.1
Bhisop Sergeant central School	63.1	70.2	66.7	23.8	25.6	24.7	7.2	9.3	8.1	13.6	18.5	16.6	0.57	0.72	0.65	<0.1
Residential Building	66.9	70.7	68.8	27.4	29.5	28.5	7.1	9.4	8.1	13.6	23.3	18.9	0.70	0.85	0.79	<0.1
Residential Building near Irish house	77.6	82.8	80.2	31.3	34.6	33.0	9.5	13.4	11.4	22.8	28.3	26.2	0.85	1.02	0.94	<0.1
Gnana Barathi school Yelahanka	59.5	66.8	63.2	24.7	30.1	27.4	6.3	7.4	6.8	13.1	17.6	15.7	0.38	0.56	0.45	<0.1
Nitte Meenakshi Institute of Technology	57.4	61.6	59.5	22.6	25.9	24.3	5.8	7.2	6.6	14.1	18.6	16.7	0.33	0.45	0.39	<0.1
Residential Building at Jalahalli	70.2	77.4	73.8	27.5	32.6	30.1	7.2	9.3	8.4	17.3	23.4	20.1	0.43	0.61	0.52	<0.1
Devanahalli RS	66.5	69.6	68.1	27.1	30.4	28.8	5.8	7.2	6.5	13.1	16.5	15.2	0.35	0.51	0.41	<0.1
Nirmithi Kendra near Pro. Akkupete Depot	46.6	50.1	48.4	16.8	19.4	18.1	<5.0	<5.0	<5.0	5.4	8.1	6.6	0.16	0.25	0.20	<0.1
Standards	**100**			**60**			**80**			**80**			**2**			**0.5**
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara																
Govt. School, Benniganahalli	77.9	86.4	82.2	20.6	28.8	24.7	7.3	9.7	8.5	16.4	22.6	19.3	0.60	0.81	0.71	< 0.1
Mother Mary English School	66.4	83.2	74.8	34.5	40.5	37.5	6.7	20.4	9.9	14.3	21.6	18.0	0.48	0.90	0.69	< 0.1
Eunice School	69.8	75.2	72.5	25.4	28.6	27.0	6.6	8.2	7.3	16.6	18.3	17.6	0.58	0.77	0.68	< 0.1

AAQ Locations	PM10 µg/ m3			PM2.5 µg/m3			SO2 µg/ m3			NOx µg/m3			CO mg/m3			HC µg/m3
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Residential building, Kadugondanahalli	91.4	97.0	94.2	29.7	31.1	30.4	9.3	11.8	10.3	20.6	25.1	22.6	0.87	1.05	0.96	< 0.1
Lottegallanahalli	72.4	81.1	76.8	27.8	29.5	28.7	7.6	9.7	8.9	17.4	22.4	19.4	0.67	0.91	0.78	< 0.1
PR Public School	51.2	58.2	54.7	21.8	28.5	25.2	5.1	6.1	5.6	14.5	15.6	15.0	0.46	0.55	0.50	< 0.1
National Public School, Shettyhalli	64.1	75.0	69.6	28.5	32.2	30.4	5.6	7.4	6.5	14.8	17.2	16.5	0.57	0.72	0.66	< 0.1
Residential House, Chikkabanavara	87.9	93.6	90.8	30.3	31.1	30.7	7.6	9.8	8.8	14.7	19.5	17.0	0.79	0.93	0.86	< 0.1
Standards	**100**			**60**			**80**			**80**			**2**			**0.5**
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)																
Kengeri RS	89.7	97.7	93.7	27.1	31.4	29.3	6.2	12.0	9.5	15.8	27.3	21.0	0.77	0.95	0.85	<0.1
Nayandanahalli RS	60.5	60.5	60.5	21.8	21.8	21.8	5.4	7.4	6.6	11.8	17.9	15.0	0.42	0.76	0.62	<0.1
Sreechakra Industrial Unit	90.5	98.4	94.5	29.5	35.4	32.5	7.1	12.0	10.2	17.6	27.6	22.4	0.84	1.10	0.95	<0.1
Shiva & Ganesh Temple	79.0	90.4	84.7	28.9	34.7	31.8	6.5	9.3	8.1	14.7	24.7	20.1	0.69	0.88	0.78	<0.1
Karnataka Welfare Association for the Blind	91.2	97.5	94.4	28.6	39.4	34.0	7.0	12.3	10.3	17.6	27.6	23.8	0.72	1.20	0.94	<0.1
Gandhinagar School	42.7	50.3	46.5	17.0	20.1	18.6	5.1	7.7	6.3	11.5	16.5	13.7	0.33	0.50	0.41	<0.1
Mount Carmel College	43.4	54.7	49.1	18.6	23.5	21.1	5.2	7.3	6.3	11.9	20.2	16.1	0.25	0.41	0.32	<0.1
Stadium near Vasnth Nagar	53.1	58.9	56.0	22.6	27.6	25.1	5.3	7.9	6.7	13.2	25.7	18.4	0.31	0.53	0.43	<0.1
City Hospital, Pulikeshi Nagar	60.2	71.9	66.1	23.7	25.6	24.7	5.3	9.5	7.3	16.8	21.7	18.8	0.55	0.72	0.63	<0.1
Central Library, Jeevanahalli	65.8	80.6	73.2	25.1	31.4	28.3	7.0	11.2	8.9	18.8	28.1	23.9	0.63	1.00	0.82	<0.1
Govt. College. Hoodi.	57.3	65.2	61.3	21.9	24.6	23.3	5.4	7.9	6.9	13.1	21.5	17.9	0.53	0.79	0.65	<0.1
Residential at Sadarmangala	63.4	71.6	67.5	26.1	30.4	28.3	5.1	8.5	6.8	15.8	21.4	18.3	0.30	0.65	0.44	<0.1
Standards	**100**			**60**			**80**			**80**			**2**			**0.5**

AAQ Locations	PM10 µg/ m3			PM2.5 µg/m3			SO2 µg/ m3			NOx µg/m3			CO mg/m3			HC
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	µg/m3
Corridor – 4: Heelalige to Rajanukunte																
Bengaluru College of Engineering	46.9	55.4	51.2	13.5	16.8	15.2	5.1	8.5	6.8	10.8	16.1	13.7	0.42	0.60	0.50	<0.1
Norwich High School	41.3	52.4	46.9	14.4	18.0	16.2	5.1	7.7	6.0	10.4	14.5	12.4	0.31	0.50	0.41	<0.1
Carmelram Campus	44.8	62.0	53.4	15.3	22.9	19.1	5.6	9.0	6.6	10.8	18.3	14.7	0.40	0.62	0.51	<0.1
Residential Building Near Sapthagiri layout	53.7	58.6	56.2	18.9	27.2	23.1	5.3	7.8	6.3	11.2	19.4	15.8	0.37	0.60	0.49	<0.1
Govt. School	63.0	71.4	67.2	26.5	33.6	30.1	5.2	7.2	5.8	13.6	17.6	15.9	0.47	0.72	0.62	<0.1
Tata Service Center	56.9	64.4	60.7	19.7	21.3	20.5	5.2	7.9	6.5	10.4	20.6	15.7	0.54	0.70	0.61	<0.1
Geetanjali Vidyalaya	53.1	65.5	59.3	17.6	20.2	18.9	5.1	7.8	6.1	13.9	25.8	18.9	0.36	0.44	0.40	<0.1
Govt. School	50.1	54.7	52.4	16.3	20.1	18.2	5.1	6.6	5.7	11.2	18.3	14.9	0.24	0.42	0.33	<0.1
Chandsandra RS	48.6	54.7	51.7	17.4	18.5	18.0	5.2	7.2	6.0	10.4	17.9	14.2	0.37	0.60	0.47	<0.1
Ebinazer School at Horamavu	71.6	80.5	76.1	23.3	27.8	25.6	5.1	9.8	7.7	14.3	23.7	18.8	0.65	0.76	0.70	<0.1
Grace Methodist Church	66.1	73.5	69.8	22.6	25.8	24.2	5.8	7.3	6.3	13.8	18.3	15.6	0.33	0.41	0.39	<0.1
Residential at Jakkur	62.7	69.4	66.1	30.6	38.2	34.4	10.2	18.2	14.5	15.7	23.4	19.1	0.36	0.72	0.54	
Govt. PU College	36.7	42.7	39.7	17.8	25.4	21.6	7.4	14.6	10.2	13.8	26.6	19.7	0.19	0.69	0.38	<0.1
Residential Building at Vasudevapura	72.6	78.9	75.8	32.4	36.7	34.6	8.9	19.3	15.1	15.4	28.4	21.3	0.22	0.60	0.42	<0.1
Industry, Rajanukunte	67.8	74.3	71.1	24.5	28.4	26.5	7.4	16.2	10.9	12.6	26.6	19.3	0.20	0.47	0.36	<0.1
Standards		**100**			**60**			**80**			**80**			**2**		**0.5**

Observations:

Corridor 1:

PM_{10}: The maximum and minimum concentrations for PM_{10} were recorded as 91.7 µg/m^3 and 46.6 µg/m3 respectively. The maximum concentration was recorded at the Yeswanthpur RS and the minimum concentration was recorded at Nirmithi Kendra near proposed Akkupete depot. The average concentrations were ranges between 48.4– 86.3 µg/m^3.

$PM_{2.5}$: The maximum and minimum concentrations for $PM_{2.5}$ were recorded as 43.8 µg/m^3 and 16.8 µg/m3 respectively. The maximum concentration was recorded at Yeswanthpur RS and the minimum concentration was recorded at Nirmithi Kendra near proposed Akkupete depot. The average values were observed to be in the range of 18.1– 40.1 µg/m^3.

SO_2: The maximum and minimum SO_2 concentrations were recorded as 13.6 µg/m^3 and <5.0 µg/m^3. The maximum concentration was recorded at Residential Building, Srirampura and the minimum concentration was recorded at Nirmithi Kendra near proposed Akkupete depot. The average values were observed to be in the range of <5.0 -12.1 µg/m^3.

NO_x: The maximum and minimum NO_x concentrations were recorded as 28.7 µg/m^3 and 5.4 µg/m^3. The maximum concentration was recorded at Yeswanthpur RS and the minimum concentration was recorded at Nirmithi Kendra near proposed Akkupete depot. The average values were observed to be in the range of 6.6 – 25.8 µg/m^3

CO: The maximum and minimum CO concentrations were recorded as 1.22 mg/m^3 and 0.16 mg/m^3. The maximum concentration was recorded at Yeswanthpur RS and the minimum concentration was recorded at Nirmithi Kendra near proposed Akkupete depot. The average values were observed to be in the range between 0.20 mg/m^3 to 1.10mg/m^3.

HC: The maximum Methane HC concentrations were recorded as <0.1 µg/m^3 and the minimum concentration of <0.1 µg/m^3 was observed at all locations.

Corridor 2:

PM_{10}: The maximum and minimum concentrations for PM_{10} were recorded as 97.0 µg/m^3 and 51.2 µg/m^3 respectively. The maximum concentration was recorded at the Residential Building at Kadugondanahalli and the minimum concentration was recorded at PR Public School, Mohan Kumar Nagar. The average concentrations were ranges between 54.7 – 94.2 µg/m^3.

$PM_{2.5}$: The maximum and minimum concentrations for $PM_{2.5}$ were recorded as 40.5 µg/m^3 and 20.6 µg/m^3 respectively. The maximum concentration was recorded at Mother Mary English School, Chikka Banaswadi and the minimum concentration was recorded at Govt School, Benniganahalli. The average values were observed to be in the range of 24.7– 37.5 µg/m^3.

SO_2: The maximum and minimum SO_2 concentrations were recorded as 20.4 µg/m^3 and 5.1 µg/m^3. The maximum concentration was recorded at Mother Mary English School, Chikka Banaswadi and the minimum concentration was recorded at PR Public School, Mohan Kumar Nagar. The average values were observed to be in the range of 5.6 -10.3 µg/m^3.

NO_x: The maximum and minimum NO_x concentrations were recorded as 25.1 µg/m^3 and 14.3 µg/m^3. The maximum concentration was recorded at Residential Building at Kadugondanahalli and the minimum concentration was recorded at Mother Mary English School, Chikka Banaswadi. The average values were observed to be in the range of 15 – 22.6 µg/m^3

CO: The maximum and minimum CO concentrations were recorded as 1.05 mg/m^3 and 0.46 mg/m^3. The maximum concentration was recorded at Residential Building at Kadugondanahalli and the minimum concentration was recorded at PR Public School, Mohan Kumar Nagar. The average values were observed to be in the range between 0.50 mg/m^3 to 0.96 mg/m^3.

HC: The HC concentrations were recorded below the detection limit as <0.1 µg/m^3 at all locations.

Corridor 3:

PM_{10}: The maximum and minimum concentrations for PM_{10} were recorded as 97.7 µg/m^3 and 42.7 µg/m^3 respectively. The maximum concentration was recorded at the Kengeri RS and the minimum concentration was recorded at Gandhinagar School, Seshadripuram. The average concentrations were ranges between 46.5– 93.7 µg/m^3.

$PM_{2.5}$: The maximum and minimum concentrations for $PM_{2.5}$ were recorded as 39.4 µg/m^3 and 17.0 µg/m^3 respectively. The maximum concentration was recorded at Karnataka Welfare Association for the Blind, Seshadripuram and the minimum concentration was recorded at Gandhinagar School, Seshadripuram. The average values were observed to be in the range of 18.6– 34 µg/m^3.

SO_2: The maximum and minimum SO_2 concentrations were recorded as 12.3 µg/m^3 and 5.1 µg/m^3. The maximum concentration was recorded at Karnataka Welfare Association for Blind, Seshadripuram and the minimum concentration was recorded at Gandhinagar School, Seshadripuram. The average values were observed to be in the range of 6.3-10.3 µg/m^3.

NO_x: The maximum and minimum NO_x concentrations were recorded as 28.1 µg/m^3 and 11.5 µg/m^3. The maximum concentration was recorded at Central Library, Jeevanahalli and the minimum concentration was recorded at Gandhinagar School, Seshadripuram. The average values were observed to be in the range of 13.7 – 23.9 µg/m^3.

CO: The maximum and minimum CO concentrations were recorded as 1.20 mg/m^3 and 0.25 mg/m^3. The maximum concentration was recorded at Karnataka Welfare Association for Blind, Seshadripuram and the minimum concentration was recorded at Mount Carmel college, Palace Road. The average values were observed to be in the range between 0.32 mg/m^3 – 0.95mg/m^3.

HC: The maximum Methane HC concentrations were recorded as <0.1 µg/m^3 and the minimum concentration of <0.1 µg /m^3 was observed at all locations.

Corridor 4:

PM_{10}: The maximum and minimum concentrations for PM_{10} were recorded as 80.5 µg/m^3 and 36.7 µg/m^3 respectively. The maximum concentration was recorded at Ebinazer School at Horamavu and the minimum concentration was recorded at Govt. PU College, Yelahanka. The average concentrations were ranges between 39.7– 75.8 µg/m^3.

$PM_{2.5}$: The maximum and minimum concentrations for $PM_{2.5}$ were recorded as 36.7 µg/m^3 and 13.5 µg/m^3 respectively. The maximum concentration was recorded near Residential Building at Vasudevapura and the minimum concentration was recorded at Bengaluru College of Engineering, Heelalige. The average values were observed to be in the range of 15.2– 34.6 µg/m^3.

SO_2: The maximum and minimum SO_2 concentrations were recorded as 19.3 µg/m^3 and 5.1 µg/m^3. The maximum concentration was recorded near Residential Building at Vasudevapura and the minimum concentration was recorded at Govt. School, Munnekollal. The average values were observed to be in the range of 5.7-15.1 µg/m^3.

NO_x: The maximum and minimum NO_x concentrations were recorded as 26.6 µg/m^3 and 10.4 µg/m^3. The maximum concentration was recorded at Industry, Rajanukunte and the minimum concentration was recorded at Tata Service Center, Chinnappanahalli. The average values were observes to be in the range of 11.4 – 21.3 µg/m^3

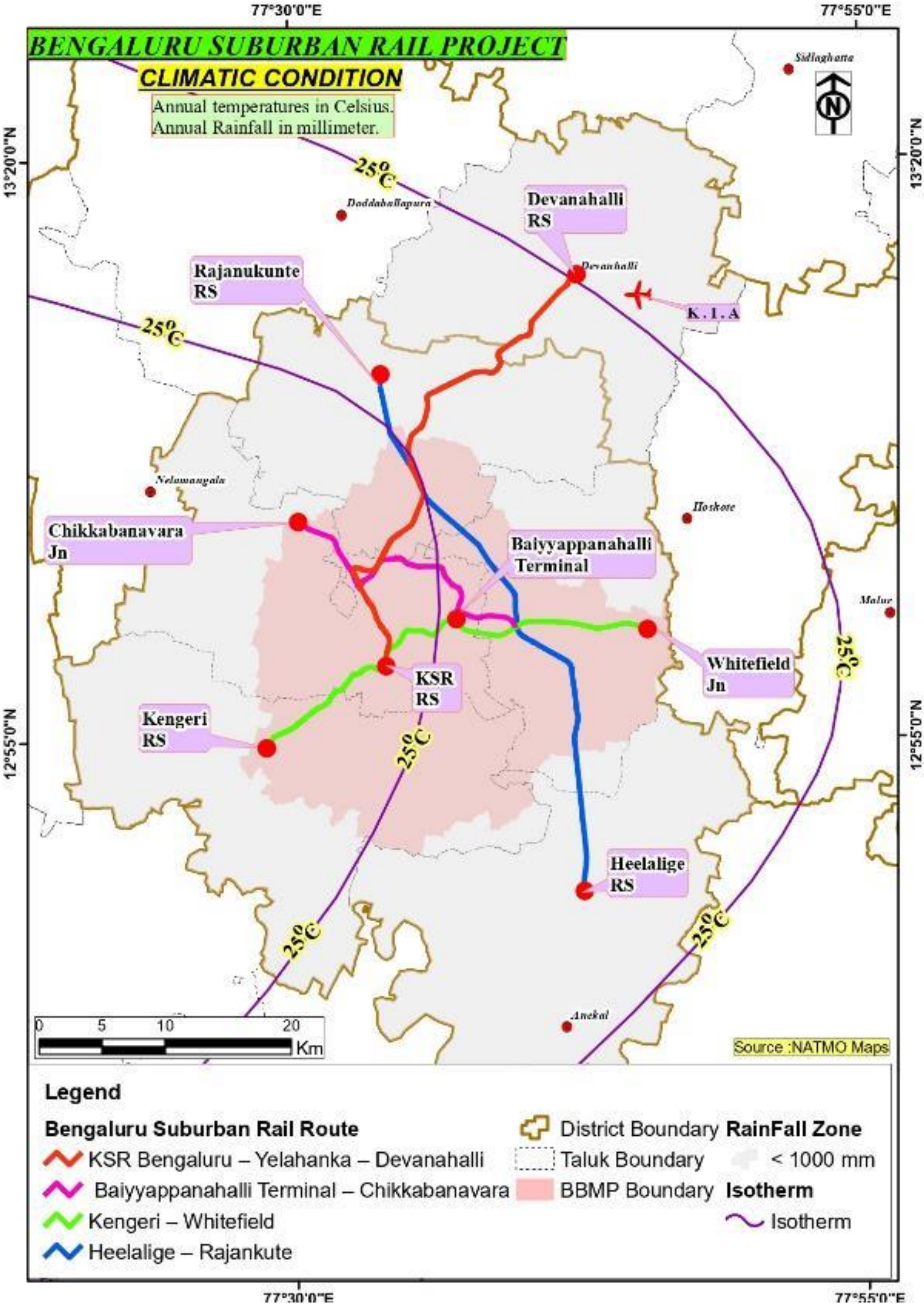
CO: The maximum and minimum CO concentrations were recorded as 0.72 mg/m^3 and 0.19 mg/m^3. The maximum concentration was recorded at Govt. School, Munnekollal and the minimum concentration was recorded at Govt. PU College, Yelahanka. The average values were observed to be in the range between 0.33 mg/m^3 – 0.70mg/m^3.

HC: The maximum Methane HC concentrations were recorded as <0.1 µg/m^3 and the minimum concentration of <0.1 µg/m^3 was observed at all locations.

The overall concentrations of PM_{10}, $PM_{2.5}$, SO_2, NOx, CO and HC were observed to be well within the standards prescribed by Central Pollution Control Board (CPCB) for Industrial, Rural, Residential and Other area for all the BSRP Corridors.

5.7.2. Meteorology & Climate

Climate: Among all other physical factors, climate is the most important factor influencing the environment as it plays a vital role in determining the evolution of landforms (erosion, soil characteristics), types of flora and fauna (ecological diversity), the productivity of ecosystems in addition to having an influence on the pollution loads on the environment. Rainfall, temperature, and winds are the principal climatic components that serve to transport, disperse various forms of pollution into the atmosphere and on the ground. Map showing Climatic condition for the project district is presented in **Figure 5.19**.



Source: National Atlas and Thematic Mapping Organisation

Figure 5.19. Climatic Condition for Project Region

India Meteorological Department (IMD) is the nodal agency responsible for monitoring and recording the climatic parameters. Long-term climatic data were obtained for the project districts to establish a general trend. Monthly average data for 30 years (1971-2000) were considered for analyzing the climatic variables such as temperature, humidity and wind speed. Rainfall, the most critical climatic variable was analyzed for its long-term trend (50 years; 1941-1990) and also for the recent phenomena (2008-2012).

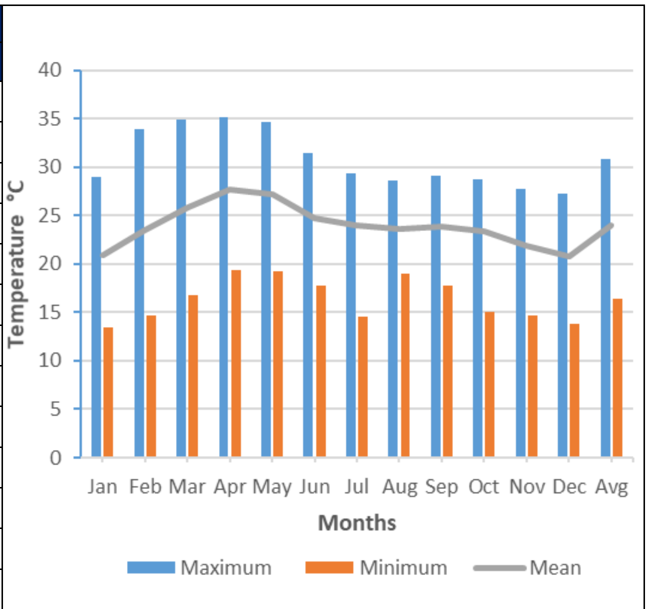
Both Bengaluru Urban and Rural districts experience semi-arid tropical climate wherein four distinct seasons viz., South west monsoon (June – Sep.), North East monsoon (Oct – Dec.), winter season (Jan. – Feb.) and summer season (April – May) are experienced.

5.7.2.1. Temperature

Temperature pattern for Bengaluru Urban and Bengaluru Rural districts are shown in **Table 5.23** and **Table 5.24**.

Table 5.23. Temperature Profile of Bengaluru Urban District

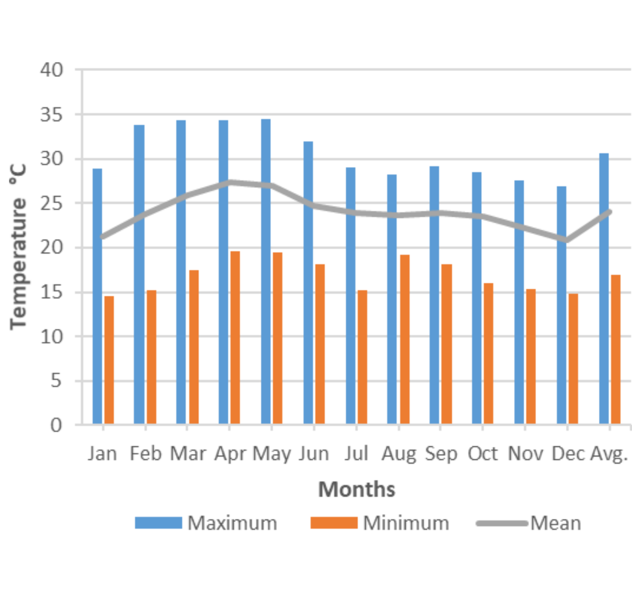
Month	Monthly Temperature Values (°C)		
	Maximum	Minimum	Mean
Jan	29	13.4	20.89
Feb	33.9	14.7	23.50
Mar	34.9	16.8	25.83
Apr	35.1	19.4	27.68
May	34.6	19.2	27.21
Jun	31.5	17.8	24.78
Jul	29.3	14.5	24.02
Aug	28.6	19	23.63
Sep	29.1	17.8	23.86
Oct	28.7	15.1	23.41
Nov	27.8	14.7	21.86
Dec	27.2	13.8	20.82
Avg.	**30.8**	**16.4**	**24.0**



Source: Data Collected from IMD, Pune.

Table 5.24. Temperature Profile of Bengaluru Rural District

Month	Monthly Temperature Values (°C)		
	Maximum	Minimum	Mean
Jan	28.9	14.5	21.2
Feb	33.8	15.2	23.7
Mar	34.3	17.4	25.9
Apr	34.4	19.6	27.4
May	34.5	19.4	27.0
Jun	31.9	18.1	24.7
Jul	29.0	15.2	23.9
Aug	28.2	19.2	23.6
Sep	29.1	18.1	23.9
Oct	28.5	16.0	23.5
Nov	27.5	15.3	22.1
Dec	26.9	14.8	20.9
Avg.	**30.6**	**16.9**	**24.0**



Source: Data Collected from IMD, Pune.

Maximum temperature recorded in the months of March-May and minimum temperature recorded in the months of November to February at both Bengaluru Urban and Rural Districts. The monthly mean temperature varies from 20.82 to 27.68 degrees at Bengaluru Urban, whereas the monthly mean temperature varies between 20.9 to 27.4 degrees at Bengaluru Rural.

5.7.2.2. Rainfall

Bengaluru Urban District: South west monsoon is predominant in the district, which accounts 80% of the rainfall. Rest of the rainfall contributed by pre-monsoon and North-east monsoon. The actual annual rainfall of the four taluks of the district from the year 2007 to 2018 is considered for studying the rainfall pattern. On assessing the annual rainfall for the year 2018, Bengaluru North taluk is the highest with 1030 mm and lowest for Bengaluru South taluk with 781 mm.

Actual Annual Normal Rainfall of the Bengaluru Urban District for the years between 2008 and 2018 is presented in **Table 5.25**.

Table 5.25. Actual Annual Normal Rainfall of the Bengaluru Urban District

Stations	Rainfall in mm (2008 -2018)										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bengaluru North	1036	736	925	920	610	957	1019	1057	1165	479	1030
Bengaluru East	889	596	877	1092	354	620	611	908	1355	1097	838
Bengaluru South	943	879	835	1058	537	862	925	1258	1403	1488	781
Anekal	950	751	844	734	437	593	433	839	922	820	814
Annual Avg.	**971**	**746**	**884**	**954**	**533**	**821**	**821**	**1059**	**1214**	**890**	**866**

Source: District Statistical Handbook, Bengaluru Urban District

Bengaluru Rural District: The district has two rainy season i.e., south-east and north-west monsoon which is between June to September and November to December respectively. The mean annual rainfall recorded in Bengaluru Rural District for the year 2016 is records to 694 mm. Doddaballapura taluk receives the lowest rainfall of 585 mm where as Devanahalli taluk receives the highest rainfall of 746 mm. Actual Annual Normal Rainfall of the Bengaluru Rural District for the years between 2006 and 2016 is presented in **Table 5.26**.

Table 5.26. Actual Annual Normal Rainfall of the Bengaluru Rural District

Stations	Rainfall in mm (2006 -2016)										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Devanahalli	416	798	848	755	868	768	492	815	720	1052	746
Doddaballapura	468	771	786	661	631	595	395	584	766	937	585
Hosakote	385	960	1015	589	787	781	611	780	716	1039	729
Nelamangala	598	880	998	712	989	851	547	966	975	1183	717
Annual Avg.	**467**	**852**	**912**	**679**	**819**	**748**	**511**	**786**	**794**	**1052**	**694**

Source: District Statistical Handbook, Bengaluru Rural District

5.7.2.3. Relative Humidity

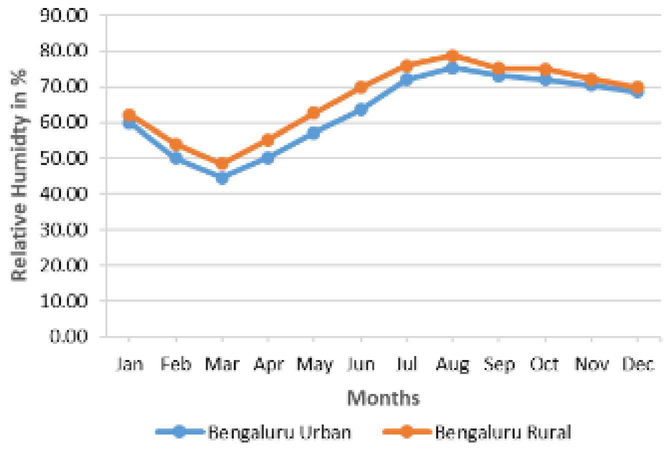
The nature and characteristics of the pollutants will vary with change of the humidity in the atmosphere. Fog provides possibility for suspended particles to coalesce and enhances chemical reaction of the gaseous pollutants.

In general, Bengaluru Urban district records higher relative humidity due to its presence in higher elevation compared to surrounding districts. Relative humidity variation between day and night are higher resulting in higher probability of pest and disease incidences. The highest humidity recorded in the month of August which is 75.4% and the lowest humidity recorded in the month of March, which is 44.6%.

In Bengaluru Rural district, relative humidity is high during the south west monsoon period and generally moderate in the rest of the year. But on an average the relative humidity is high at Bengaluru Rural district compared to that of Bengaluru Urban District. The humidity in the summer afternoons is comparatively very low. The highest humidity recorded in the month of August (~ 78.72%) and the lowest in the month of March (~ 48.47 %). Comparison of average monthly relative humidity for the project districts is presented in **Table 5.27**.

Table 5.27. Comparison of Average Monthly Relative Humidity of the Project Districts

Month	Average Relative Humidity (%)	
	Bengaluru Urban	Bengaluru Rural
Jan	59.90	62.22
Feb	50.15	53.99
Mar	44.60	48.47
Apr	50.27	55.21
May	57.15	62.60
Jun	63.57	69.83
Jul	72.06	75.99
Aug	75.40	78.72
Sep	73.12	75.15
Oct	71.98	75.06
Nov	70.40	72.19
Dec	68.63	69.92



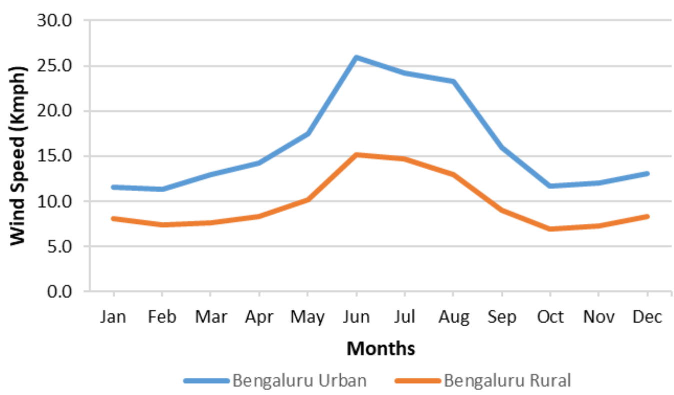
Source: Data Collected from IMD, Pune.

5.7.2.4. Wind Speed

Wind speed and wind direction have a significant role on the dispersion of atmospheric pollutants and therefore, the air quality of the area. Ground level concentrations for the pollutants are inversely proportional to the wind speed in the down wind direction, while in upwind direction no effect will be observed and in cross wind direction partial effect due to the emission sources is observed.

Table 5.28. Comparison of Average Monthly Wind Speed of the Project Districts

Month	Average Wind Speed (Kmph)	
	Bengaluru Urban	Bengaluru Rural
Jan	11.5	8.0
Feb	11.3	7.4
Mar	12.9	7.7
Apr	14.2	8.3
May	17.5	10.2
Jun	25.9	15.1
Jul	24.2	14.7
Aug	23.2	13.0
Sep	16.0	9.1
Oct	11.7	6.9
Nov	12.0	7.3
Dec	13.1	8.3

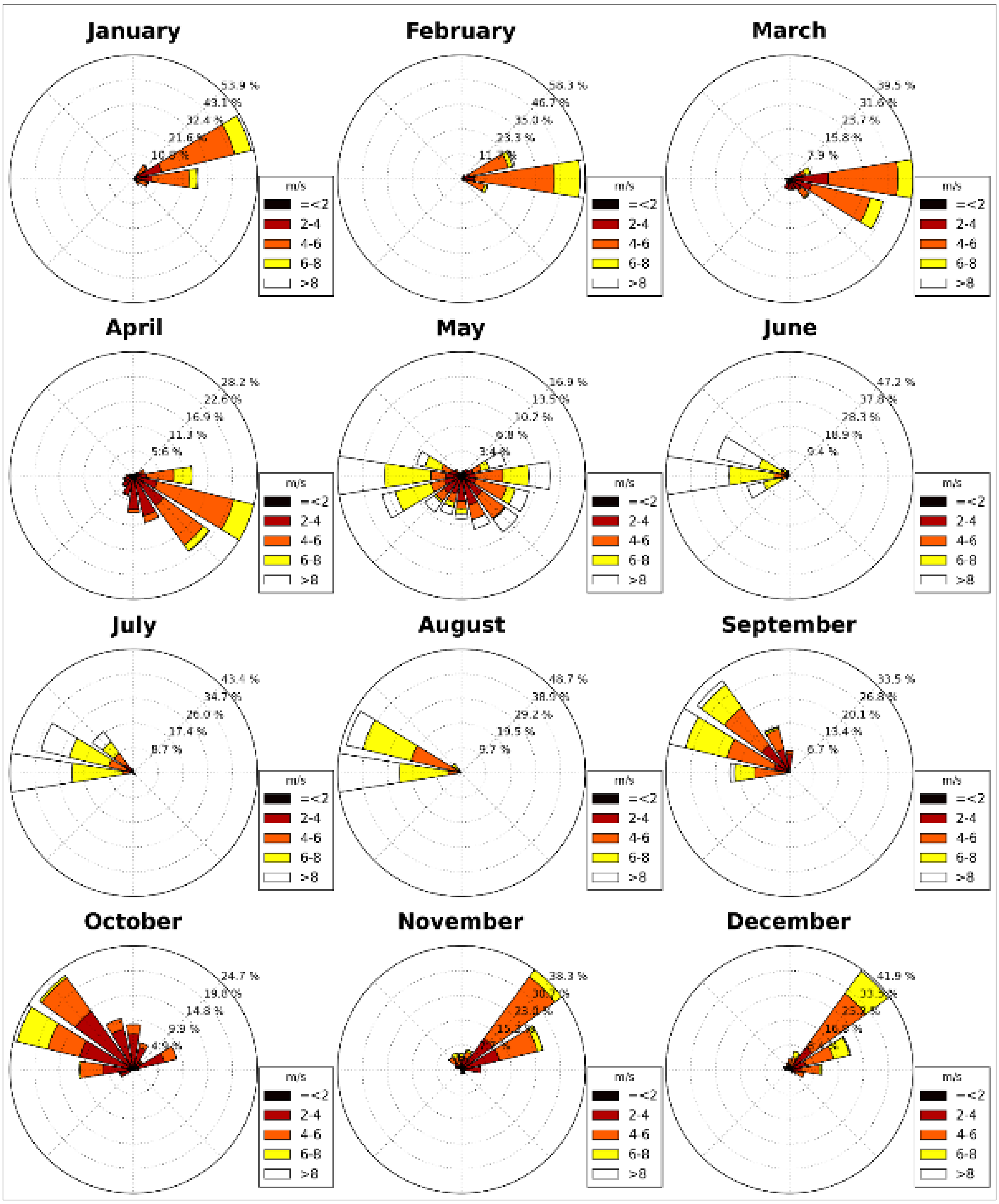


Source: Data Collected from IMD, Pune.

In Bengaluru Urban district, during October to March, wind blows generally from North Easterly and Easterly directions. South westerly and westerly winds predominate from May to September. The wind speed is least in October to February, while it is higher from July to September.

Winds are generally light to moderate with some strengthening in monsoon season in Bengaluru Rural district. The region is influenced by winds from south-west and north-west during the period from May to September and from north-east and south-east during the period from October to April.

Comparatively, the Bengaluru Urban experience high wind speed than Bengaluru Rural district, which helps in higher dispersion of pollution in the project region. Wind Rose diagram of Bengaluru for the year 2016 is presented in **Figure 5.20**.



Source: https://urbanemissions.info/india-apna/bengaluru-india/

Figure 5.20. Wind Rose Diagram of Bengaluru Urban District for the Year 2016

5.8. Noise & Vibration Environment

5.8.1. Ambient Noise Level Monitoring

Noise in general is unwanted / undesired sound, which is composed of many frequency components of varying 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.

- Leq - 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.
- Lday - The equivalent noise level from 6:00 hours to 22.00 hours.
- Lnight - The equivalent noise level from 22:00 hours to 6.00 hours.

In order to assess the baseline noise level along the project corridors, ambient noise monitoring network was designed considering the land use and presence of sensitive receptors along the project corridors. Noise monitoring locations were selected as per CPCB guidelines and Guidelines on Noise & Vibration study for Metro Rail Transit system by RDSO. An NABL accredited laboratory i.e., Enviro Solutions & Labs, Coimbatore was engaged to carry out monitoring of ambient Noise level in the project region. Monitored results were compared with CPCB standards.

The objective of assessing baseline noise levels 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. Hourly Leq values were computed by the noise integrating sound level meter and statistical analysis was done for measured noise levels at the pre-selected locations in the study area. Corridor wise Ambient Noise level monitoring locations are presented in **Table 5.29**. Photographs of the ambient noise level monitoring locations are presented in **Annexure 5.4**.

Table 5.29. Details of Ambient Noise Level Monitoring Locations along the BSRP Corridors

Location Code	Name of the Location	Co-ordinates	Classification of Location as per Standards
Corridor – 1: KSR Bengaluru City to Devanahalli			
NQ1	KSR Bengaluru Rly. Qtr. Electrical office	12°58'44.07"N 77°34'3.29"E	Residential building left side of the corridor which was 15m from the railway track
NQ2	Residential Building Srirampura PRS	12°59'19.31"N 77°34'11.87"E	Residential building left side of the corridor which was 20m from the railway track
NQ3	Residential Building at Srirampura	12°59'36.8"N 77°34'05.7"E	Residential building left side of the corridor which was 20m from the railway track
NQ4	Malleshwaram RS Station building	13° 0'1.52"N 77°33'48.90"E	Commercial area which was located at railway station 10 m distance from the track
NQ5	Ayyappa swamy temple, Malleswaram	12°59'44.95"N 77°33'59.48"E	A silent zone which was located at 33m distance from the left side of the track
NQ6	Manipal Hospital,Yeshwanthpur	13° 0'52.08"N 77°33'22.75"E	A silent zone which was located at 38m distance from the right side of the track
NQ7	Nitte Meenakshi Institute of Technology, Yelahanka	13° 7'39.64"N 77°35'9.61"E	Residential building left side of the corridor which was adjacent to the railway track
NQ8	Cluny convent high school, Malleshwaram	13° 0'15.48"N 77°33'42.06"E	A silent zone which was located at 25m distance from the right side of the track
NQ9	Yeswanthapur RS	13° 1'22.77"N 77°33'4.41"E	Commercial area which was located at railway station 10 m distance from the track
NQ10	Residential Building near Mathikere	13° 2'18.26"N 77°33'27.34"E	Residential building left side of the corridor which was adjacent to the railway track
NQ11	Lottegollahalli RS	13° 2'37.06"N 77°33'47.25"E	A commercial area railway station
NQ12	Bishop Sargent Secondary school, Devinagar	13° 3'2.69"N 77°34'2.17"E	A silent zone which was located at 5m distance from the right side of the track
NQ13	Residential Building of the Tatanagar	13° 3'21.86"N 77°34'13.14"E	Residential building left side of the corridor which was adjacent to the railway track
NQ14	Residential Building at Meenakunte	13°10'49.91"N 77°38'30.82"E	Residential building left side of the corridor which was 13m from the railway track

Location Code	Name of the Location	Co-ordinates	Classification of Location as per Standards
NQ15	Kodigehalli RS	13° 3'47.70"N 77°34'35.37"E	A commercial area railway station
NQ16	Residential Building near irish house	13° 5'18.57"N 77°35'41.57"E	Residential building left side of the corridor which was 13m from the railway track
NQ17	Yelahanka Gnanabarathi School	13° 6'45.31"N 77°35'20.49"E	Educational institution building right side of the corridor which was 80m to the railway track
NQ18	Near Airport Terminal PRS	13°11'55.45"N 77°39'32.91"E	A busy traffic area with lot of vehicle movements towards airport
NQ19	Devanahalli RS	13°14'50.89"N 77°42'19.15"E	A commercial area railway station
NQ20	Nirmithi Kendra near prop. Akkupete Depot	13°14'56.80"N 77°41'10.05"E	A rural settlement with limited movement of vehicle
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara			
NQ1	Govt. School, Benniganahalli	12°59'41.56"N 77°39'49.15"E	A silent zone which was located at 5m distance from the right side of the track
NQ2	Mother Mary English School, Chikka Banaswadi	13° 0'18.95"N 77°38'55.08"E	A silent zone which was located at 5m distance from the right side of the track
NQ3	Eunice English school , Lingarajapuram	13° 0'33.34"N 77°37'15.20"E	A silent zone which was located at 5m distance from the right side of the track
NQ4	Residential Building Kadugondanahalli	13° 1'26.98"N 77°37'18.77"E	Residential building left side of the corridor which was 13m from the railway track
NQ5	Residential Building, Kadugondanahalli	13° 2'27.05"N 77°36'14.24"E	Residential building left side of the corridor which was 13m from the railway track
NQ6	Public Library, MK Nagar	13° 2'43.72"N 77°34'50.65"E	A silent zone which was located at 5m distance from the right side of the track
NQ7	Lottegollanahalli RS	13° 2'37.06"N 77°33'47.25"E	A commercial area railway station
NQ8	P.R Public School, Mohan Kumar Nagar	13° 1'53.30"N 77°33'9.50"E	A silent zone which was located at 5m distance from the right side of the track
NQ9	Sheela Engineerings, Kammagondanahalli	13° 3'30.89"N 77°31'55.69"E	Industrial area which was adjacent to corridor
NQ10	Residential Building, Kammagondanahalli	13° 4'23.15"N 77°30'28.74"E	Residential building left side of the corridor which was 13m from the railway track
NQ11	National Public School, Shettyhalli	13.071269 N, 77.509686 E	A silent zone which was located at 5m distance from the right side of the track
NQ12	Residential House, Chikkabanavara	13° 4'38.20"N 77°30'15.17"E	Residential building left side of the corridor which was 13m from the railway track

Location Code	Name of the Location	Co-ordinates	Classification of Location as per Standards
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)			
NQ1	Kengeri RS	12°55'0.73"N 77°29'0.56"E	Residential building left side of the corridor which was adjacent to the railway track
NQ2	Bengaluru Institute of Management Studies, Kengeri	12°55'33.57"N 77°29'57.41"E	A silent zone which was located at 5m distance from the right side of the track
NQ3	Residential near Nayandanahalli RS	12°56'31.89"N 77°31'18.93"E	Residential area
NQ4	SreeChakra Industrial Unit Nayandanahalli	12°56'45.27"N 77°31'34.40"E	Industrial area adjacent to railway track
NQ5	Shiva & Ganesh temple Krishnadevaraya Halt	12°57'31.56"N 77°32'22.84"E	A silent zone which was located at 5m distance from the right side of the track
NQ6	Subramanya Swamy Temple, Krishnadevaraya	12°58'3.76"N 77°33'4.72"E	A silent zone which was located at 5m distance from the right side of the track
NQ7	Holy Gopsee Prayer House	12°58'6.18"N 77°33'36.52"E	A silent zone which was located at 5m distance from the right side of the track
NQ8	Karnataka Welfare Association for the Blind School, Sheshadripuram	12°59'4.80"N 77°34'29.84"E	A silent zone which was located at 5m distance from the right side of the track
NQ9	Residential near Nehru Circle Sheshadripuram	12°59'17.16"N 77°34'42.44"E	Residential building left side of the corridor which was adjacent to the railway track
NQ10	Mount Carmel College Palace Road, Jeevanahalli	12°59'45.67"N 77°35'0.56"E	Residential building left side of the corridor which was adjacent to the railway track
NQ11	Residential near Cantonment RS	12°59'30.04"N 77°36'8.90"E	Residential building left side of the corridor which was adjacent to the railway track
NQ12	Anugraha AG church Jeevanahalli	13° 0'0.47"N 77°40'9.37"E	Residential building left side of the corridor which was adjacent to the railway track
NQ13	City Hospital, Pulikeshi Nagar	13° 0'5.80"N 77°36'45.52"E	Residential building left side of the corridor which was adjacent to the railway track
NQ14	Central Library, Jeevanahalli	12°59'41.72"N 77°37'40.79"E	A silent zone which was located at 5m distance from the right side of the track
NQ15	Govt. PU College, Hoodi	12°59'44.33"N 77°43'5.75"E	A silent zone which was located at 5m distance from the right side of the track
NQ16	Residential at Sadarmangala	12°59'53.04"N 77°44'16.93"E	Residential building left side of the corridor which was adjacent to the railway track

Location Code	Name of the Location	Co-ordinates	Classification of Location as per Standards
Corridor – 4: Heelalige to Rajanukunte			
NQ1	Bengaluru College of Engineering, Heelalige	12°48'48.32"N 77°42'38.42"E	A silent zone which was located at 5m distance from the right side of the track
NQ2	Norwich High School, Electronic City Phase II	12°49'29.97"N 77°42'43.75"E	A silent zone which was located at 5m distance from the right side of the track
NQ3	Carmelram Campus, Chikkabellandur	12°54'33.42"N 77°42'21.62"E	Residential building left side of the corridor which was adjacent to the railway track
NQ4	iSmile Dental Care, Sapthagiri Layout, Marthalli	12°56'53.27"N 77°42'21.77"E	A Commercial place adjacent to track
NQ5	Lions Airport City Hospital, Munnekollal	12°57'18.31"N 77°42'18.45"E	A Commercial place adjacent to track
NQ6	Kies mansion School, Chinnappanahalli	12°57'44.03"N 77°42'12.93"E	A silent zone which was located at 5m distance from the right side of the track
NQ7	Geethanjali Vidyalaya, Mahadevapura	12°58'51.16"N 77°41'8.76"E	A silent zone which was located at 5m distance from the right side of the track
NQ8	Ayappaswamy Temple Kaggadasapura	12°59'0.76"N 77°40'49.76"E	A silent zone which was located at 5m distance from the right side of the track
NQ9	Sai Speciality Hospital, Benniganahalli	12°59'58.55"N 77°39'46.14"E	A silent zone which was located at 5m distance from the right side of the track
NQ10	Ebinazer School at Horamavu	13° 1'20.83"N 77°39'40.25"E	Residential building left side of the corridor which was adjacent to the railway track
NQ11	Grace Methodist Church, Shanthinagar	13° 2'22.66"N 77°38'52.74"E	A silent zone which was located at 5m distance from the right side of the track
NQ12	Ayappaswamy Temple Kaggadasapura	13° 4'49.08"N 77°36'31.25"E	Residential building left side of the corridor which was adjacent to the railway track
NQ13	Govt. PU College, Yelahanka	13° 5'50.08"N 77°35'41.26"E	A silent zone which was located at 5m distance from the right side of the track
NQ14	Residential Building at Vasudevapura	13° 7'3.87"N 77°35'2.25"E	A silent zone which was located at 5m distance from the right side of the track
NQ15	Industry, Rajanukunte	13°10'44.89"N 77°33'55.82"E	Industrial Area adjacent to railway track
NQ16	Residential near RGA Tech Park	12°54'9.23"N 77°42'21.75"E	Residential building left side of the corridor which was adjacent to the railway track
NQ17	Residential near Belandur Pro RS	12°56'9.14"N 77°42'24.21"E	Residential building left side of the corridor which was adjacent to the railway track
NQ18	Residential near Doddanakundi	12°58'16.62"N 77°42'5.46"E	Residential building left side of the corridor which was adjacent to the railway track

Location Code	Name of the Location	Co-ordinates	Classification of Location as per Standards
NQ19	Residential near Pai layout	12°59'21.29"N 77°40'13.96"E	Residential building left side of the corridor which was adjacent to the railway track
NQ20	Residential near Arkavathi Layout	13° 1'55.72"N 77°39'12.16"E	Residential building left side of the corridor which was adjacent to the railway track
NQ21	Residential near Arkavathi Layout	13° 3'43.53"N 77°37'44.16"E	Residential building left side of the corridor which was adjacent to the railway track
NQ22	Residential near Nagenahalli Village	13° 7'53.50"N 77°34'33.13"E	Residential building left side of the corridor which was adjacent to the railway track
NQ23	Residential near Sai Layout	13° 8'50.13"N 77°34'13.58"E	Residential building left side of the corridor which was adjacent to the railway track
NQ24	Residential near Rajanukunte RS	13°10'17.67"N 77°33'55.67"E	Residential building left side of the corridor which was adjacent to the railway track

The Leq day and Leq night and Leq Max and Leq Min calculated for various locations in the project area are presented in **Table 5.30.** The values are compared with the standards prescribed by CPCB for various zones.

Table 5.30. Corridor wise Ambient Noise Level Monitoring Results

Location Code	Name of the Location	Noise Level Results (Leq)				Standards*	
		Max [dB(A)]	Min [dB(A)]	Day [dB(A)]	Night [dB(A)]	Day [dB(A)]	Night [dB(A)]
Corridor – 1: KSR Bengaluru City to Devanahalli							
NQ1	KSR Bengaluru RQ	92.3	41.8	57.1	45.3	55	45
NQ2	Srirampura PRS	87.3	37.4	56.1	43.9	55	45
NQ3	Residential Building at Srirampura	88.1	38.8	54.8	41.3	55	45
NQ4	Malleshwaram RS	90.2	36.9	53.5	43.8	65	55
NQ5	Ayyappa swamy temple	88.6	37.5	52.8	41.6	55	45
NQ6	Manipal Hospital	87.9	36.1	55.7	42.8	55	45
NQ7	Nitte Meenakshi Institute of Technology	87.5	33.2	51.6	38.5	50	40
NQ8	Cluny convent high school	88.3	35	52.1	40.6	50	40
NQ9	Yeswanthapur RS	91.7	42.1	60.8	48.2	65	55
NQ10	Residential Building near Mathikere	88.5	36.8	53.5	41.8	55	45
NQ11	Lottegollahalli RS	89.8	35.1	53.2	42.9	65	55
NQ12	Bishop Sargent Secondary school, Devinagar	87.6	34.3	52.8	41.7	50	40

Location Code	Name of the Location	Noise Level Results (Leq)				Standards*	
		Max [dB(A)]	Min [dB(A)]	Day [dB(A)]	Night [dB(A)]	Day [dB(A)]	Night [dB(A)]
NQ13	Residential Building of the Tatanagar	88.2	37.1	53.9	40.8	55	45
NQ14	Residential Building at Meenakunte Hosur	87.9	34.6	52.5	41.1	55	45
NQ15	Kodigehalli RS	88.8	35.9	53.1	41.9	65	55
NQ16	Apartment of the irish house	89.4	38.5	54.6	42.8	55	45
NQ17	Yelahanka Gnanabarathi School	87.1	37.8	51.9	39.2	50	40
NQ18	Near Airport Terminal PRS	88.5	38.5	53.6	42.7	65	55
NQ19	Devanahalli RS	90.9	36.2	52.4	41.1	65	55
NQ20	Nirmithi Kendra near Pro. Akkupete Depot	82.5	31.4	48.9	37.6	55	45
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara							
NQ1	Govt. School, Benniganahalli	87.5	37.6	54.3	43.6	50	40
NQ2	Mother Mary English School	89.1	35.3	52.1	41.4	50	40
NQ3	Eunice English school , Lingarajapuram	86.9	38.1	52.7	41.9	50	40
NQ4	Residential Building Kadugondanahalli	89.4	39.7	56.7	44.6	55	45
NQ5	Residential Building, Kadugondanahalli	88.1	38.5	54.2	43.5	55	45
NQ6	Public Library MK Nagar	91.5	39.3	56.1	45.8	50	40
NQ7	Lottegollanahalli RS	89.8	35.1	53.2	42.9	65	55
NQ8	P.R Public School, MK Nagar	90.5	35.8	55.8	43.6	50	40
NQ9	Sheela Engineerings. Kammagondanahalli	89.4	39.6	53.6	44.1	75	70
NQ10	Residential Building, Kammagondanahalli	87.6	37.3	52.8	43.7	55	45
NQ11	National Public School, Shettyhalli	87.1	33.2	51.4	40.8	50	40
NQ12	Residential House, Chikkabanavara	93.8	40.1	60.6	47.6	55	45
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)							
NQ1	Kengeri RS	91.3	39.2	53.8	42.9	65	55
NQ2	Bengaluru Institute of Management Studies	88.1	36.4	52.6	39.1	50	40
NQ3	Residential near Nayandanahalli RS	89.5	37.6	53.5	40.8	55	45

Location Code	Name of the Location	Noise Level Results (Leq)				Standards*	
		Max [dB(A)]	Min [dB(A)]	Day [dB(A)]	Night [dB(A)]	Day [dB(A)]	Night [dB(A)]
NQ4	SreeChakra Industrial Unit Nayandanahalli	88.7	36.1	52.8	41.4	75	70
NQ5	Shiva & Ganesh temple Krishnadevaraya Halt	90.4	35.2	57.1	43.9	55	45
NQ6	Subramanya Swamy Temple, Krishnadevaraya	90.1	36.3	56.2	42.7	55	45
NQ7	Holy Gopsee Prayer House	90.6	36.9	52.2	41.9	50	40
NQ8	Karnataka Welfare Association for the Blind, Sheshadripuram	90.3	37.1	54.1	42.6	50	40
NQ9	Residential near Nehru Circle Sheshadripuram	89.8	39.5	54.3	44	55	45
NQ10	Mount Carmel College Palace Road	88.7	35.2	52.2	40.4	50	40
NQ11	Residential near Cantonment RS	90.2	36.6	53.1	41.6	65	55
NQ12	Anugraha AG church Jeevanahalli	88.3	35.1	51.9	40.3	50	40
NQ13	City Hospital, Pulikeshi Nagar	89.5	35.3	52.6	42.4	50	40
NQ14	Central Library, Jeevanahalli	88.2	33.8	51.7	40.8	50	40
NQ15	Govt. PU College, Hoodi	91.1	34.7	52.3	40.9	55	45
NQ16	Residential at Sadarmangala	92.2	37.1	51.4	41.4	55	45
Corridor – 4: Heelalige to Rajanukunte							
NQ1	Banglore Colleage of Engineering, Heelalige	87.4	31.9	51.2	39.6	50	40
NQ2	Norwich High School, Electronic City Phase II	85.2	36.4	52.8	42.7	50	40
NQ3	Carmelram Campus, Chikkabellandur	87.3	38.8	51.6	43.9	55	45
NQ4	iSmile Dental Care, Sapthagiri Layout, Marthalli	88.2	36.9	53.1	42.8	55	45
NQ5	Lions Airport City Hospital, Munnekollal	88.7	36.5	52.4	41.6	55	45
NQ6	Kies mansion School, Chinnappanahalli	89.1	37.1	51.7	41.2	50	40
NQ7	Geethanjali Vidyalaya, Mahadevapura	89.7	37.2	50.6	43.5	50	40
NQ8	Ayappaswamy Temple Kaggadasapura	90.3	36.4	52.2	42.6	55	45

Location Code	Name of the Location	Noise Level Results (Leq)				Standards*	
		Max [dB(A)]	Min [dB(A)]	Day [dB(A)]	Night [dB(A)]	Day [dB(A)]	Night [dB(A)]
NQ9	Sai Speciality Hospital, Bennaganahalli	89.5	37.1	53.7	41.9	55	45
NQ10	Ebinazer School at Horamavu	88.5	36.8	54.8	40.9	55	45
NQ11	Grace Methodist Church, Shanthinagar	89.8	36.1	52.5	41.2	55	45
NQ12	Ayappaswamy Temple Kaggadasapura	87.6	37.3	53.4	40.6	55	45
NQ13	Govt. PU College, Yelahanka	88.2	37.1	53.8	39.2	50	40
NQ14	Residential Building at Vasudevapura	87.4	36.6	54.8	42.8	55	45
NQ15	Industry, Rajanukunte	88.5	37.9	50.3	41.4	75	70
NQ16	Residential near RGA Tech Park	88.8	37.5	52.1	40.8	55	45
NQ17	Residential near Belandur Pro RS	88.3	36.8	53.3	43.5	55	45
NQ18	Residential near Doddanakundi	87.6	36.5	52.9	39.7	55	45
NQ19	Residential near Pai layout	88.4	36.2	51.8	42.9	55	45
NQ20	Residential near Arkavathi Layout	89.8	37.4	52.5	41.6	55	45
NQ21	Residential near Arkavathi Layout	88.3	36.2	53.5	43.9	55	45
NQ22	Residential near Nagenahalli Village	89.4	37.4	51.9	41.8	55	45
NQ23	Residential near Sai Layout	88.8	36.4	53.8	43.6	55	45
NQ24	Residential near Rajanukunte RS	92.1	37.5	52.9	40.5	55	45

**Standard as per Environmental Protection Act 1986, the principle rules published for Ambient Noise Level Standard (Area Category: Industrial/Residential/Commercial Area).*

Observations:

Corridor 1

Day time Noise Levels

Noise levels during day time were found to be in the average range of 48.9 to 60.8 dB (A). The maximum noise level was observed as 60.8 dB (A) at Yeshwanthapur RS and a minimum of 48.9 dB (A) was observed at Nirmithi Kendra near proposed Akkupete depot.

Night time Noise Levels

Noise levels observed to fall in the range 37.6 to 48.2 dB (A) during the night time. A maximum of 48.2 dB (A) was observed at Yeshwanthapur RS and a minimum of 37.6 dB (A) was observed at Nirmithi Kendra near proposed Akkupete depot.

Corridor 2

Day time Noise Levels

Noise levels during day time were found to be in the average range of 51.4 to 60.6 dB (A). The maximum noise level was observed as 60.6dB (A) at Residential Building, Chikkabanavara and a minimum of 51.4 dB (A) was observed at National Public School, Shettyhalli.

Night time Noise Levels

Noise levels observed to fall in the range 40.8 to 47.6 dB (A) during the night time. A maximum of 47.6 dB (A) was observed at Residential Building, Chikkabanavara and a minimum of 40.8dB (A) was observed at National Public School, Shettyhalli.

Corridor 3

Day time Noise Levels

Noise levels during day time were found to be in the average range of 51.4 to 57.1 dB (A). The maximum noise level was observed as 57.1dB (A) at Shiva & Ganesh Temple, Chikkabanavara and a minimum of 51.4 dB (A) was observed at Residential at Sadarmangala.

Night time Noise Levels

Noise levels observed to fall in the range 39.1 to 44 dB (A) during the night time. A maximum of 44 dB (A) was observed at Residential near Nehru Circle Sheshadripuram and a minimum of 39.1dB (A) was observed at Bengaluru Institute of Management Studies.

Corridor 4

Day time Noise Levels

Noise levels during day time were found to be in the average range of 50.3 to 54.8 dB (A). The maximum noise level was observed as 54.8dB (A) at Masjid and Residential at Horamavu, and a minimum of 50.3 dB (A) was observed at Industry, Rajanukunte.

Night time Noise Levels

Noise levels observed to fall in the range 39.2 to 43.9 dB (A) during the night time. A maximum of 43.9 dB (A) was observed at Residential near Akravathi layout and a minimum of 39.2dB (A) was observed at Govt. PU College, Yelahanka.

5.8.2. Ambient Vibration Monitoring

Vibration is an oscillatory motion which can be described in terms of the displacement, velocity, or acceleration. As the motion is oscillatory, there is no net movement of the vibration element and the average of any of the motion descriptors is zero. Displacement is the easiest descriptor to understand.

For a vibrating floor, the displacement is simply the distance that a point on the floor moves away from its static position. The velocity represents the instantaneous speed of the floor movement and acceleration is the rate of change of that speed.

Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing ground-borne vibration. Most transducers used for measuring ground-borne vibration use either velocity or acceleration. Further, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration.

Ground-borne vibration are generated at the wheel/rail interface, when the vehicle travels on the rail, the quasi-static and the dynamic forces arise from the contact points.

Quasi-static forces are the outcome of the self-weight of the train, and they dominate near the field up to one-quarter of the wavelength. The quasi-static deflection of a typical track is a picture of such forces (and thus of the vibration generated). This is illustrated in **Figure 5.21** and can be deduced from a simple configuration.

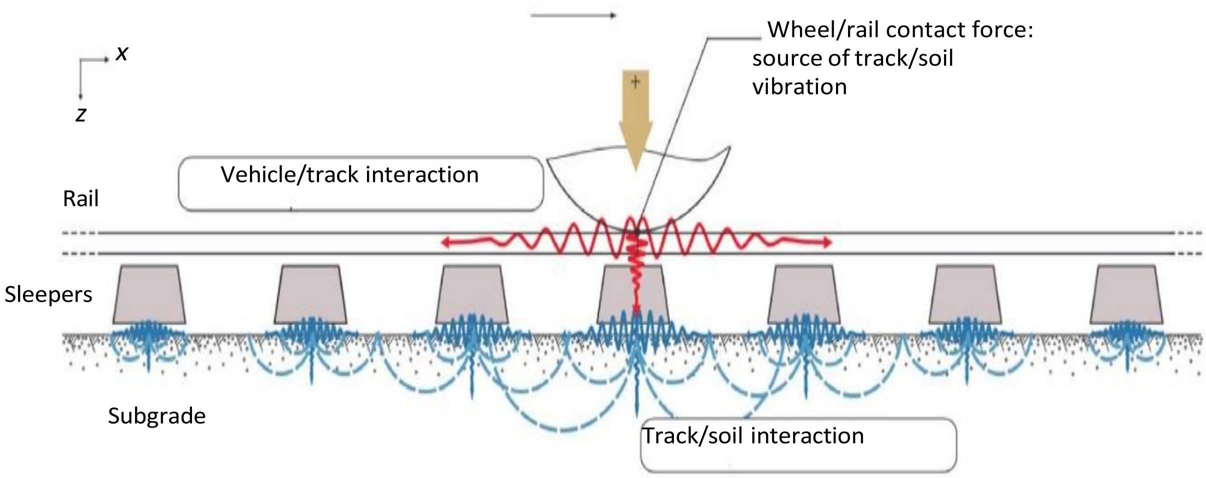


Figure 5.21. Vibration from Rail Sources

The train wheels rolling on the rails create vibration energy that is transmitted through the track support system into the transit structure. The amount of energy that is transmitted into the transit structure is strongly dependent on factors such as the smoothness of the wheels and rails and the resonance frequencies of the vehicle suspension system and the track support system. These systems, like all mechanical systems, have resonances which result in increased vibration response at certain frequencies, called natural frequencies.

The baseline vibration monitoring must be conducted prior to the commencement of actual construction. This process will help to measure any subsequent changes due to actual construction that may be attributed to the ground vibrations. Freezing the baseline of vibration level is done after collecting multiple data sets on all the 12 monitored locations with tri-axial sensors under normal operating conditions. Once a baseline has been established, vibration analysts use the signature as a point of reference to track changes due to construction activities. The monitoring periods ranged was continues 24 hours for each location. Vibration study has been undertaken by Esperto Novero Inspection and Engineering Consultancy (ENIECO) Pvt. Ltd. from 23rd March 2022 to 6th April 2022.

The monitoring locations were selected in each corridor to represent the actual baseline vibration levels. The selected locations are in close proximity to the (100 m) proposed rail routes. The monitoring locations are near to the urban settlements and thus are sensitive to project development activity.

Vibration impacts for this project are based on the criteria as defined in the FTA guidance manual Transit Noise and Vibration Impact Assessment (FTA Report FTA-VA-90-1003-06, May 2006) and Research Designs & Standards Organisation (RDSO) guidelines. The criteria for acceptable ground-borne vibration are expressed in terms of rms velocity levels in decibels and the criteria for acceptable ground-borne noise are expressed in terms of A-weighted sound levels. The limits are specified for the three land-use categories defined below:

Vibration Category 1 – High Sensitivity: Included in Category 1 are buildings where vibration would interfere with operations within the building, including levels that may be well below those associated with human annoyance. Typical land uses covered by Category 1 are: vibration-sensitive research and manufacturing, hospitals with vibration-sensitive equipment, and university research operations. The degree of sensitivity to vibration will depend on the specific equipment that will be affected by the vibration. Equipment such as electronic microscopes and high-resolution lithographic equipment can be very use when vibration is well below the human annoyance level. Manufacturing of computer chips is an example of a vibration- sensitive process.

Vibration Category 2 – Residential: This category covers all residential land uses and any buildings where people sleep, such as hotels and hospitals. No differentiation is made between different types of residential areas. This is primarily because ground-borne vibration and noise are experienced indoors and building occupants have practically no means to reduce their exposure. Even in a noisy urban area, the bedrooms often will be quiet in buildings that have effective noise insulation and tightly closed windows. Moreover, in certain cities street traffic often abates at night when trains continue to operate. Hence, an occupant of a bedroom in a noisy urban area is likely to be just as exposed to ground-borne noise and vibration as someone in a quiet suburban area. The criteria apply to the transit-generated ground-borne vibration and noise whether the source is subway/tunnel or surface running trains.

Vibration Category 3 – Institutional: This category includes schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference. Although it is generally appropriate to include office buildings in this category, it is not appropriate to include all buildings that have any office space. For example, most industrial buildings have office space, but it is not intended that buildings primarily for industrial use be included in this category.

Corridor wise Ambient Vibration monitoring locations are presented in **Table 5.31**. Photographs of the ambient Vibration monitoring locations are presented in **Annexure 5.4.**

Table 5.31. Details of Ambient Vibration Monitoring Locations along the BSRP Corridors

Corridors	Code	Monitoring Location Name/General	Co-ordinates	Category*
Corridor 1	V-1	Manipal Hospital, Malleshwaram	13°0'7"N 77°33'49"E	Category 1
	V-2	Residential Building at Muthyalanagar	13°2'22"N 77°32'57"E	Category 2

Corridors	Code	Monitoring Location Name/General	Co-ordinates	Category*
	V-3	NITTE Global Institute, Yelahanka	13°7'45"N 77°35'12"E	Category 3
Corridor 2	V-1	Mother Mary English School, Kasturi Nagar	13° 0'18.79"N 77°38'55"E	Category 3
	V-2	Residential Building at Lottagollanahalli	13°2'35"N 77°33'46"E	Category 2
	V-3	National Public School, Chikkabanavara	13°4'15"N 77°30'35"E	Category 3
Corridor 3	V-1	Suhasini hospital, Kengeri	12°55'12"N 77°29'7"E	Category 1
	V-2	Residential House at Telecom Layout, Vijayanagar	12°57'22"N 77°32'15"E	Category 2
	V-3	Karnataka Welfare Association for the Blind, Sheshadripuram	12°59'6.08"N 77°34'29.71"E	Category 3
Corridor 4	V-1	Lions Airport City Hospital, Marathahalli	12°57'18.38"N 77°42'18.68"E	Category 1
	V-2	Center for Artificial Intelligence and Robotics (CAIR,DRDO), Nagawaraplaya	12°59'21"N 77°40'9"E	Category 1
	V-3	Govt. PU College, Yelahanka New Town	13°5'47"N 77°35'42"E	Category 3

**Location categorisation as per Guidelines for Noise & Vibration as per Metro Rail Transit system, RDSO*

A summary of the maximum baseline vibration recorded at each location is shown in **Table 5.32.**

Table 5.32. Ambient Vibration Monitoring Results for BSRP Corridors

Sl. No.	Date of Monitoring	Corridor No./ Vibration Code	Location Details	Trans Peak Value (Mm/S)	Vertical Peak Value (Mm/S)	Long Peak Value (Mm/S)	Peak Particle Velocity (Ppv) (Mm/S)
1	26-27 March 2022	Corridor 1 V-1	Manipal Hospital	0.378	1.096	0.449	1.107
2	25-26 March 2022	Corridor 1 V-2	Residential Building at Muthyalanagar	0.244	0.465	0.158	0.531
3	31 March-01 April 2022	Corridor 1 V- 3	NITTE Global Institute	0.102	0.087	0.110	0.128
4	24-25 March 2022	Corridor 2 V-1	Mother Mary English School	0.252	0.686	0.402	0.718
5	5-6 April 2022	Corridor 2 V-2	Residential Building at Lottagollanahalli	0.213	0.757	0.197	0.792
6	23-24 March 2022	Corridor 2 V-3	National Public School	0.370	0.701	0.331	0.705

Sl. No.	Date of Monitoring	Corridor No./ Vibration Code	Location Details	Trans Peak Value (Mm/S)	Vertical Peak Value (Mm/S)	Long Peak Value (Mm/S)	Peak Particle Velocity (Ppv) (Mm/S)
7	29-30 March 2022	Corridor 3 V-1	Suhasini Hospital	3.878	0.315	4.800	6.171
8	28-29 March 2022	Corridor 3 V-2	Residential House at Telecom Layout	0.307	0.654	0.284	0.675
9	27-28 March 2022	Corridor 3 V-3	Karnataka Welfare Association for the Blind	6.211	5.943	2.554	8.636
10	4-5 April 2022	Corridor 4 V-1	Lions Airport City Hospital	0.418	0.741	0.891	0.949
11	2-3 April 2022	Corridor 4 V-2	Centre for Artificial Intelligence and Robotics (CAIR,DRDO)	0.205	1.269	0.292	1.313
12	1-2 APRIL 2022	Corridor 4 V-3	Govt. PU College	0.331	0.591	0.355	0.634

Observations:

Based on the summary of the baseline vibration monitoring performed, except for Corridor 1 V3 location – NITTE Global Institute, Yalahanka where the Peak Particle Velocity (PPV) is 0.128 mm/s which is less the threshold trigger level (05 mm/s). In rest of the locations, the PPV is higher than the threshold trigger level. The maximum PPV recorded was at Corridor 3 V-3 location, Karnataka Welfare Association for the Blind, Sheshadripuram which showed a PPV of 8.636 mm/s. The second highest was recorded at Corridor 3 V-1 location, Suhasini Hospital, Kengeri which recorded a PPV of 6.171 mm/s. These two areas fall under the Corridor 3 and proper action has to be taken to reduce the baseline vibration levels. Corridor 1 V-1 location recorded a PPV of 1.107 mm/s and Corridor 4 V-2 location recorded a PPV of 1.313 mm/s, which is the third highest value and proper remedial actions has to be taken to bring down the vibration level below the threshold trigger level.

All other locations are less than 1.00 mm/s but higher than 0.5mm/s the threshold trigger level. Hence, the construction team must give priority and take proper corrective and preventive action to mitigate and reduce the vibration level.

5.9. Biological Environment

Bengaluru is also known has 'garden city', which has well designed green space and natural and man-made lakes. In recent years, city is experiencing rapid unscientific and unplanned urbanisation due to growing demand for residential and commercial spaces. This resulted in concretisation of the city by losing its green space. In addition, to provide enhanced connectivity for these urban agglomerates, many new infrastructure facilities have been introduced, which also created pressure on the biological environment of the region.

Garden City of India has two nationally renowned botanical gardens Cubbon Park which is located at the centre of Bengaluru city at a distance of 2.8 km (nearest aerial distance) from the Corridor 3 of BSRP alignment and Lal Bagh which is also located at the centre of Bengaluru city at a distance of 1.67 km (nearest aerial distance) from the Corridor 3 of BSRP alignment. The Cubbon Park was established in the year 1870 by John Meade and has a history of over 100 years. Indigenous and exotic botanical species are found in the park. There are about 68 genera and 96 species with a total of around 6,000 plants/trees. Some of the indigenous species found in the park are Artocarpus species, Cassia fistula, Ficus species, Polyalthias, etc., and exotic species such as Araucaria, Bamboo, Castanospermumm Australe, Grevillea robusta, Millettia, Peltophorum, Schinusmolle, Swieteniamahagoni, Tabebuia species, etc. Lalbagh, is a botanical garden and has been a treasure house of plants. The rich floral wealth of Lalbagh extends over an area of 97 hectares (240 acres) accommodating 1,854 species 673 genera and 890 cultivars of plants. It is also home to numerous wild species of birds and other wildlife.

5.9.1. Forests and Protected Areas

5.9.1.1. Forests

In 1982, a Forest Division was created under the name Bengaluru Green Belt Division which was entrusted with the job of greening of Bengaluru Metropolitan Region. Later on, the same has been enlarged to cover the Bengaluru District (including Bengaluru Rural district). The natural vegetation consists of species like Albizzia amara, Albizzia lebbek, Anogiessuslatifolia, Acacia species, Shoreatalura and Santalum album, etc.

The total forest area of the Bengaluru Districts are around 2.3 percent (50.55 Sq.km) and 4.93 percent (113.22 Sq.km) respectively of the total geographical area. The forests are of tropical dry deciduous type mostly containing Acacia, Albizia, Wrightia tinctoria, Zizyphus, Dendrocalamus strictus, Anogeissus latifolia etc. Forest areas in the project districts are multitude of Reserved Forest, Plantations, Reserves and protected areas.

Consequent to the division of Bangalore District into Bangalore Urban and rural districts vide Government Order No. Rd/56/LRD/86 dated 31-7-1986, Bangalore urban and rural districts came into existence in 01.4.1988 with the jurisdiction coinciding with that of Bangalore urban and Rural Districts respectively. Subsequently, Bangalore Rural Forest Division came into existence in 21-8-2007.

Bengaluru Urban Forest Division:

Bengaluru Urban division is situated on the southern portion of Karnataka. The division has about 6712.94 Ha of forest area. It has two sub-divisions, namely, Bengaluru North sub-division and Bengaluru South sub-division, and consists of five ranges, namely, Anekal, Bengaluru, Krishna Raja Puram, Kaggalipura and Yelahanka. The forests of Bengaluru Urban division are of dry deciduous scrub type, and consist of species such as Chigare, Pachali, Bekke, Kakke, Kagali, Lantana, Bandarike, Jalari, etc. There are no prominent fauna species present in the forest areas of the division. There was no prominent wild animals noticed during surveys and no wild animal presence mentioned during discussion with concerned forest official of the project region. Abstract of forest land available with Bengaluru Urban division is presented in **Table 5.33**.

Table 5.33. Abstract of Forest Land Available with the Bengaluru Urban Forest Division

Sl. No.	Name of the Range	Notified Forest in Ha.	Unclassified (Deemed) Forests in Ha	Total Area in Ha
1	Anekal	333.92	476.45	810.37
2	Bengaluru	1285.75	168.49	1454.24
3	Krishna Raja Puram	287.74	310.45	598.19
4	Kaggalipura	2261.08	758.67	3019.75
5	Yelahanka	808.45	21.94	830.39
Total Forest Area in Ha		**4976.94**	**1736.0**	**6712.94**

Source: Working Plan Bengaluru Urban Forest Division Year 2021-22.

Bengaluru Rural Forest Division:

The geographical area of the Bangalore rural division is 2266 sq. km or 226600 Ha out of which 18642.92 Ha are forest lands. Forests therefore constitute about 8.25% of the geographical area of the division. The forests are of tropical dry deciduous type mostly containing Acacia, Albizia, Wrightia tinctoria, Zizyphus, Dendrocalamus strictus, Anogeissus latifolia etc. Common fauna found in forest area of the Bengaluru Rural Forest Division are Slot bear, panther, Block buck, Chital, Spotted deer, large verity of retails, Hares, Porcupine , Jackal, Fox, Peacocks etc. However, there was no wild animals noticed during surveys and no wild animal presence mentioned during discussion with concerned forest official of the project region. Abstract of forest land available with Bengaluru Rural division is tablulated in **Table 5.34**.

Table 5.34. Abstract of Forest Land Available with the Bengaluru Rural Forest Division

Sl. No.	Name of the Range	Notified Forest in Ha.	Unclassified (Deemed) Forests in Ha	Total Area in Ha
1	Devanahalli	2586.32	519.14	3105.46
2	Doddaballapura	6704.00	1279.60	7983.60
3	Hoskote	3565.55	60.70	3626.25
4	Nelamangala	3611.39	316.22	3927.61
Total Forest Area in Ha		**15623.19**	**2175.66**	**18642.92**

Source: Working Plan Bengaluru Rural Forest Division Year 2011-12 t o 2020-21.

In order to collect the forest land details in Bengaluru Urban District, consultant team met Territorial Forest Division. It was informed that, there is no forest map readily available for the district. However, it was informed to refer forest land marked in Toposheet prepared by Survey of India for the proposed BSRP project.

As per Survey of India Toposheet, BSRP corridors are not crossing/abutting the forest land except Corridor 1 – Bengaluru City (KSR) to Devanahalli as railway alignment is abutting forest land towards LHS at Chainage km 19/700 (the present landuse in this location is residential). However, suburban rail is proposed on RHS, so there is no impact of flora and fauna of forest and no forest land diversion envisaged. Forest land present within project study area ie., 5Km on either side of the proposed railway alignment is presented in **Table 5.35**.

Table 5.35. Forest Area present within Project Study Area (5 Km on either side of the Project)

Sl. No.	Name of the Forest	Forest Division	Forest Range	Forest Area in Ha.	Nearest Aerial Distance from BSRP Corridor	Remarks
1	Jarakabande Reserved Forest	Bengaluru Urban	Yelahanka Range	199.92	2.3 Km from Corridor 4	
2	Jarakabande Reserved Forest				4.2 Km from Corridor 4	
3	Sulikere Reserved Forest	Bengaluru Urban	Kagalipura Range	212.48	3.8 Km from Corridor 3	
4	TurahalliGudda Protected Forest	Bengaluru Urban	Kagalipura Range	238.97	2 Km from Corridor 3	
5	TurahalliGudda Protected Forest				4.9 Km from Corridor 3	
6	Badamanavarti Reserved Forest	Bengaluru Urban	Kagalipura Range	566.80	4.8 Km from Corridor 3	
7	Reserved Forest	Bengaluru Urban	Bengaluru Urban Range		4.9 Km from Corridor 2	
8	Yaratiganahalli Reserved Forest	Bengaluru Rural	Devanahalli Range	215.42	0.4 Km from Corridor 1	Diverted for Kempegowda International Airport.
9	Rayasandra Reserved Forest	Bengaluru Rural	Devanahalli Range	93.08	3.6 Km from Corridor 1	Diverted for Kempegowda International Airport.
10	Reserved Forest	Bengaluru Rural	Devanahalli Range		0.1 Km from Corridor 1	Existing landuse is built-up.
11	Koramangala Extension Reserved Forest	Bengaluru Rural	Devanahalli Range	415.65	4.1 Km from Corridor 1	
12	Bettakote Reserved Forest	Bengaluru Rural	Devanahalli Range	426.52	4.2 Km from Corridor 1	Diverted for Kempegowda International Airport.
13	Akkupete Reserved Forest	Bengaluru Rural	Devanahalli Range	83.77	1.1 Km from Corridor 1	Proposed to divert 18.6Ha for Akkupete Depot for BSRP.

The forest land located in the indirect impact zone is depicted in Survey of India Toposheet presented in **Annexure 4.1**.

The BSRP alignments are proposed along the existing Indian Railway alignment for the entire length. The nearest forest land as per the above table is TurahalliGudda Protected Forest, which is located at 2.1Km from the proposed Corridor 3 railway alignment. As per the above table, BSRP alignment is not crossing/abutting any reserved/ protected forest land. Forest Department has taken up barricading, trenches and fencing of most of these forest lands to conserve wild animals and preventing human-animal conflicts.

Hence, there is no impact on flora or fauna of the forest land considering its proximity and urban growth. Engaging a biodiversity expert to carry out further biodiversity impact assessment due to proposed project on these forest lands does not required.

Further, a suburban railway depot is proposed in reserved forest land at Akkupete (13°14'50.40"N & 77°41'26.37"E) near Devanahalli station, which requires about 18.6 Ha of forest land for construction of depot. As per the information received from Forest Dept., the proposed forest land was taken up for compensatory afforestation for 25 Ha in the year 2001. *Eucalyptus fibrosa* and *Acacia mangium* tree species are predominantly planted in the forest land under Compensatory Afforestation scheme. There is no presence of wild animals observed during site visits. Photographs of the proposed depot at Akkupete is presented in **Figure 5.22**. Google earth image of Akkupete Depot site is presented in **Figure 5.23**.

Figure 5.22. Photographs of Forest Land Considered for Depot at Akkupete

Classification of Habitats

The term “Habitat” is defined as a terrestrial, freshwater, or marine geographical unit or airway that supports assemblages of living organisms and their interactions with the nonliving environment.

Habitats vary in their significance for conserving globally, regionally and nationally important biodiversity, their sensitivity to impacts, and in the significance different stakeholders attribute to them. Because, in most instances, habitat loss, degradation or fragmentation represents the greatest threat to biodiversity, much of the focus of biodiversity conservation actions is on maintaining or restoring suitable habitats.

Hence, It is the responsibility of the project proponent to compesate the lossess incurred due to implementation of the project. As per the World Bank ESS 6, the Habitats are classified into three categories;

- **Modified Habitat:** Modified habitats are areas that may contain a large proportion of plant and/or animal species of nonnative origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include, for example, areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands.
- **Natural Habitat:** Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.
- **Critical Habitat:** Critical habitats are areas with high biodiversity importance or value and shall include Critically Endangered or Endangered species as listed in the IUCN Red List of threatened species or equivalent national approaches, endemic or restricted-range species, habitat supporting globally or nationally significant concentrations of migratory or congregatory species. Critical habitats are also highly threatened or unique ecosystems and habitat that maintain ecological functions, which are having key scientific value and/or associated with key evolutionary processes.

As per the biodiversity assessment carried out for the project, there are no Natural and Critical Habitates are present along project. However, there are modified habitates characterising agricultural land and forest plantations (Akkupete depot) present along the project corridors. As mentioned above, these modified habitats are devoid of any IUCN listed threatened, endangered, endamic flora and fauna species.

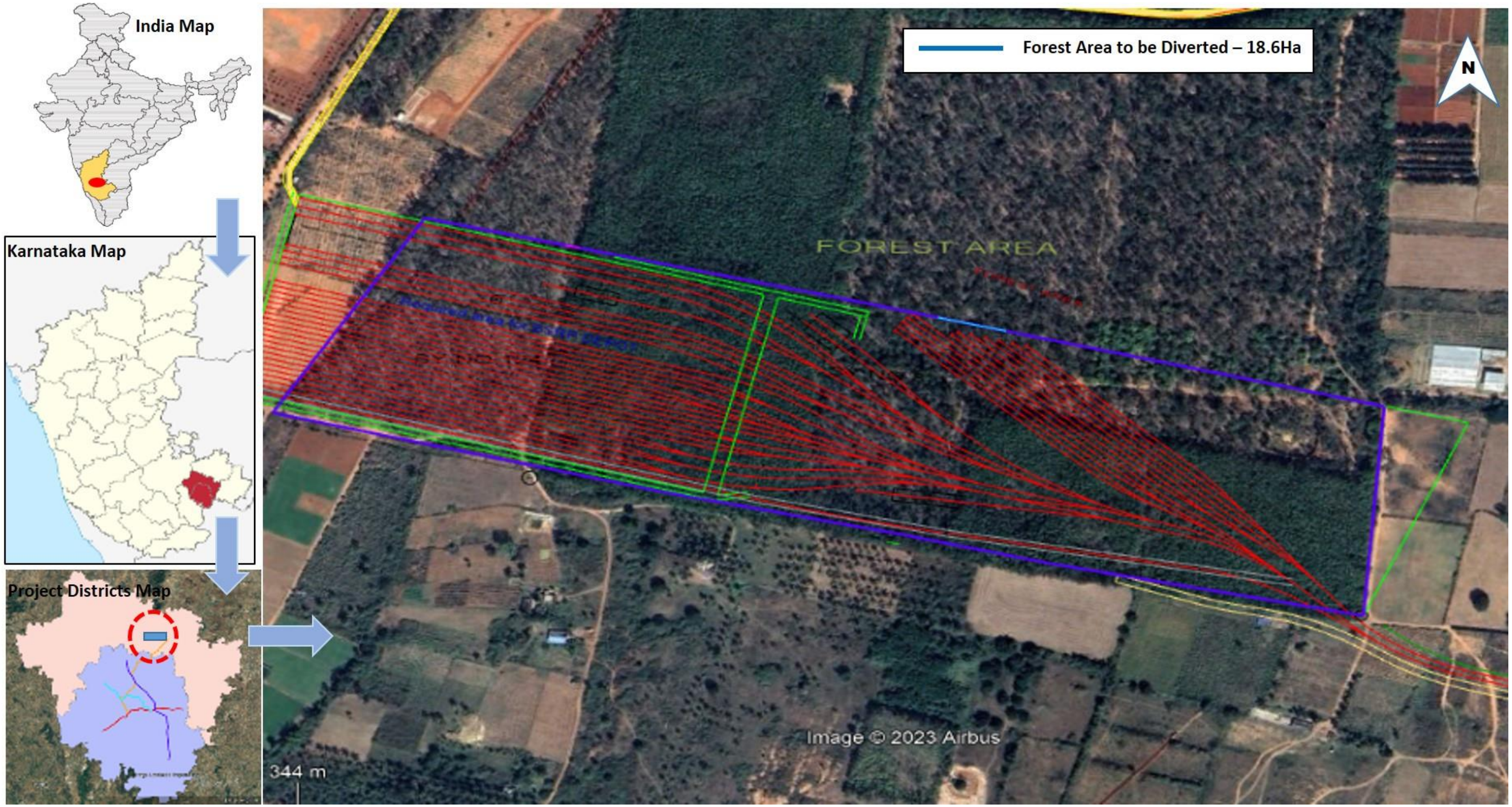


Figure 5.23. Google Earth Image Showing Proposed Akkupete Depot site in Forest land

5.9.1.2. Protected Areas

The proposed BSRP corridors are not passing through or abutting any protected areas such as National Park, Wildlife Sanctuary and Conservation reserves. The BSRP alignments are proposed along the existing Indian Railway alignment for the entire length. However, there are two protected areas such as Puttenahalli Lake Birds Conservation Reserve and Bannerghatta National Park present in the Bengaluru Urban District. There are no protected area present within indirect impact zone in Bengaluru Rural district.

The nearest protected area present is Puttenahalli Lake Birds Conservation Reserve (13° 6'40.03"N & 77°34'32.63"E) which is 850m (aerial distance) from the Corridor 4 - Heelalige to Rajanukunte railway corridor and 970m from the Corridor 1 - – Bengaluru City (KSR) to Devanahalli. Puttenahalli Lake birds conservation reserve is located near Vinayaka Bhadavane on Doddabalapura road. The conservation reserve is surrounded by dense human habitat with multi-storied buildings. The total area of the lake is 15 Ha, which is owned by Forest department. The lake is managed by forest department, which has plant nursery too. The bird species found in the lake are Darters, Painted storks, Black-crowned Night Herons, Purple Herons, Pond Herons, Egrets, Asian Open bill Storks, Eurasian Spoonbills, Spot-billed Pelican, Little Grebe, Little Cormorant, Spot-billed Ducks, Purple Moor-hen, Common Sandpiper, etc.,

It is observed that, the birds identified in the lake are having plentiful of forage and roost in the lake vicinity compared to rather than surrounding urbanised and built-up areas. They are not observed to fly to areas where there is high pollution and disturbance from anthropogenic activities. Google image showing Puttenahalli Lake Birds Conservation Reserve with BSRP corridors in **Figure 5.24**.

Figure 5.24. Map Showing Nearest Distance from Puttenahalli Lake Birds Conservation Reserve to Project Corridors

Bannerghatta National Park located at 12.7 Km (12°50'5.87"N & 77°34'53.72"E) (aerial distance) from the Corridor 4 - Heelalige to Rajanukunte. This national park is peculiarly shaped having a length of 59 km and varying width from 0.3 km to 13.8 km which is mainly due to the impact of urbanization. This park establishes crucial wildlife landscape by connecting the Eastern and Western ghats which mainly support elephant habitat. The State Government has notified the eco-sensitive zones – buffer zones – around this protected space declaring approximately 200 sq km as buffer zone based on the conservation standpoint. Forest Department has taken up barricading, trenches and electrical fences to conserve wild animals and preventing human-animal conflicts. Map showing the aerial distance from Corridor 4 to boundary of Eco-sensitive zone of Bannerghatta National Park is presented as **Figure 5.25**.

There is unlikely any impact on these protected areas either on the land or its flora and fauna from the project because of its distance and presence of urban settlements around it.

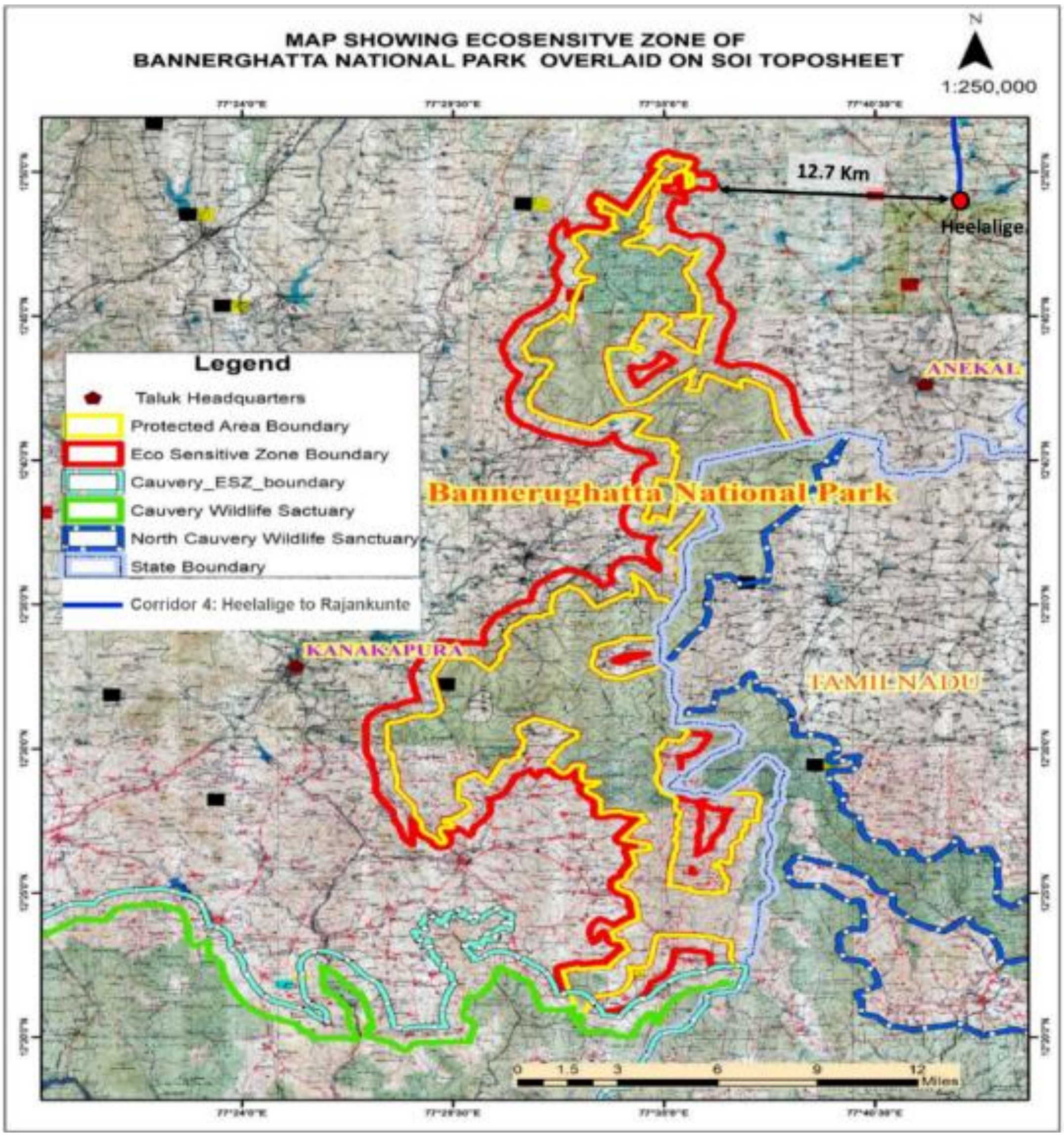


Figure 5.25. Eco- Sensitive Zone Map of Bannerghatta National Park Showing Nearest Distance from Corridor 4 - Heelalige to Rajanukunte

5.9.2. Flora

Vegetative cover in the proposed BSRP Corridors are ornamental and indigenous tree species. Common tree species present affected due to project is Rain tree (*Samanea saman*), Peepal tree (*Ficus religiosa*), Indian Cork tree (*Millingtonia hortensis*), Gulmohar (*Delonix regia),* Jamun tree (*Syzygium cumini*), Copper pod tree (*Peltophorum pterocarpum Becker*), Tulip tree (*Liriodendron*), Black siris tree (*Albizia odoratissima*), Pongamia tree (*Pongamia Pinneta*) etc..

Tree marking and enumeration has been completed for all the BSRP Corridors. Total trees affected in BSRP Corridors are 32572 trees (Corridor-1 is 7198, Corridor-2 is 3469, Corridor- 3 is 2072, Corridor-4 is 2306, Akkupete Depot – 17505 and Soladevanahalli Depot - 22). Survey for recently design modified locations was conducted for any presence of floral species and trees present along these design modified locations are incorporated in the below tables.

List of top ten trees present in BSRP Corridors are presented in **Table 5.36 to 5.39**. Girth wise tree species affected due to project Corridors are listed in **Table 5.40** to **Table 5.43**. IUCN Categorization of trees present in BSRP Corridors are presented in **Table 5.44**.

Table 5.36. Top Ten Tree Species Commonly present along Corridor 1 - KSR Bengaluru City to Devanahalli

Sl. No.	Local Name of the Tree	Scientific Name of the Tree
1	Silver tree	*Leucadendron argenteum*
2	Honge Mara	*Pongamia pinnata*
3	Bhevu	*Azadirachta indica*
4	Neelagiri	*Eucalyptus globulus*
5	Iju	*Schima liukiuensis*
6	Seemethangdi	*Senna siamea*
7	Kaagada Uppu Nerale	*Broussonetia papyrifera*
8	Maale mara	*Samanea saman*
9	Indian rosewood	*Dalbergia sissoo*
10	Nerale mara	*Acacia acuminata*

Source: Environmental survey

Table 5.37. Top Ten Tree Species Commonly present along Corridor 2 - Baiyyappanahalli Terminal to Chikkabanavara

Sl. No.	Local Name of the Tree	Scientific Name
1.	Kaagada Uppu Nerale	*Broussonetia papyrifera*
2.	Maale mara	*Samanea saman*
3.	Honge	*Pongamia pinnata*
4.	Niligiri	*Eucalyptus globulus*
5.	Thengu	*Cocos nucifera*
6.	Seemethangdi	*Ailanthus excelsa*
7.	Karuhaale	*Tremma orientalis*
8.	Seeme Hunase	*Pithecellobium dulce*
9.	Chigugu	*Leucaena leucocephala*
10.	Bhevu	*Azadirachta indica*

Source: Environmental survey

Table 5.38. Top Ten Tree Species Commonly present along Corridor 3 - Kengeri to Whitefield (via KSR and Cantonment)

Sl. No.	Local Name of the Tree	Scientific Name of the Tree
1.	Gulmhar	*Delonix regia*
2.	Maale mara	*Samanea saman*
3.	Flower Tree	*Magnoliophyta*
4.	Kaagada Uppu Nerale	*Broussonetia papyrifera*
5.	Seemethangdi	*Ailanthus excelsa*
6.	Babul	*Vachellia nilotica*
7.	Honge Mara	*Millettia pinnata*
8.	Neelagiri	*Eucalyptus globulus*
9.	Thengu	*Cocos nucifera*
10.	Hole dasavala	*Lagerstroemia speciosa*

Source: Environmental survey

Table 5.39. Top Ten Tree Species Commonly present along Corridor 4 - Heelalige to Rajanukunte

Sl. No.	Local Name of the Tree	Scientific Name of the Tree
1.	Niligiri	*Eucalyptus globulus*
2.	Jali	*Vachellia nilotica*
3.	Aurculis	*Acacia auriculuous*
4.	Seeme Hunase	*Pithecellobium dulce*
5.	Honge mara	*Pongamia pinnata*
6.	Bamboo	*Bambusa balcooa*
7.	Bhevu	*Azadirachta indica*
8.	Male Mara	*Samanea saman*
9.	Banni Mara	*Senegalia ferruginea*
10.	Tabebuia	*Tabebuia rosea*

Source: Environmental survey

Table 5.40. Girth Wise Tree Species Affected due to Corridor 1 - KSR Bengaluru City to Devanahalli

Sl. No.	Forest Range/Dept.	Girth Wise Trees					Total
		<30 Cm	31Cm - 60Cm	61Cm - 90Cm	91Cm - 180Cm	>180Cm	
1	Bengaluru Urban Range	4	370	180	93	41	688
2	Yelahanka Range	15	1749	1240	326	37	3367
3	Devanahalli Range	5	1376	886	129	6	2402
4	BBMP	0	234	80	59	10	383
5	Airport Link	0	156	144	57	1	358
Total Girth Wise		**24**	**3885**	**2530**	**664**	**95**	
Total Girth Wise in Percent		**0.3%**	**54%**	**35%**	**9%**	**1%**	
Total Number of Trees Affected in Corridor 1							**7198**

Table 5.41. Girth Wise Tree Species Affected due to Corridor 2 - Baiyyappanahalli Terminal to Chikkabanavara

Sl. No.	Forest Range/Dept.	Girth Wise Trees					Total
		<30 Cm	31Cm - 60Cm	61Cm - 90Cm	91Cm - 180Cm	>180Cm	
1	Bengaluru Urban Range	45	791	365	218	42	1461
2	Yelahanka Range	134	795	491	442	70	1932
3	KR Puram Range	13	38	13	9	3	76
Total Girth Wise		**192**	**1624**	**869**	**669**	**115**	
Total Girth Wise in Percent		**6%**	**47%**	**25%**	**19%**	**3%**	
Total Number of Trees Affected in Corridor 2							**3469**

Table 5.42. Girth Wise Tree Species Affected due to Corridor 3 - Kengeri to Whitefield (via KSR and Cantonment)

Sl. No.	Forest Range/Dept.	Girth Wise Trees					Total
		<30 Cm	31Cm - 60Cm	61Cm - 90Cm	91Cm - 180Cm	>180Cm	
1	Kagalipura Range	3	176	191	183	27	580
2	Bengaluru Urban Range	3	80	254	191	64	592
3	Yelahanka Range	13	144	146	50	27	380
4	BBMP	0	82	146	195	97	520
Total Girth Wise		**19**	**482**	**737**	**619**	**215**	
Total Girth Wise in Percent		**1%**	**23%**	**36%**	**30%**	**10%**	
Total Number of Trees Affected in Corridor 3							**2072**

Table 5.43. Girth Wise Tree Species Affected due to Corridor 4 - Heelalige to Rajanukunte

Sl. No.	Forest Range/Dept.	Girth Wise Trees					Total
		<30 Cm	31Cm - 60Cm	61Cm - 90Cm	91Cm - 180Cm	>180Cm	
1	Bengaluru Urban Range	80	279	225	649	69	1302
2	Yelahanka Range	112	440	233	211	8	1004
Total Girth Wise		**192**	**719**	**458**	**860**	**77**	
Total Girth Wise in Percent		**8%**	**31%**	**20%**	**37%**	**3%**	
Total Number of Trees Affected in Corridor 4							**2306**

Table 5.44. IUCN Categorisation for Trees Present in BSRP Corridors

Sl. No.	Scientific Name of the Tree	IUCN Categorisation	Sl. No.	Scientific Name of the Tree	IUCN Categorisation
1	*Leucadendron argenteum*	Vulnerable	38	*Juglons Regia*	Categorisation Not Available
2	*Pongamia pinnata*	Least Concern	39	*Erythrina*	Categorisation Not Available
3	*Azadirachta indica*	Least Concern	40	*Mangifera indica*	Data Deficient
4	*Eucalyptus globulus*	Least Concern	41	*Docony oose tree*	Categorisation Not Available
5	*Schima liukiuensis*	Categorisation Not Available	42	*Anacardium occidentale*	Least Concern
6	*Senna siamea*	Least Concern	43	*Fraxinus*	Categorisation Not Available
7	*Broussonetia papyrifera*	Least Concern	44	*Ziziphus mauritiana*	Least Concern
8	*Samanea saman*	Least Concern	45	*Moringa oleifera*	Least Concern
9	*Dalbergia sissoo*	Least Concern	46	*Podocarpus latifolius*	Least Concern
10	*Acacia acuminata*	Least Concern	47	*Tamarindus indica*	Least Concern
11	*Delonix regia*	Least Concern	48	*Malus sylvestris*	Data Deficient
12	*Vachellia nilotica*	Least Concern	49	*Swietenia*	Categorisation Not Available
13	*Albizia lebbeck*	Categorisation Not Available	50	*Albizia lebbeck*	Least Concern
14	*Cocos nucifera*	Categorisation Not Available	51	*Dacryodes edulis*	Categorisation Not Available
15	*Prosopis juliflora*	Categorisation Not Available	52	*Limonia acidissima*	Categorisation Not Available
16	*Coffea*	Categorisation Not Available	53	*Regia*	Categorisation Not Available
17	*Pinc poui*	Categorisation Not Available	54	*Terminalia catappa*	Least Concern
18	*Markhamia lutea*	Least Concern	55	*Casuarina equisetifolia*	Least Concern
19	*Millingtonia hortensis*	Categorisation Not Available	56	*Hages tree*	Categorisation Not Available
20	*Tectona grandis*	Categorisation Not Available	57	*Mheothukumara*	Categorisation Not Available
21	*Ficus religiosa*	Categorisation Not Available	58	*Sver green Oak*	Categorisation Not Available
22	*Ficus benghalensis*	Categorisation Not Available	59	*Kigelia africana*	Least Concern
23	*Ziziphus glabrata*	Categorisation Not Available	60	*Magnolia champaca*	Least Concern
24	*Saraca asoca*	Vulnerable	61	*Salix babylonica*	Data Deficient
25	*Senna alata*	Least Concern	62	*Tecoma stans*	Least Concern
26	*Geranium*	Categorisation Not Available	63	*Terminalia arjuna*	Categorisation Not Available
27	*Bauhinia purpurea*	Least Concern	64	*Acerifollium*	Categorisation Not Available

Sl. No.	Scientific Name of the Tree	IUCN Categorisation	Sl. No.	Scientific Name of the Tree	IUCN Categorisation
28	*Jacaranda mimosifolia*	Vulnerable	65	*Cassia fistula*	Least Concern
29	*Carica papaya*	Data Deficient	66	*Maliama*	Categorisation Not Available
30	*Aegle marmelos*	Near threatened	67	*Pithecellobium dulce*	Least Concern
31	*Ficus racemosa*	Least Concern	68	*Psidium guajava*	Least Concern
32	*Artocarpus heterophyllus*	Categorisation Not Available	69	*Ulmus glabra huus*	Categorisation Not Available
33	*Leucaena leucocephala*	Categorisation Not Available	70	*Ailanthus excelsa*	Categorisation Not Available
34	*Tremma orientalis*	Categorisation Not Available	71	*Acacia auriculuous*	Categorisation Not Available
35	*Bambusa balcooa*	Categorisation Not Available	72	*Senegalia ferruginea*	Vulnerable
36	*Tabebuia rosea*	Least Concern	73	*Lagerstroemia speciosa*	Categorisation Not Available
37	*Magnoliophyta*	Categorisation Not Available			

5.9.3. Fauna

Faunal distribution along the proposed corridor alignment is limited to common species since being located well within the extensively developed areas of Bengaluru Urban limit. **Table 5.45** presents the list of fauna observed along the project region. Apart from this, common domestic animals such as cow, street dogs, cat, pigs, etc., are found along the project corridor.

Table 5.45. List of Fauna found in the Project Study Area

Name of the Species	IUCN Category	Conservation Status as per Wildlife act 1972
I. AMPHIBIA		
1. *Euphlyctis hexadactylus* (Indian Green Frog)	Least Concern	Nil
2. *Rana tigrina* (Indian bullfrog)	Least Concern	Schedule-IV
3. *Duttaphrynus melanostictus* (Black-spectacled Toad)	Least Concern	Nil
II. REPTILIA		
1. *Chameleon sp.* (Green Lizard)	This taxon has not yet been assessed for the IUCN Red List	Schedule-II
2. *Calotes verticolour* (Garden Lizard)	This taxon has not yet been assessed for the IUCN Red List	Nil
3. *Varanus sp* (Monitor lizard)	Least Concern	Schedule-II
4. *Testudo elegans* (Tortoise)	Lower Risk/least concern	Schedule-IV
Sub Class : SNAKES		
1. *Naja naja* (Indian Cobra)	No Special Status	Schedule-II
2. *Ptyas mucosa* (Rat Snake)	This taxon has not yet been assessed for the IUCN Red List	Schedule-II
III. BIRDS		
1. *Eudynamys scolopaceus* (Common Koel)	Least Concern	Schedule-IV
2. *Passer domesticus* (House Sparrow)	Least Concern	Schedule-IV
3..*Acridotheres tristis* (Common Mynah)	Least Concern	Schedule-IV
4.*Spilopelia chinensis* (Spotted Dove)	Least Concern	Schedule-IV
5.*Francolinus pondicerianus* (Grey Partridge)	Least Concern	Schedule-IV
6.*Dinopium benghalense* (golden backed wood pecker)	Least Concern	Schedule-IV
7. *Corvus splendens* (House Crow)	Least Concern	Schedule-V
8. Psittaciformes sp. (Parrot)	Least Concern	Schedule-IV
9. Pavo cristatus (Indian Peafowl)	Least Concern	Schedule-I
10. *Merops orientalis* (Green Bee Eater)	Least Concern	Schedule-IV
11. *Bubulcus ibis* (Cattle Egret)	Least Concern	Schedule-IV
12. *Halcyon smyrnensis* (White- breasted Kingfisher)	Least Concern	Schedule-IV
13. *Coracias benghalensis* (Indian roller)	Least Concern	Schedule-IV
IV. MAMMALIA		
1. *Suncus murinus* (House Shrew)	Least Concern	Schedule-V
2. *Pteropus giganteus* (Indian Flying Fox)	Least Concern	Schedule-V

Name of the Species	IUCN Category	Conservation Status as per Wildlife act 1972
3. *Funambulus palmarum* (Palm Squirrel)	Least Concern	Schedule-IV
Fishes		
Catla catla (Catla)	Least Concern	Nil
Oreochromis niloticus (Tilapia)	Least Concern	Nil
Labeo rohita (Rohu)	Least Concern	Nil
Channa gachua (Snake head fishes)	Least Concern	Nil
Poecilia reticulate (Guppies)	Least Concern	Nil
Aristichthys nobilis (Bighead Crap)	Data Deficient	Nil
Thinnichthys sandkhol (Sandkhol Crap)	This taxon has not yet been assessed for the IUCN Red List	Nil

Source: Field observations, Consultations with local people and forest department, http://envfor.nic.in/legis/wildlife/wildlife1.html ; http://www.iucnredlist.org/search

Impact on local flora and fauna and its mitigation measures are listed in **Chapter 8.** Survey for recently design modified locations was conducted for any presence of faunal species. However, there are no new faunal spcies present along recently design modified locations.

5.9.4. Presence of Vulnerable, Threatened and/or Endangered Species of Flora and Fauna

As per the IUCN red list for Flora, there are few tree species ie., *Leucadendron argenteum, Saraca asoca, Jacaranda mimosifolia* and *Senegalia ferruginea* falls under vulnerable category and *Aegle marmelos* tree species falls under near threatened category.

However, there are no vulnerable, threatened or endangered species of fauna present along the project corridors.

5.9.5. Presence of Invasive Alien Species

The MoEFCC in cooperation with Botanical Survey of India, has identified the invasive alien species[3] that displace native biota or threatens valued environmental, agricultural or personal resources by the damage it causes are considered invasive. As per the list prepared by MoEFCC, there are no invasive alien flora and fauna species present along the project corridors. Hence, the plants and animals found along the project corridors are common to the region as per MoEFCC and in IUCN list too.

5.10. Socio- Economic Environment

Bengaluru is the sixth largest city of India and one of the fastest growing cities of Asia. It has acquired the name of 'Silicon City", due to its progressive trend in Information technology. Now, after the IT boom, Bengaluru city has suddenly overgrown its size and the district administration is facing a challenging task for providing necessary infrastructures to the related economic activities, trade, commerce and housing facilities. Major revenue generating industries such as Aerospace, aviation, automobile, Biotechnology, IT industry, real estate and hospitality, agriculture, horticulture and dairy and all types of manufacturing industries are present in the district. According to the Oxford

[3] http://www.bsienvis.nic.in/database/invasive_alien_species_15896.aspx

Economic's Annual Global Cities Report, Bengaluru city will see an annual GDP growth rate of about 8.5% between 2019- 2035. Bengaluru's per capita income is highest in the state for the year 2018-19.

5.10.1. Administrative Profile

In the year 1986, Bengaluru district was divided into Bengaluru Urban and Bengaluru rural districts.

Bengaluru Urban District: The district is located in the south-eastern part of Karnataka. The Bengaluru urban district is divided into five taluks namely: Bengaluru North (Bengaluru), Bengaluru South (Kengeri), Bengaluru East (Krishnaraja Pura), Bengaluru central and Anekal. The taluks are further divided into 17 hoblies, 668 villages, 9 municipal corporations.

Bengaluru Rural District: The district comprises of 4 taluks, 17 hoblis, 951 inhabited and 101 uninhabited villages. 2 towns and 98 Grama Panchayaths. Doddaballapura taluk is the largest taluk with an area of 778 sq.km and Devanahalli is the smallest taluk with an area of 431 sq.km.

5.10.2. Demography

Bengaluru Urban District: As per the 2011 census, total population of the Bengaluru urban district is 95,88,910 with population density of 4,378 persons per sq.km compared to 2,985 persons per sq.km in the year 2001. The sex ratio is 908 females among thousand males and the literacy rate of the district has increased from 83.91% on 2001 to 88.48 % in 2011.

Bengaluru Rural District: The population of Bengaluru rural district as per 2011 census was 9,87,257 persons comprising 5,07,486 males and 4,79,743 females. Urban population accounts for 18% of the population of the district, while the rural population accounts for the balance 82%. The population density in the district as 323 per sq.km.

5.10.3. Economic Profile

Bengaluru Urban District: The GDDP, NDDP, Per Capita income of the district for 2012-13 at constant prices (2004-05) was ₹ 99,325.10 crore, ₹ 85567.26 Cr and ₹ 20240 respectively. The GDDP constituted 33% of the State's GDP. The share of Service Sector (Tertiary) showed an increase of 4% over previous year constituting 69% to the GDDP at ₹ 68329.64 crore followed by manufacturing sector contributing 32% at ₹ 30,012.17 crore while the share of Agriculture and allied activities shrunk further to 1% at ₹ 983.29 crore.

Aerospace, aviation, automobile, IT, Biotechnology and all types of manufacturing activities are predominant in the district. The service space is dominated by IT industry, Real Estate and Hospitality. Major activities under Agriculture are horticulture and Dairy. Major crops in the district are Paddy and Ragi followed by maize, cereals and groundnuts. Apart from IT and Biotechnology sector and their ancillary industries the district is largely moving into protected cultivation for vegetables and cut flowers.

Bengaluru Rural District: The total Gross District Domestic Product (GDDP) of the Bengaluru Rural district estimated during the year 2012-13 is ₹ 77,726. In the year 2012-13, the per capita annual income of the district was ₹ 1,09,380. Small scale industrial activities, agriculture and horticulture activities are the major source of income for the district.

5.10.4. Agriculture

Bengaluru Urban District: Bengaluru has 14.09% of its land for cultivation. Amongst this,cereals and pulses occupy 66.36% and 9.94% of the land respectively. Bengaluru is best known for ragi, especially in Anekal Taluk which is called 'Ragi Bowl' in the State. Bengaluru Urban is recognized as Class A destination for floriculture projects. Major crops grown are paddy, ragi, maize, horse gram and oilseeds along with horticultural crops like banana, grapes, papaya, mango sapota, pomegranate and plantation crops like coconut and rose. The district also has 649 milk co-operatives that annually produce 119 Million liters of milk, 34.7 million Eggs, and 5,880 tonnes of meat.

Bengaluru Rural District: The main crops grown in the district are Paddy, jowar, Bajara, Maize, Wheat pulses oilseeds like groundnut, sunflower vegetables fruits and cash crop like sugarcane and others. Field crops are cultivated over 50,000 ha of agricultural land and the major crops are finger millet, maize, redgram, fieldbean, bengalgram, horsegram, groundnut and sunflower. Fruits like grapes, mango, banana, etc. are cultivated in over 10,000 ha. Commercial cultivation of vegetables like tomato, potato, cabbage, chilli, brinjal, Green leafy vegetables is practiced in 6,500 ha. Dairy, backyard poultry and fisheries are generating additional income to the farmers. The district's soil and climatic conditions are congenial for the cultivation of mulberry, rearing of silkworms, and production of silk, besides other agro-based industries. There are a number of wineries and quantity of production of wine has been increasing.

5.10.5. Archaeological and Historical Monuments

There are four Archaeological Survey of India notified Archaeological monuments present in project study area. They are 1) Tippu Sulthan's Summer Palace, Bengaluru, 2) Old Dungeon Fort & Gates, Bengaluru, 3) Fort, Devanahalli and 4) Tippu Sulthan's Birth Place. Out of which Tippu Sulthan's Birth place (13°14'57.35"N & 77°42'34.88"E) (aerial distance - 271m) and Fort in Devanahalli (13°14'46.49"N & 77°42'25.90"E) (aerial distance -228m) are falling within Regulated zone i.e., 300 m from the proposed alignment of Corridor 1 - KSR Bengaluru City to Devanahalli. Photographs of ASI protected monument near Devenahalli Station is presented as **Figure 5.26**. Map showing the ASI protected monument in the project study area is presented as **Figure 5.27**. Google image showing Corridor 1 with ASI protected monuments in **Figure 5.28**.

Fort, Devanahalli

Tippu's Birth Place

Figure 5.26. Photographs of ASI Protect Monuments at Devanahalli near Corridor 1 - KSR Bengaluru City to Devanahalli

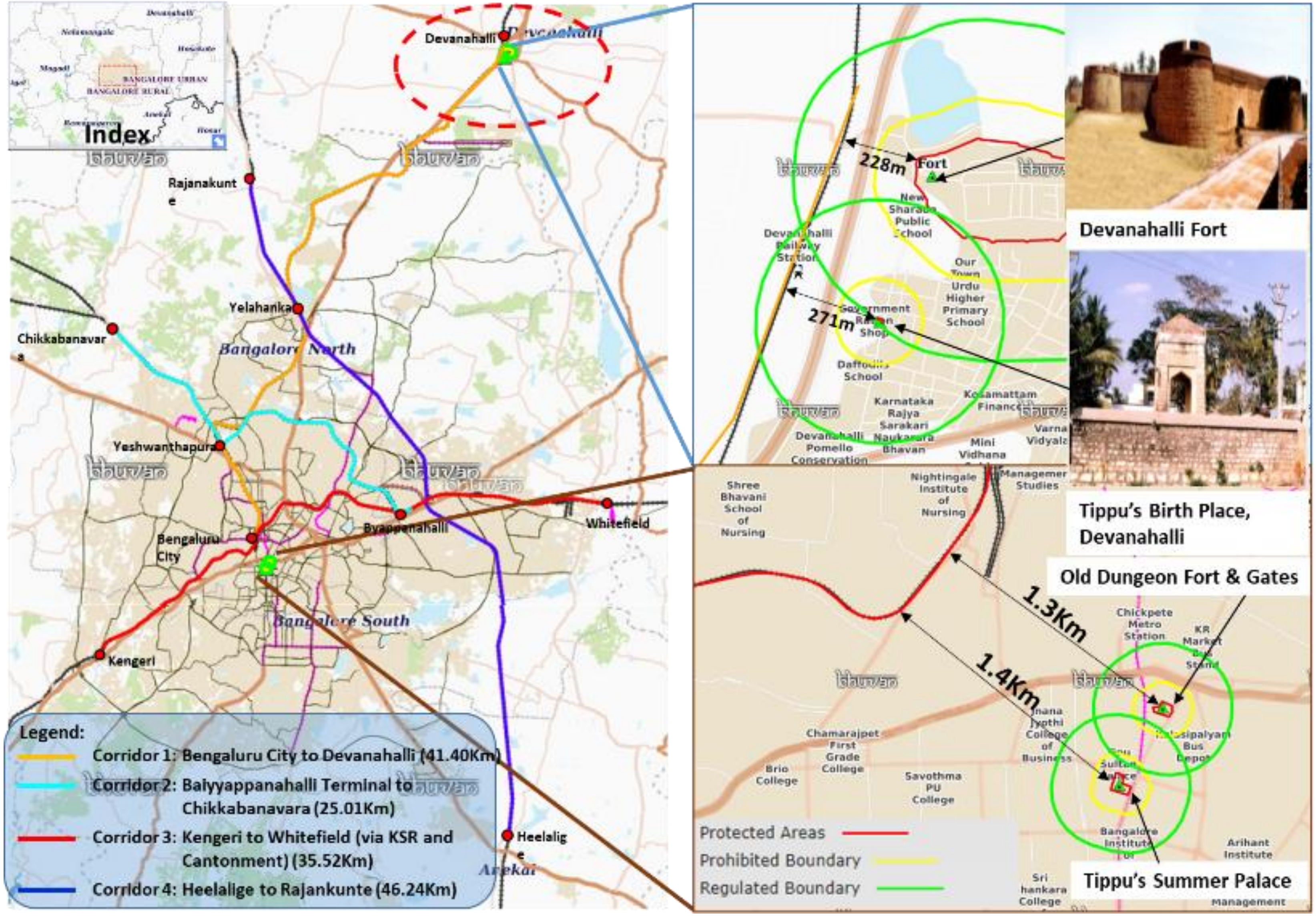


Figure 5.27. Map Showing the Archaeologically Protected Monument by ASI Present along the BSRP Corridors

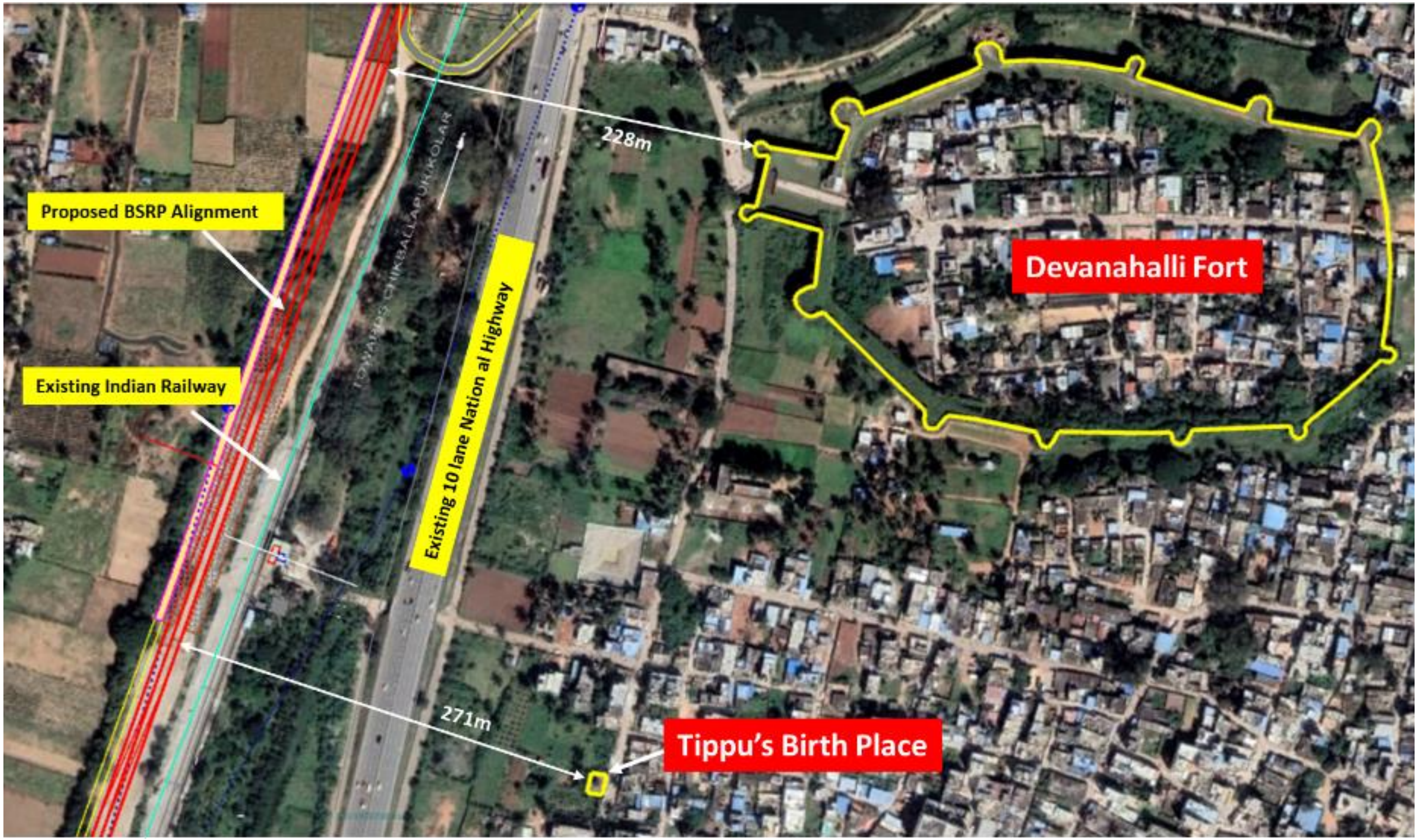


Figure 5.28. Google Imagery Showing Land Use around Archaeologically Monuments Protected by ASI Present along the BSRP Corridors

5.10.6. Environmental & Social Sensitive Features Present along the Project Corridors

Inventories for environmental sensitive features are collected by conducting walk-through survey along the proposed BSRP corridors including stations, Depots and major intersection with roads and other railway alignments. There are 43 environmental sensitive features were listed out and inventories were conducted to record these features along the project corridors. Re-survey for recently design modified locations was conducted. However, there are no environmental features present along recently design modified locations. **Table 5.46** shows the survey outcome of deisgn modification locations. List of environmental features to identify along the project corridors are presented in **Annexure 5.2**. Survey was conducted within direct impact zone i.e., 30m on either side from existing Row as delineated in Section 3.2.2 of Chapter 3. Details of Cultural Resources and Sensitive receptors present along the BSRP corridors are presented in **Table 5.47**;

Table 5.46. Survey outcome of Design Modification Locations of BSRP Corridors

Corridor no.	Stations	Updates	Remarks
Corridor 1	KSR Bengaluru Station	Change in location of Station to Railway Station Road	No Envi. & Social features present. About 56 trees affected.
	Srirampura Station	Conversion of Future Station to Present Station	No Envi. & Social features present. No trees affected.
	Yesvantpur Station	Change in level and location of the station (to front side of existing station)	No Envi. & Social features present. About 50 trees affected.
	Yelahanka Station	Sharing of station with Corridor 4 at Level-1 & Corridor 1 at Level-2	No Envi. & Social features present. No trees affected.
	Nitte Meenakshi & Doddajala	Change in location of station towards KSR Bengaluru City	No Envi. & Social features present. No trees affected.
	Airport KIADB	Conversion of present station to future Station	No Envi. & Social features present. About 12 trees affected.
	New Future Station	Inclusion of a future station between Airport KIADB and Devanahalli Stations	No Envi. & Social features present. About 33 trees affected.
Corridor 2	Hebbal Station	Change in the location shifted towards Banaswadi side after Hebbal Flyover	No Envi. & Social features present. About 14 trees affected.
	Lottegollanahalli Station	Change in location shifted towards Mathikere Junction	No Envi. & Social features present. About 3 trees affected.
	Soladevanahalli Depot	Extension of alignment till Soladevanahalli Depot	No Envi. & Social features present. About 55 (33 alignment + 22 Depot) trees affected.
Corridor 4	Yelahanka Station	Sharing of station with Corridor 4 at Level-1 & Corridor 1 at Level-2	No Envi. & Social features present. No trees affected.
	New future station	Inclusion of a future station between Marathahalli and Doddanekundi Stations	No Envi. & Social features present. About 7 trees affected.

5.10.6.1. Cultural Resources

There are considerable amount of cultural and religious structures present along the BSRP corridors. Structures like Temples, Tree shrines, Shrines, Mosques, Darghas, Churches, Grave Yards etc., were recorded. There are no archaeologically protected monuments present along the BSRP corridors except Corridor 1, where Devanahalli Fort and Tippu Sulthan's Birth Place monuments are present within Regulated Area i.e., 300 m from the Rail alignment and Devanahalli Railway Station as mentioned in Section 5.1.6.2. Re-survey for recently design modified locations was conducted. However, there are no cultural resources present along recently design modified locations. Details of cultural resources found along the BSRP is presented in **Table 5.47** and the details of the same with photographs is incorporated **Annexure 5.5**. Photographs of cultural resources found along the BSRP is presented in **Figure 5.29.**

Table 5.47. Details of Cultural Resources found along the BSRP Corridors

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
Corridor 1: KSR Bengaluru City to Devanahalli						
LHS						
1	0/100	Shree Ram Mandir, Sevashram.	-	80	2	No Compound Wall
2	0/180	Ganapathi Temple, Sevashram.	10	50	8	-
3	1/750	Veeranjaneya Temple Sevashram.	-	15	6	No Compound Wall
4	1/850	Ganapathi Temple, Shrirampura.	-	10	8	No Compound Wall
5	3/200	Tree Shrine	-	-	-	No Compound Wall
6	3/200	Shree Varasiddivinayaka Temple,Malleshwaram.	-	5	6	No Compound Wall
7	3/200	Shree Veeranjaneyaswamy Temple, Malleshwaram.	-	5	5	No Compound Wall
8	3/220	Tree Shrine, Malleshwaram	-	5	2	No Compound Wall
9	3/550	Shakthi Mariyamma Temple, Malleshwaram.	10	5	3	-
10	3/600	Shree Bhaktanjaneyaswamy Temple, Kirloskar Road, Milk Colony,	-	3	5	No Compound Wall
11	3/660	Tree shrine	-	7	-	Along with 5m
12	3/700	Tree shrine	-	7	-	No Compound Wall
13	9/450	Shani Mahatma Temple, Poornappa Garden, Mathikere.	-	5	4	No Compound Wall
14	Dec-30	Shree Muneshwara Temple	-	30	1	No Compound Wall
15	23/50	Burial Ground, Devanahalli	-	30	-	-

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	Remarks
RHS						
1	0/800	Temple	30	30	4	-
2	2/700	Shree Varadanjaneya Temple, Malleshwaram.	-	30	8	-
3	3/430	Shree Shakhi Temple, Malleshwaram.	-	10	11	No Compound Wall
4	3/750	San Claret Publications,Church	10	20	18	-
5	8/650	Shree Shree Shree Shanthamoorthi Shanideva Temple, Bandappa Garden.	20	20	6	-
6	9/600	Sri Devi Karumariyamman Temple, R M V 2nd Stage, Lottegollahalli.	-	25	5	-
7	11/300	Temple, Lottegollahalli.	20	20	8	-
8	5/00	Shree Anjaneyaswamy Temple	-	30	6	No Compound Wall
9	9/210	Tree shrine	-	10	3	No Compound Wall
10	11/390	Temple, Chikkajalla	-	15	6	No Compound Wall
11	12/350	Shree Anjaneyaswamy Temple,Doddajala.	-	50	2	No Compound Wall
12	12/680	Temple, Doddajala.	15	15	5	-
13	17/050	Anjaneya Temple	15	40	5	-
Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara						
LHS						
1	208/400	APM Church Maruthi Seva Nagar.	7	10	18	-
2	208/950	Sri Vinayaka Swamy Temple, Maruthi Seva Nagar.	-	12	4	No Compound Wall
3	209/150	Paniel Assembly of God Church, Maruthi Seva Nagar.	10	11	18	-
4	211/230	Temple, Kadugondanahalli.	15	15	8	-
5	212/350	Temple	-	20	5	No Compound Wall
6	213/920	Temple	15	20	7	-
7	215/870	Tree shrine	-	15	-	No Compound Wall
8	216/200	Yallamma Temple, Hebbal.	20	23	8	-
9	216/700	Sri Pillekamma Temple, Hebbal.	-	20	8	No Compound Wall
10	217/780	Tree shrine temple	-	10	-	No Compound Wall
11	218/830	Shree Nagasubramanya Swamy Temple.	-	15	-	No Compound Wall

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	Remarks
12	220/400	Sri Karumariamman Temple, Yeshwanthpur.	8	8	30	-
13	15/120	Ashwathkatte, 103, 1st main road, M R J Colony, Mathikere, Bengaluru, Karnataka	-	-	-	Realignment
14	15/300	Trinity Assembly of god Church, 1st main road, Gokula Extension, Mathikere.	-	-	4	Realignment
15	20/300	Temple, Kemmagondanahalli.	7	10	3	-
16	20/730	Muneshwara Temple, Kemmagondanahalli.	-	7	5	No Compound Wall
17	22/970	Anjaneya Temple, Shettihalli Road, Chikkabanavar.	40	45	10	-
RHS						
1	204/850	Jesus Grace Church, Doorvani Nagar.	34	34	14	-
2	205/170	Muneshwara Temple, Koli Chikkanna Colony.	-	30	2	No Compound wall
3	205/860	Maha Ganapathi Temple, Dooravani Nagar.	-	45	4	-
4	207/750	Full Gospel Bethesda AG Church, Kanaka Nagar, Hebbal.	20	21	6	-
5	208/820	Shree Muneshwaraswamy Temple, Maruthi Seva Nagar.	-	13	3	No Compound wall
6	208/690	Shree Kateramma Temple, Maruthi Seva Nagar.	-	5	4	No Compound wall
7	208/950	Temple	-	20	3	No Compound wall
8	211/080	Temple	-	50	4	No Compound wall
9	212/780	Hosanna mandir, (Nagawara), Kadugondanahalli Railway Gate.	60	60	9	-
10	213/750	Jauhar Shifa Khana, Clinic in Byrappa Layout, R M V 2nd Stage.	-	35	8	No Compound wall
11	213/800	Sunni Masjid -e -Garib Nawaz, mosque, M R Garden, Govindapura, Hebbal.	-	32	8	No Compound wall
12	213/850	Indian Evenjaelical Church, Govindapura Main Road, Byrappa Layout, Nagavara.	20	21	8	-

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	Remarks
13	214/460	Shree Muneshwaraswamy Temple, Nagavara.	-	21	2	No Compound wall
Corridor 3: Kengeri to Whitefield (via KSR and Cantonment)						
LHS						
1	9/020	Shree Abhaya Anjaneyaswamy, Temple, Mysore Road.	7	25	20	-
2	9/010	Mutturayaswamy Temple, Mutturaya Nagar.	-	5	8	No Compound Wall
3	9/000	Tree shrine Mutturaya Nagar.	-	10	-	No Compound Wall
4	8/100	Tree shrine, Mallathahalli	-	14	-	No Compound Wall
5	7/250	Gangamma Temple	-	15	5	No Compound Wall
6	7/250	Muneshwara Temple	-	15	15	No Compound Wall
7	6/940	Prasanna Gangadhareshwara Temple, Nayandahalli	14	15	15	-
8	4/680	Shiva Temple, Hampinagar.	-	15	7	No Compound Wall
9	4/580	Shree Siddhi Vinayaka Temple, Hampinagar.	-	10	10	No Compound Wall
10	4/440	Venkateswara Temple	-	11	15	Along with 110m
11	2/735	Maramma Temple, Binnipete, Kempapura.	10	10	8	-
12	2/450	Kadpa Swamy Temple, Binnipete, Kempapura, Agrahara.	-	12	8	No Compound Wall
13	1/795	Shree Poonavardham Temple, Cottonpet.	8	11	7	Along with 50m
14	1/670	Nagaveni Temple, Nagamma Nagar, Cottonpet.	7	7	15	-
15	1/888	Church, Cottonpet.	10	10	8	-
16	1/520	Muneswara Temple, Nagamma Nagar, Cottonpet.	10	14	10	-
17	1/00	Nagasubramanya Swamy Temple, Binnipet.	5	5	8	Along with 50m
18	353/930	Vinayakaswamy Temple	10	15	15	-
19	353/240	Church	10	15	35	-
20	353/980	Sadhasiva Ashram	10	10	30	-
21	349/600	Sri Lakshmi VenkateshwaraswamyTemple.	25	40	6	-
22	344/400	St Anthony Church, Bharathi Nagar.	-	15	1	No Compound Wall

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	Remarks
23	347/500	Shree Vinayaka Temple	15	20	15	Along with 150m
24	347/180	Saraswathi Temple, KHB Colony.	19	25	7	-
25	339/400	Eid gah e Jahangheer Trust, Masjid, Haledevasandra, Krishnarajapuram.	10	35	20	Along with 500m
26	388/830	Temple	20	25	10	-
27	377/400	Sappalamma Temple, Saketha Nagar,Hoodi.	5	15	4	No Compound Wall
RHS						
1	8/700	Temple	-	11	3	No Compound Wall
2	6/970	Temple	10	14	4	-
3	5/900	Masjid E Salmania, Mosque, Roshan Nagar.	-	12	30	No Compound Wall
4	5/450	Ganapathi Temple, Deepanjali Nagar.	-	15	5	No Compound Wall
5	4/500	Vidyaganapathi Temple	-	10	-	No Compound Wall
6	3/450	Shree Muneshwara Temple, Hosahalli Main Road, Padarayanapura.	10	12	-	-
7	2/930	Masjid-E-Mustafa, Mosque, Padarayanapura.	10	12	-	-
8	2/250	Shree Swayambhu Nagaraja, Balasubramanyaswamy, Temple, Padarayanapura.	-	14	-	No Compound Wall
9	2/500	Shree Chowdeshwari Temple	-	10	-	No Compound Wall
10	1/980	Hanuman Temple Jagajeevanram Nagar.	-	10	-	No Compound Wall
11	1/850	Holy Gospel Prayer Church, Kempapura Agrahara.	10	12	20	-
12	1/500	Nagamma Temple	-	18	5	No Compound Wall
13	354/560	Shri Vasupujyaswami Shwetamber JainTemple, Madhava Nagar, Gandhi Nagar.	8	12	10	-
14	353/800	Nagamma Temple, Kumarkrupa East.	10	12	-	-
15	352/330	Veeranjaneya Swamy Temple	10	10	-	-
16	352/210	Shiva Temple	8	10	-	-
17	351/850	Durgadevi Temple	15	15	-	-

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	Remarks
18	349/970	Benguluru Telugu Church, Pulikeshi Nagar.	20	20	-	-
19	349/610	St, Anthony Church, Pulikeshi Nagar.	10	10	-	-
20	349/580	Ganesha Temple, Pulikeshi Nagar	10	10	-	-
21	348/280	Temple, Pulikeshi Nagar.	10	10	-	-
22	347/680	Ganapathi Temple	8	10	-	-
23	346/900	Church	10	15	20	-
24	346/510	Kuru Mariyamma Temple	-	12	10	No Compound Wall
25	346/400	Church	10	13	15	-
26	342/900	Shree Ramalaya Temple	10	10	10	-
27	339/000	Shree Shaneshwara Temple	20	25	10	-
28	338/860	Temple	15	20	5	-
29	337/650	Om Shakthi Temple	10	15	8	-
30	337/650	Shiva shakthi , Hoodi.	10	14	20	-
Corridor 4: Heelalige to Rajanukunte						
LHS						
1	193+450	Masjid	10	13	15	
2	6+610	Ganesha Temple	-	-	-	No Compound wall
3	6+700	New Jerusalem Church	30	32	5	
54	18+100	Masjid	10	11	10	
RHS						
1	203+050	Shree narayana matrudevi ayyappa Devasthanam Kaggadasapura.	30	30	5	-
2	5+50	Grace Methodist Church, Horamavu.	15	15	9	-
3	8+200	Church		60	3	No Compound Wall
4	15+580	Shree Sankatahara Ganapathi Temple		25	10	No Compound Wall
5	15+750	Temple		15	6	No Compound Wall
6	21+700	Temple		15	-	No Compound Wall
7	23+950	Temple	-	10	-	No Compound Wall
8	25+330	Temple	-	32	-	No Compound Wall

Figure 5.29. Photographs of Cultural Resources Present along BSRP Corridors

5.10.6.2. Sensitive Receptors

Sensitive receptors includes educational institutes, hospitals, Clinics, etc. All these features are socially very sensitive and needs critical care in preserving them during implementation of Suburban rail project. There are no environmental sensitive features present in proposed Akkupete and Soladevanahalli Depots. Survey for recently design modified locations was conducted for any presence of environmental features. However, there are no new sensitive features present along recently design modified locations.

Summary of sensitive receptors found along the BSRP is presented in **Table 5.48** and the details of the same with photographs is incorporated **Appendix 5.4**. Photographs showing sensitive receptors present along the project corridors are presented in **Figure 5.29**.

Table 5.48. Details of Environmental Sensitive Receptors Present along the BSRP Corridors

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
Corridor 1: KSR Bengaluru City to Devanahalli						
LHS						
1	9/900	BEL Academy, Sundarnagar, Gokula Extention Mathikere.	15	25	15	-
RHS						
1	2/100	New Clinton Public High School, Srirampura.	35	38	18	-
2	2/770	Manipal Hospital, Malleshwaram.	45	47	18	-
3	3/200	Cluny Convent High School Malleshwaram	10	30	18	-
4	10/900	Bishop Sergeant Central School, Lottegollahalli.	10	10	12	-
5	3/100	Nitte Global Institute, Yelahanka.	25	50	25	Along with 700m
6	3/150	Hostel, Nitte Global Institute, Yelahanka.	30	50	20	-
7	10/00	Sri Revana Siddeswara Institute of Technology, Chokkanahalli, Chikkajala.	20	35	18	-
Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara						
LHS						
1	205/360	Government Higher Primary School, Benniganahalli.	30	32	14	-
2	205/780	Little Angels Modern High School, NGEF Layout, Sadananda Nagar, Benniganahalli.	32	34	14	-
3	210/210	School, Lingarajapuram.	-	15	10	No Compound Wall
4	210/600	Eunice English Medium High School, Thomas Town, Lingarajapuram, Bengaluru.	15	20	20	-
5	210/650	Manahil English High School, Kadugondanahalli.	5	8	18	-

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
6	213/250	Beacon English High School, 1st main Road, Shampura, Kaval Bairasandra.	15	18	18	-
7	213/640	School, Kaval Bairasandra.	30	34	23	-
8	214/380	BIG Institute of Managerial	15	20	22	-
9	215/50	Government School	20	22	9	-
10	216/900	Hebbal Agriculture School	15	18	12	-
11	218/830	BBMP, Public Library	-	15	4	No Compound Wall
12	220/410	Anganawadi Kendra, Yeshwanthpur.	-	8	30	No Compound Wall
13	15/550	St. Antony primary School, Mathikere.	-	-	18	Realignment
14	16/150	P.R Public School, Mohankumar Nagar, Yeshwanthpur.	-	-	16	Realignment
15	23/460	Cecilia English Nursery & High School, Maruthi Seva Nagar.	25	35	30	-
RHS						
1	204/890	New Pratham Public School, Mahadevapura.	34	35	15	-
2	207/440	Mother Mary English School, Chikkabanasawadi.	-	30	14	No Compound wall
3	210/710	Siddhartha PU College, 7th Cross Lingarajapura Hennur Main Road.	60	70	6	-
4	214/680	St Pauls Public School and Apartment, Arabic college Road, Jogappa Layout Nagavara.	30	45	130	-
5	15/550	Clinic	-	-	15	Realignment
6	15/800	Hospital	-	-	20	Realignment
7	16/500	Clinic	-	-	14	Realignment
8	23/700	R.R Institute college	5	35	24	-
9	23/900	National Public School, Chikkabanavara.	10	15	27	-

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
Corridor 3: Kengeri to Whitefield (via KSR and Cantonment)						
LHS						
1	11/950	Dr.Suhasini Hospital, Kengeri Satellite Town.	-	18	30	No Compound Wall
2	11/470	National Public School, Kengeri Satellite Town.	20	24	35	-
3	9/320	Indian Statistical Institute, Mysore Road, RVCE Post.	10	20	-	-
4	8/150	Sports Authority of India, Opposite Bengaluru University Hostel, Mallathahalli.	5	15	15	-
5	5/150	Ananya Hospital	15	16	25	-
6	4/950	Dhanvantari Clinic, Railway Parallel Road, Vijayanagar.	-	15	20	No Compound Wall
7	4/925	St. Michaels, High School, Hampinagar.	-	15	22	
8	2/130	Roses Convent School, Binnipete, Kempapura.	10	14	20	-
9	353/890	Star Health Allied	10	13	30	Along with 50m
10	353/680	Eye Hospital and Squite Centre.	14	15	12	-
11	377/340	Chaithanya Clinic, Saketha Nagar, Hoodi.	10	10	8	No Compound Wall
12	336/350	Shree Balaji Medical Clinic, Kadugodi.	10	10	10	No Compound Wall
RHS						
1	10/500	BIMS, Boys Hostel, Kengeri Satellite Town.	15	17	40	-
2	10/400	Orchids School, Mysore Road, Kengeri satellite Town.	10	15	30	3
3	10/300	Benguluru Institute of Management, Mysore Road, Kengeri Satellite Town.	10	15	10	-
4	8/150	College	12	15	15	-

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
5	6/830	Piles and Fistula Clinic	-	15	9	No Compound Wall
6	5/900	Madarasa Women's Arabic School, Roshan Nagar.	-	10	-	No Compound Wall
7	5/860	Government Urdu Primary School, Roshan Nagar.	10	11	10	-
8	354/700	Karnataka Chitrakala Parishath, Kumarkrupa East.	10	20	30	-
9	349/570	City Multi Speciality and Trauma Centre, Hospital, Pulikeshi Nagar.	15	16	20	-
10	348/540	Government Primary School, Pulikeshi Nagar	12	14	25	-
11	339/250	The Brigade School, Mahadevapura.	15	25	20	-
Corridor 4: Heelalige to Rajanukunte						
LHS						
1	180/600	Athreya Hospital Anekal main Road, Suryanagar phase 1.	40	45	30	-
2	181/290	Green dot Montessori School, Chandapura.	-	60	10	No Compound wall
3	182/800	Banglore college of Engineering, Heelalige, Bommasandra.	40	50	15	
4	184/100	School	20	25	10	
5	203/050	Dental Hospital	20	22	15	
6	23/100	Sai Speciality Center,Hospital East of NGEF Layout, Kasturi Nagar.	-	10	15	No Compound wall
7	15/650	Dental Health Center	-	10	5	No Compound wall
RHS						
1	191/050	College	25	30	4	-
2	197/790	Smile Dental Care,Munnekollal, Marathahalli.		20	14	No Compound Wall

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Remarks
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)	
3	198/580	Lions Airportcity Hospital, Munnekollal, Marathahalli.	22	30	10	-
4	199/290	Kids Mansion School, Chinnappanahalli.	15	18	9	-
5	202/400	Geethanjali Vidyalaya & Montress, Kaggadaspura.	40	50	18	-

Figure 5.30. Photographs of Sensitive Receptors Present along BSRP Corridors

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Chapter 6. Public Consultation and Stakeholder Engagement

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 stakeholder 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 and environmental impacts and to reduce the magnitude of the impacts of the project by suggesting suitable measures, to identify the environmental hotspots for further enhancement, while consultations during implementation stage helps to facilitate a smooth resettlement of the PAFs thereby enabling speedy implementation of the project.

As part of the project preparation, screening stage Public consultation and stakeholder enegement was conducted along the BSRP corridors to gather the information on environmentally sensitive sites which needs to be taken care during designing of the rail alignment and issues identified as the regulatory requirements of the GoI, GoK and World Bank's ESS. Further, more consultation and stakeholder enagement program has been designed through various project cycle which is detailed in **Annexure 6.4**.

6.1. Types / Categories of Stakeholder Consultation

For consultation and participation, primary and secondary stakeholders will be identified. Major stakeholders to be consulted are as follows.

- All Project Affected Persons (PAPs) and Beneficiaries of the Project, including representatives of project users;
- Elected representatives, Community leaders of PAPs, representatives of CBOs;
- Representatives of local NGOs
- Officials of Government Departments related to Environment and Climate Change

6.2. Methodology Adopted for Stakeholder Consultation

The overall goal of the consultation programme is to disseminate project information and to incorporate PAPs views in the Suburban Railway proposal and social and environmental risks & impacts. 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;
- Address the environmental concerns of public in design interventions and enhance project benefits; and
- To make project environmental friendly and climate resilient.

6.2.1. Stages of Consultation 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, meetings, and public interactions. The consultation programmes are scheduled at for several stages of the project, which can be broadly classified as:

- Project preparation phase – Information gathered from field surveys/consultation on project to be incorporated in the design phase of the project.
- Project initiation phase – It is the site preparation stage where necessary consultation to obtain approvals/NOC/Clearance from various regulatory bodies, site preparation for Construction and labour camp and ensuring initiation of proper resettlement and rehabilitation of project affected parties is carried out.
- Project implementation phase – Consultation during construction stage with regulatory bodies & other stakeholders, public residing next to construction site and Labours engaged in work and project affected parties on implantation of resettlement and rehabilitation measures.
- Post implementation phase – Consultation with Public using Suburban Railway, community residing next to project and regulatory bodies and other stakeholders and feedback from project affected parties who are rehabilitated due to project.

Project Preparation Phase: The current phase is the project preparation phase where in the information gathered from field surveys are incorporated in the design phase of the project and preparation of Environmental Screening Report and Social Screening Report. At this stage following methodologies were used by the Consultants for public consultation and information dissemination.

- Public Interactions/Focus Group Discussions
- Institutional Level Stakeholder Consultation
- Public Consultation Meetings

Consultations with PAPs ensured that views of PAPs are fully incorporated in finalizing the rail route alignment and formulation of compensation and rehabilitation measures.

6.2.1.1. Public Interactions/Focus Group Discussions

Public interactions/Focus group discussions were conducted at representative settlements, near sensitive locations etc. in order to collect the opinions of public regarding the BSRP corridors. Represent of consultant described the objectives of the project to the public and documented their opinions, suggestions, objection in the prescribed forms. Public residing next to proposed railway alignment were interacted to understand the pollution levels for air and noise and any incidents of flooding in the region. Also any historical monuments present along the project corridors and suggestions sought for any environmental issues due to existing rail and its improvements in the regions. Lists of attendance sheet on public interacted is provided in **Annexure 6.1**. Summary of location wise public interactions/ FGDs and issues discussed for the BSRP corridors are presented in **Annexure 6.2**.

Public interactions/FGDs were conducted at 30 locations in Corridor 1, 46 Locations in Corridor 2, 20 locations in Corridor 3 and 39 locations in Corridor 4. Various categories of people from housewives to Auto drivers to govt. officers were interacted to understand the environmental condition of the region and to obtain the views/suggestions/opinion on the project for the betterment of environment. Also, FGD was consucted at proposed Soladevanhalli Depot to understand baseline conditions and environmental and social sensitivity of the depot site. In general, public present along the proposed Suburban Railway track were asked about the Air Quality, Noise level and water logging issues. Graphical representation showing Corridor wise opinion received on the pollution levels in the region is presented in **Figure 6.1 to Figure 6.4**.

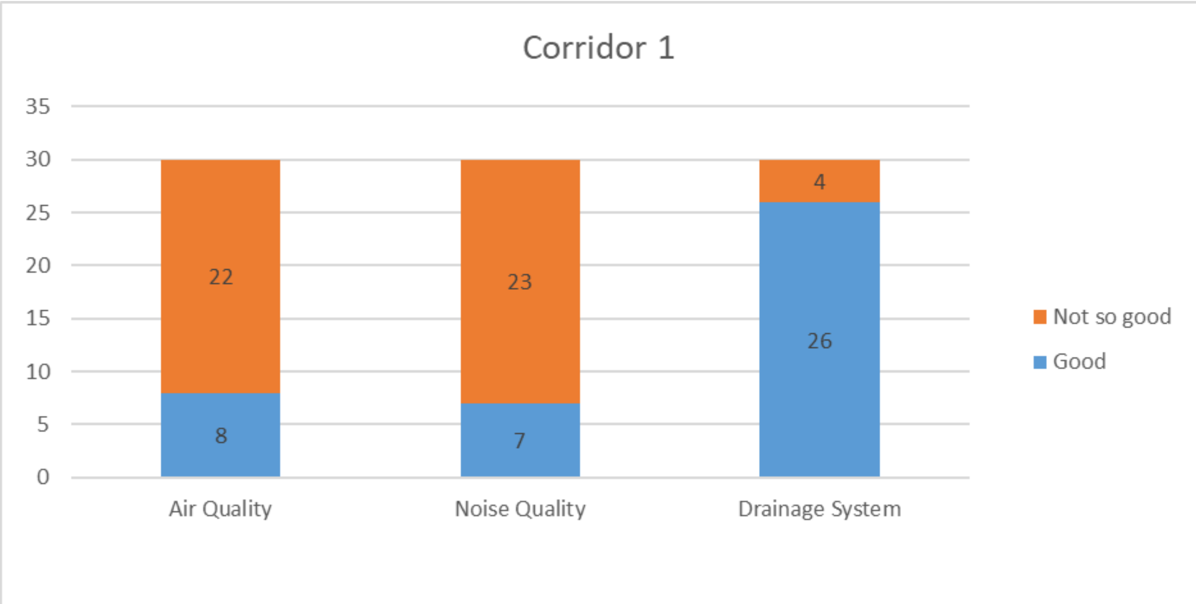


Figure 6.1. Graphical chart showing Public Opinion on Pollution Level in Corridor 1 - KSR Bengaluru City to Devanahalli

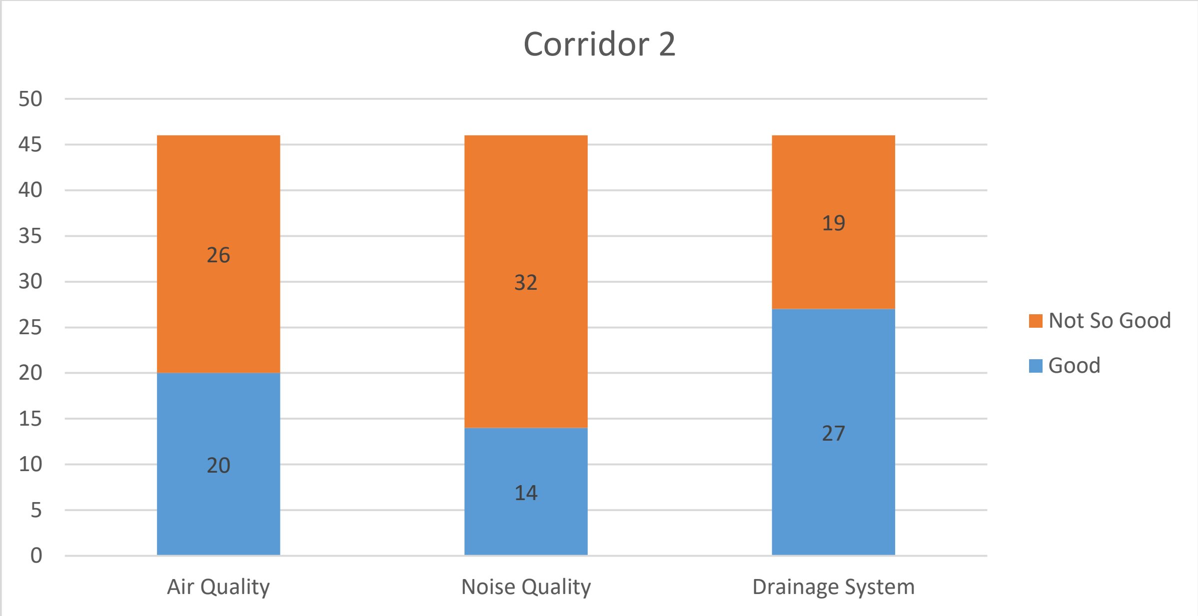


Figure 6.2. Graphical chart showing Public Opinion on Pollution Level in Corridor 2 - Baiyyappanahalli Terminal to Chikkabanavara

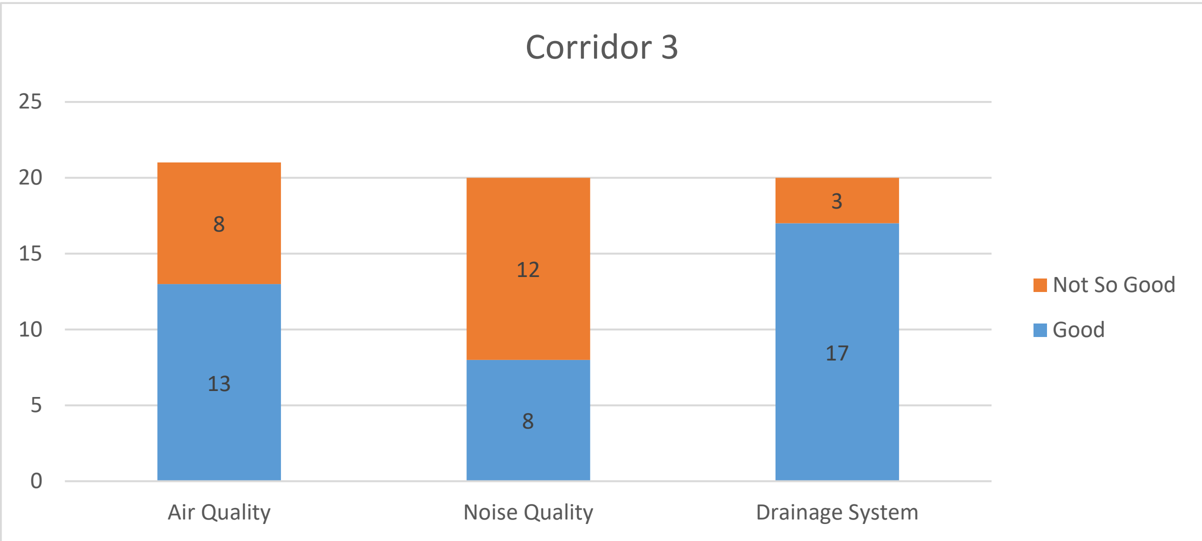


Figure 6.3. Graphical chart showing Public Opinion on Pollution Level in Corridor 3 - Kengeri to Whitefield (via KSR and Cantonment)

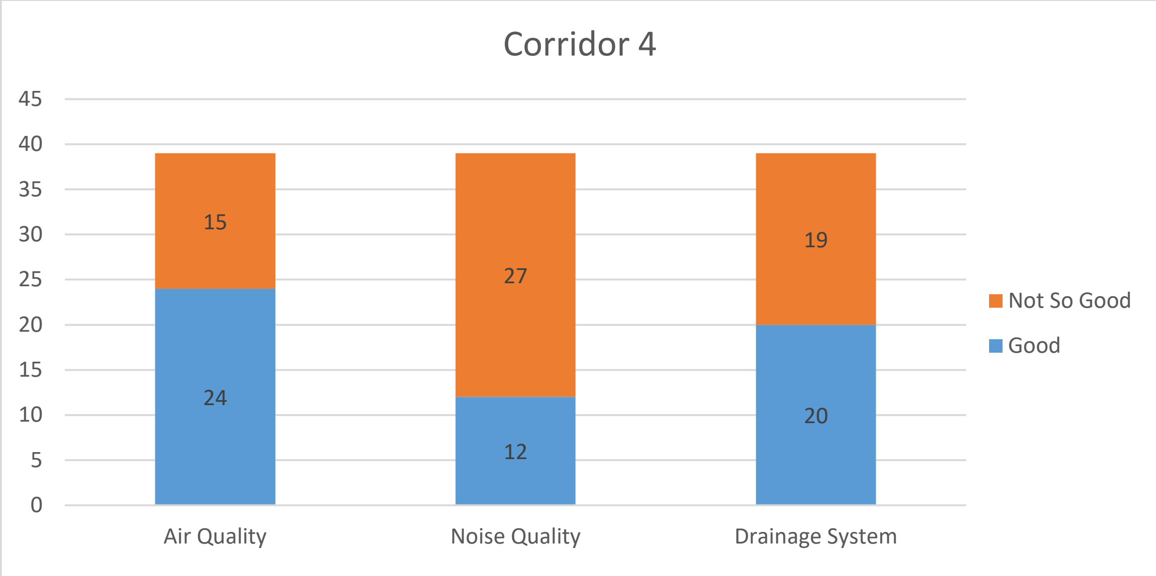


Figure 6.4. Graphical chart showing Public Opinion on Pollution Level in Corridor 4 - Heelalige to Rajanukunte

Further, out of 135 public interactions/FGDs, 81 FGDs i.e., 60% informed that, introduction of Suburban Railway will enhance the overall environmental condition of the region, however remaining 54 FGDs i.e., 40% told that, Suburban Railway project will not make any difference to the environment and public transportation system. Following are the key demands/ suggestions/ opinion received from Public during the interaction;

- Requested for appropriate noise control measures also suggested to not to honk within the city limit.
- Suggested to provide adequate drainage system along the BSRP corridors to avoid inundation/ water logging during rainy seasons and proper maintenance of the same.
- Demanded for adequate underpasses to cross railway from one side to another side.
- Requested for proper fencing at road junctions to avoid dumping of construction waste and garbage along the alignment.
- Demanded to minimise the tree felling and undertake tree plantation and landscaping along the railway track to enhance the green cover and to improve aesthetics of the region.
- Suggested to complete the construction of Suburban Railway project quickly within a given timeframe.
- Proposed improvement should be limited and to have minimum impact on their land and their property.
- Demanded for appropriate compensation for loss of land property and livelihood.

Stakeholders have made various suggestions during implementation of the project. These suggestions are being considered by the K RIDE during the project implementation duly considering local regulations, legal requirements and safety measures to the extent practicable and feasible.

6.2.1.2. Institutional level stakeholder consultation

Institutional level stakeholder consultation was conducted to collect their opinion about the project and collected secondary details for the study area. Details of government officials consulted during FGDs and information disseminated for the project are presented in **Table 6.1**. Photographs showing Institutional level consultations conducted are presented as **Figure 6.5**.

Assi. Superintending Archaeologist, ASI, RO, Bengaluru	Senior Environmental Officer, KSPCB
Divisional Safety Officer, South Western Railways	

**The name, Photo and contact details (Mobile No. & email ID) of the Institutional Stakeholder consultation participants are available in KRIDE records, but due to its sensitivity, the same is not disclosed.*

Figure 6.5. Photographs showing Institutional Level Consultation

Table 6.1. Details of Institutional Level Interactions for the BSRP Corridors

Sl No	Name of the Person	Date	Position	Opinion/suggestion/data sought
1		22.12.2021	Deputy Conservator of Forest, Bengaluru Forest Division – [redacted]	Requested for Forest map for Bengaluru Urban Forest Division, and understood forest clearance and tree felling permission (non-forest) process.
2		05.03.2022	First Division Clerk, Bengaluru Rural Forest	Discussed about status of Akkupete Forest Land and clarified Forest clearance process.
3		12.04.2022	Range Forest Officer, ICTC Cell, Forest Head Office, Bengaluru – Ph:	Discussed on forest spread along project corridors and requested to provide the digitised forest map for Bengaluru rural and Urban Districts.
4		22.12.2021	First Division Clerk, Bengaluru Urban Forest – Ph: [redacted]	Discussed on forest spread along project corridors
5		22.12.2021	First Division Clerk, Bengaluru Urban Forest– Ph: [redacted]	Discussed on forest spread along project corridors and requested to provide the forest

Sl No	Name of the Person	Date	Position	Opinion/suggestion/data sought
				map for Bengaluru Urban District.
6.		21.03.2022	Divisional Safety Officer, South Western Railways – Ph:	Discussed on safety aspects with respect to Indian Rail alignment and at Stations in project area. Further, clarified any contaminated area/harzard area identified along the project railway alignment to undertake extra-care during the baseline study. However, it was confirmed that, no such areas were located along the project corridors.
7.		20.04.2022	Assistant Superintending Archaeologist, Regional Office, Archaeological Survey of India, Bengaluru – Ph: 080-[redacted]	Information disseminated on project corridors and presense of ASI monuments in Devanahalli near Corridor 1. Information gathered on ASI clearance process.
8.		20.04.2022	Senior Environmental Officer, Bengaluru City Zone, KSPCB, Bengaluru – Ph: 080 [redacted]	Discussed on improvement proposal of project corridors. Requested for data on contaminated area/harzard areas/waterbodies identified along the project railway alignment to undertake extra-care during the baseline study. However, it was confirmed that, no such area was located along the project corridors. Also applicability of Air & Water Acts to the project were discussed.
9.		27.04.2022	Engineer (Civil), Ground floor, Karnataka Seed Bhavan, Bellary Road, Near Hebbal, Bengaluru – Mob-.	Discussed on improvement proposal of project corridors. And informed that, corridor 1 & 4 are abutting few lakes and crossing stormwater drains. It was adviced to undertake necessary mitigation measures to avoid any pollution or

Sl No	Name of the Person	Date	Position	Opinion/suggestion/data sought
				affecting the carrying capacity of the lakes/stormwater drains. Further, It was told by concerned Engineer that, legal obligation of Karnataka Tank Conservation and Development Act is applicable for the projects and explined that necessary permission required to obtain from this Authority prior to intiating the site activity.
10.		27.04.2022	Manager, BBMP Forest Wing, Annex Building, BBMP, Corporation Circle, Bengaluru. Ph. – 080 [redacted]	Information disseminated on project corridors. Details of gaint trees and historical trees present within the limit. It was informed that, no such trees present align the railway alignment. Requested on procedure involved in tree felling permission (within BBMP limit) process. It was informed to submit the tree felling application with tree details such as tree species, girth, height, tree coordinates and photos for obtaining permission for the project.

**The name and contact details (Mobile No. & email ID) of the Institutional Stakeholder consultation participants are available in KRIDE records, but due to its sensitivity, the same is not disclosed.*

Opinion/suggestions and data gathered with respect to legal implications of the project and mitigation measures are suitably considered in the preparation of EIA report. Also, guidelines and application forms collected from these statutory bodies are being utilized for obtaining NOC/permissions.

Proceedings of institutional level consultation conduced with South Western Railway Dept. official, Forest officials, Archaeological Survey of India officials and Pollution Control Board officials, Lake Authority and BBMP Forest wing dept. are presented in **Annexure 6.3.** Stakeholder engagement plan prepared for the project cycle is presented as **Annexure 6.4.**

6.2.1.3. Stakeholder Consultation at Cultural Heritage Sites

As part of Public interaction and information dissemination process, a consultation has been undertaken near ASI protected cultural heritage sites ie., 1) Fort, Devanahalli and 2) Tippu Sulthan's Birth Place, which are falling within 300m from the project site. Since, there are no communites/

organisation managing these protected monuments, regular users and public residing near these monuments were consulted to receive the opinion/suggestions on the project.

As per the interactions, the public residing the monuments didn't anticipates any threat to the monuments due to the project. Instead they opined that, due to introduction of suburban rail, there will be arrival of more visitors to these ASI monuments resulting economic development of the region. Some of the suggestion/opinions expressed by the public are as follows;

- They demanded for a rest area/toilet facility near these monuments for the visitors
- Requested to provide proper storm water drainage situated along northern part of the fort to avoid flooding during rainy season
- Suggested to develop Sihineerina Kere/Lake (adjacent to Fort) under CSR to attract more tourists.

Photographs of the Public interaction neat ASI Monuments are presented as **Figure 6.6.**

**The name, Photo and contact details (Mobile No. & email ID) of the Institutional Stakeholder consultation participants are available in KRIDE records, but due to its sensitivity, the same is not disclosed.*

Figure 6.6. Photographs showing Stakeholder Consultation near ASI Monuments

6.2.1.4. Public Consultation Meetings

Public Consultation refers to the process by which the concerns of local affected persons and others who have plausible stake in the environmental impacts of the project or activity are ascertained with a view to taking into account all the material concerns in the project or activity design as appropriate. Local affected persons are the stakeholders (such as land owners, tenants) who are directly affected by the proposed project activities. Other concerned persons are local NGOs, officials of various government departments and local residents who are indirectly affected by project activities. A structured pre-informed public consultation meeting will be organised to desiminate the project improvements once after finalising the draft EIA & SIA reports.

6.2.2. Summary of Public Consultation and Stakeholder Engagement held as part of EIA

Summary of consultation conducted during the EIA report preparation process is presented in below Table;

Table 6.2. Summary of Public Consultation and Stakeholder Engagement held as part of EIA

Sl. No.	Types of Consultation	Time Period	Number of Locations/ Departments	Number of Participants

1.	Focus Group Discussion	From March 2022 to December 2022*	Corridor 1 - 30 Corridor 2 - 46 Corridor 3 - 20 Corridor 4 - 39	Corridor 1 - 92 Corridor 2 - 146 Corridor 3 - 72 Corridor 4 -161
2.	Institutional Level Stakeholder Consultation	December 2021 to April 2022	7 Departments	14
3.	Consultation with individuals near Cultural Heritage site (ASI Monuments	March 2023	10 locations	21

** FGDs including modified Locations.*

Chapter 7. Analysis of Alternatives

7.1. Introduction

This chapter presents a comparative analysis of various alternatives considered to avoid or minimize impacts that would be inevitable if technically (based on design speed and geometrics) and environmentally best-fit, alignment is followed. Cross sections adopted for the development component are flexible in design to avoid most of the impacts within RoW. An analysis of various alternatives is attempted to arrive at the technically and environmentally best-fit alignment.

7.2. Integration of Environmental Consideration in the Alternatives

The social and environmental considerations were integral parts of the design and environmental assessment process. There are considerable number of building both commercial and residential as seen in the baseline environmental scenario along the corridors, where there is constricted existing Indian railway RoW and as well as various environmental impacts. Several alternatives are analysed for avoiding localized environmental impacts and arriving at the best-fit alignment. The analysis of alternatives has been prepared in accordance with the requirements of the World Bank and GoI guidelines.

7.3. "With" And "Without" Scenarios

In the case of the current project, consideration of the 'No Action' and 'Action Alternatives' have been examined as provided in the following subsections;

7.3.1. No Action Alternative

The no action alternative will result in an increase in accidents, deterioration of air and noise quality and pedestrian safety. This will be acute during the peak hours. As per the recent study, average traffic speed is about 12 Kmph in peak hour. The project area is relatively undergoing an increased scale of developments and vehicular growth. Thus the "No action alternative" will not reduce the current traffic chaos.

The steady increase in number of new and better vehicles will increase the number of vehicle year after year and will lead to traffic congestion and leads to economic loss. Accidents and road safety will remain as an issue to be resolved. The present traffic demand will increase primarily due to growth in activities earmarked for developments besides socio-economic growth of the influencing areas.

Metro rails are easing the traffic congestion to the limited extent specific to certain areas. However, about 80% of the other city areas still in the need of better eco-friendly public connectivity. Apart from routine maintenance and rehabilitation of existing at-grade and elevated city roads, there is no augmentation of roads to increase its carrying capacity. Limited road infrastructures such as parking asphalting, street lightings maintenance of drain cum footpaths, reinforcement of traffic signals, there are no alternative mode of transportation proposed to resolve the traffic conditions.

In the absence of adequate public transport system, people are using the personalized modes which is not only leading to congestion on limited road network but also increasing environmental pollution.

An average citizen of Bengaluru spends more than 240 hours stuck in traffic every year. Such delays result in loss of productivity, reduced air quality, reduced quality of life, and increased costs for services and goods.

The unsafe conditions and the environmental consequences (air and noise pollution and degraded environmental conditions) will continue and worsen. The no improvement condition in the long term would be a serious obstacle to the development of the economy and thus to the improvement of conditions for all sections of the population.

7.3.2. Action Alternative

Population and traffic growth will continue to occur and exacerbate in an already critical situation. The "Actions Alternative" scenario, has been determined to be economically viable and would meet the local communities aspirations to a large degree. It would, thereby, contribute to ease the existing traffic congestion, enhance economic efficiency and growth potential of the area, and improve the well-being and livelihood of those within the potentially affected area of the project region. Potential negative environmental impacts associated with the "Action Alternative" scenario can be reduced through good engineering practice and, where warranted, appropriate mitigation and enhancement actions as specified herein.

A comparative statement of No Action Alternative and Action Alternative is shown in **Table 7.1.**

Table 7.1. Comparison of No Action and Action Alternatives

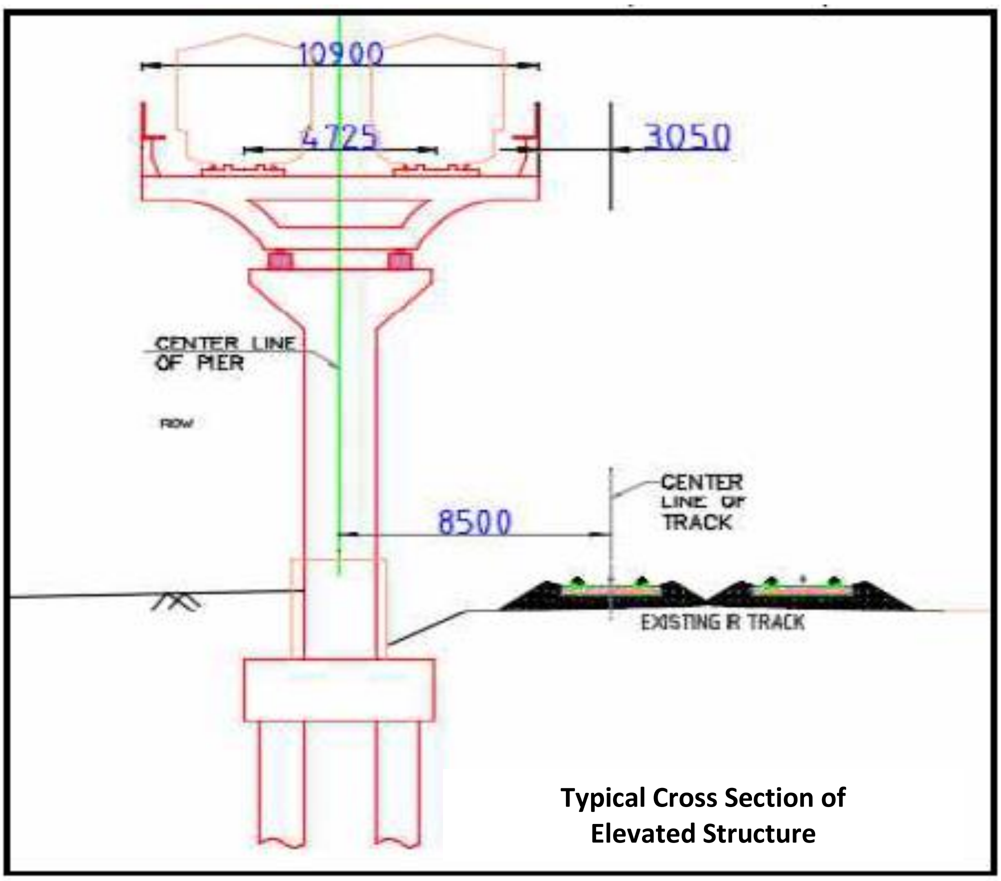
No Action Alternative	Action Alternative
Congested corridor remains	It will ease the road congestion, by introducing suburban railway which will link Bengaluru to its satellite townships, suburbs, surrounding areas and provide a mass rail based rapid transit system
Chaotic traffic scenario will continue	Streamline the traffic control system
Travel time saving does not arise	Plenty of time is saved avoiding congestion
No interaction & awareness will be built in the local Groups and NGOs	There will be a number of interaction & awareness meetings to the local people & NGOs
Accidents and safety issues will continue to be the same	Proposed suburban reduce the risk of accidents
Aesthetic quality remains dull	Aesthetic quality of the corridor will increase. (One can enjoy the panoramic view of the city)
Vehicular emission will increase over a period of time	Reduce the vehicular emission
There will not be any environmental enhancement to the project region	There will be a number of measures for improving the environmental conditions.
Increased financial burden of the personal vehicle users and other public transport commuters	Affordable fares compared to other mode of transport will help lakhs of daily commuters

The analysis clearly shows that the ‘no action’ alternative is not a prudent course of action. This alternative “do nothing” is not acceptable and has already been rejected by the Project Authorities.

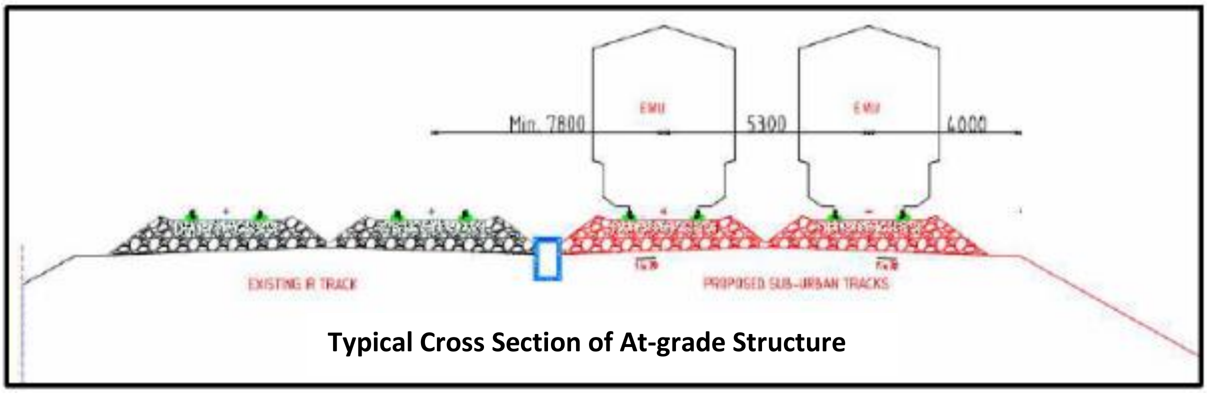
7.4. Structure Alternative Options

The BSRP Corridors are passing through both busy central business district and peri-urban areas of Bengaluru City. Since, about 90% of the land required for BSRP is with existing ROW of Indian railway line, there is no major land acquisition issues raised during project design. However, at certain locations (especially rail alignment within Bengaluru City limit), there is no sufficient RoW available with Indian railway to propose at-grade suburban railway facility. Hence, at those locations (refer Figure 2.1 BSRP System map) elevated railway system is proposed in order to avoid land acquisition and social issues. Typical Cross Section of Elevated & At-grade Structures is presented in **Figure 7.1.** Benefits of elevated structure alternative are detailed listed as follows;

- Elevated structures can be constructed at location where limited Indian railway existing RoW to avoid additional private land acquisition and due existing infrastructure like Metro, existing grade separators, major storm water drain, etc.,
- No fresh land acquisition, rehabilitation and resettlement of PAPs is required
- Very impacts on community division compared to At-grade railway alignment
- At elevated structure tracks will not be submerged during heavy rainy days
- There is no stagnation of water or inundation of surroundings due to surface runoff from high raised embankment railway tracks
- Rate of attenuation of noise & vibration is more in elevated structures compared to At-grade railway alignment
- Elevated structure feels more liberated than reinforce at-grade structure, but the design needs to consider the landscape
- Very less impact on trees and no fragmentation of biodiversity



Typical Cross Section of
Elevated Structure



Typical Cross Section of At-grade Structure

Figure 7.1. Typical Cross Sections of Elevated and At-grade Structures

7.5. Alternative Alignment Options

As discussed earlier, about 90 percent of the BSRP alignment is proposed within the existing Indian Railway land, which are connected to the city in five radial rail corridors and connecting north-south and east-west part of the city. Hence, it has been proposed to utilize maximum extent of Indian Railway land to develop BSRP corridors. Developing the BSRP by acquiring fresh land within the city limit to de-route from existing Indian railway alignment will not be a feasible option for the project. Hence, studying alternative options for the alignment is not warranted for the project.

7.6. Stations Alternative Options

Stations are inevitable part of suburban railway project, which connects various commuter destinations within the city limits and suburban areas. BSRP Corridors Stations are proposed at the locations of existing Indian railway stations in order to avoid the fresh land acquisition. Hence, there are no alternative options studied for Stations in BSRP corridors.

7.7. Depot Alternative Options

As part of BSRP, two depot is proposedie., Soladevanahalli village and Akkupete village. Total extent of land area required for Soladevanahalli and Akkupete depots are 9.3 Ha and 18.6 Ha respectively. The depots are strategically selected by considering accessibility to BSRP Railway alignment and availability of large extent of land. The land identified for the Akkupete depot belongs to State Forest Dept. Google images of Akkupete Depot are presented in **Figure 3.23** and **Figure 5.23** of this report. Considering land scarcity the Akkupete depot land is proposed in forest land.

7.8. Technology Options

BSRP will be developed utilizing Electric Multiple Unit (EMU) train, which consist of self-propelled carriages that uses electricity as the motive power. EMU does not required separate locomotive engine, as one or more electric traction motors will be incorporated in the train. An EMU is usually formed of two or more semi-permanently coupled carriages, but electrically powered single-unit railcars are also generally classified as EMUs.

EMUs are popular on commuter and suburban rail networks around the world due to their fast acceleration and pollution-free operation. Being quieter than Diesel Multiple Units (DMU) and locomotive-drawn trains, EMUs can operate later at night and more frequently without disturbing nearby residents.

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Chapter 8. Assessment of Potential Environmental Risks and Impacts with Mitigation Measures

8.1. General

This Chapter highly points the potential Environmental impacts anticipated during project implementation. The potential environmental impacts could be positive or negative, direct or indirect and induced and localized or regional and reversible or irreversible impacts. The potential impacts due to proposed project activities have been analyzed and assessed based on the project description (Chapter 3); and identified impacts from primary and secondary baseline information and data as presented in the (Chapter 5). The quantitative and qualitative assessment has been carried out for the identified potential environmental impacts. Matrix method has been adopted to evaluate the impacts on the environment.

Attempts have been made to envisage the impacts due to proposed project during construction and operation. The project impacts on ambient air quality, noise and vibration level have been quantified while project impacts on water, soil and archaeological / heritage assets are evaluated considering the stipulated norms and standards. National Standards for Air, Water, Noise and effluent discharge standards are given as **Annexure 8.1** to **8.5**. Impact on ecology has been assessed quantitatively in terms of total trees to be felled / relocated and in terms of adverse impact on aquatic species or their habitats. Other impacts have also been prophesied. Significant impacts during pre-construction, construction and operation of the project have also been assessed.

Impact identification and assessment starts with scoping and continues through the remainder of the IA Process. The principal IA steps summarized in figure below and comprises of:

- Impact prediction: to determine what could potentially happen to resources/receptors because of the Project s and its associated activities.
- Impact evaluation: to evaluate the significance of the predicted impacts by considering their magnitude and likelihood of occurrence, and the sensitivity, value and/or importance of the affected resource/receptor.
- Mitigation and enhancement: to identify appropriate and justified measures to mitigate negative impacts and enhance positive impacts.
- Residual impact evaluation: to evaluate the significance of impacts assuming effective implementation of mitigation and enhancement measures.

The methodology adopted in assessment of potential positive and negative impact during construction and opertation phase is given in below paragraph and presented as Environmental Impact assessment matrix below in the **Table 8.1**.

The evaluation of the environmental impacts is based on Matrix system derived from the analysis and assessment of primary and secondary data collected through direct and indirect communication/consultation with local people and concerned authorities. Environmental impact scores developed in the EES are based on the magnitude of specific environmental impacts and their relative importance. The impacts assessed prior to the provision of mitigation measures.

Table 8.1. Environmental Impact Assessment Matrix

S. No.	Environmental Impacts	Impact Rating	Impact Characteristics
A.	**IMPACTS DUE TO PROJECT LOCATION AND DESIGN**		
1.	Displacement and loss of livelihood of Project Affected People (PAPs)	Assessed as part of SIA Report	Permanent, negative, small scale and mitigable.
2.	Change of Land use	R2	Permanent, negative, small scale and mitigable.
3.	Loss of trees and impact on ecology	R1	Permanent with both positive and negative impact, Small scale and mitigable.
4.	Drainage and Utilities: Diversion/shifting	R2	Short term and/or permanent, negative, small scale and mitigable.
5.	Impact on Archaeological Monuments and Heritage Assets	R2	Permanent with both positive and negative impacts, Small scale, and mitigable.
6.	Use of Energy and Water at stations and depots	R1	Permanent with both positive and negative impact, mitigable.
7.	Risk Due to Natural Hazards	R1	Permanent, negative, Small scale and mitigable.
B.	**IMPACTS DUE TO PROJECT CONSTRUCTION**		
1.	Air pollution: Particulate air pollution due to activities like excavation; emissions due to transportation of muckand material Noise, Vibration	R1	Large scale, permanent,, negative and mitigable.
2.	Disposal of muck, C&Dwaste and hazardous waste; pre-casting and material yards	R2	Temporary, negative, small scale and mitigable
3.	Water demand and water quality	R2	Temporary, negative, small scale and mitigable.
4.	Soil erosion and land subsidence	R2	Temporary, negative, small scale and mitigable.
5.	Traffic diversions	R2	Temporary, negative, small scale and mitigable.
6.	Labor camp and on-site labour safety/welfare	R2	Temporary, negative, small scale and mitigable.
7.	Supply of construction material	R2	Temporary, negative, small scale and mitigable.
C.	**IMPACTS DUE TO PROJECT OPERATION**		
1.	Noise and Vibration	R1	Permanent, negative, large scale and mitigable.
2.	Energy and water supply at stations and depots	R2	Permanent, negative, Small scale and mitigable.

S. No.	Environmental Impacts	Impact Rating	Impact Characteristics
3.	Traffic congestions around stations	R2	Permanent, negative, Small scale and mitigable.
4.	Impacts due to Depots: Water supply, Waste water disposal, Oil Pollution, Noise Pollution, Solid Waste disposal, Loss of trees.	R2	Permanent, negative, small scale and mitigable.
D.	**POSITIVE IMPACTS DUE TO PROJECT**		
1.	Employment Opportunities	Positive impact	Permanent, positive and large scale.
2.	Benefits to Economy: access, reduced costs of road infrastructure, vehicle operating & time, accidents.	Positive impact	Permanent, positive and large scale.
3.	Reduction in road traffic	Positive impact	Permanent, positive and large scale.
4.	Reduction in road accidents	Positive impact	Permanent, positive and large scale.
5.	Reduction in fuel conumption	Positive impact	Permanent, positive and large scale.
6.	Reduction in air pollutants and savings in GHG emissions.	Positive impact	Permanent, positive and large scale.

*Note: *Rating: R1: Significant negative impact is expected. R2: Some negative impact is expected. R3: Extent of impact is unknown R4: No impact is expected*

This Chapter is concerned about the potential negative impacts on the environment due to proposed project activities. It is noticed that only pollutants which are solid, liquid and gaseous in nature will be generated due to the proposed project activities mainly during construction and operation stages. Additionally, negative impacts on various aspects of the environment likely to result from the proposed development activity are identified, analyzed and assessed in this Chapter. The potential positive impacts are elucidated in the next **Chapter 9**. The recommendations for mitigating measures have been elaborately provided in **Chapter 10**.

8.2. Potential Negative Environmental Impacts

The potential negative impacts due to proposed project on the following environmental components have been identified and appraised during various phases of project cycle namely project Location, design, construction and operation.

- Land Environment,
- Water Environment,
- Air Environment,
- Noise Environment,
- Biological /Ecological Environment
- Historical, Archaeological and Cultural heritages
- Socio-economic Environment

The potential negative impacts have been described under the listed headings below:

- Impacts due to Project Location and Design (Pre-construction Phase)
- Impacts due to Project Construction (Construction Phase), and
- Impacts due to Project Operation (Post-construction or Execution Phase).

8.3. Risks and Impacts due to Project Location & its Mitigation Measures

The potential risks and impacts predicted due to the project layout and design have been assessed in this section. These are listed below and discussed in the following sub-sections:

The potential impacts due to project location se are listed below and discussed in the following sub-sections:

- Land requirement and its impact on Displacement of People, Encroachment Clearance and loss of livelihood of Project Affected People (PAPs)
- Risks & Impacts on land and Change in Land Use
- Risks & Impacts on Diversion of Forest land
- Risks & Impacts on Biological/Ecological Environment
- Risks & Impacts on Climate Change
- Risks & Impacts on Utility/Drainage System
- Potential Social Impacts
- Risks & Impacts on Religious Structures /Archaeological / Historical and Cultural Monuments/ Heritage Sites
- Risks and Impacts on Environmental Sensitive Receptors
- Risks and Impacts on Local Transport Facilities

The potential impacts enlisted due to project design are as given below :

- Platform Inlets and outlets
- Illumination and Ventilation
- Impact of Noise and Vibration
- Right of Way Alignment, Stations, Track Design and Architecture
- Spatial Planning of Stations and Inter Modal Integration
- Consumption of Energy for Illumination, Ventilation and Water at Stations and Depots
- Risks Due to Natural Hazards
- Robust Design with Provisions for Green Buildings
- Efficient Material Re-use and Conservation
- Conservation of Flora/Preservation of Trees
- Utility Plan
- Design Improvement to Minimise the Vibration

8.3.1. Land requirement and its impact on Displacement of People, Encroachment Clearance and loss of livelihood of Project Affected People (PAPs)

Risks and Impacts : A minimum to moderate impact on land and people were noticed due to the project, since the project utilizes government land in majority for the project.

Mitigation Measures : Alignments are designed to utilise Government and Indian Railway lands to the maximum and to avoid or minimize impacts on private land or properties, in accordance with Land Acquisition Act, 1894 and Rehabilitation and Resettlement Act, 2013 and WB ESS 5 & EIB's ESS 6.

Residual Impacts and Measures : Impact on the livelihood of Project Affected People (PAPs) due to displacement will be suitably compensated as per the R&R plan. Hence, there is no residual impacts anticipared. The project affected people (PAPs) including both title holder and non-titled holder land owners and their loss of livelihood are addressed separately under Rehabilitation and Resettlement (R&R) Section of the Social Impact Assessment (SIA) Report.

8.3.2. Risks & Impacts on land and Change in Land Use

Corridor wise land requirement including private land acquisition details is presented in table below. The area estimated for corridor -2 is final as the joint measurement is completed and the land acquisition works are in final stage. The details provided for the other corridors are based on the draft design report. The proposed BSRP requires acquisition of land permanently for stations, depots and running corridor sec-tions. Both government and private land will be acquired for the project. The Government land includes about 145.3 Ha of Railway Land, 18.62 Ha of Forest Land, 8.66 Ha of State Govt. land, and 3.63 Ha of other government land. The private land required is about 56.88 Ha. The railway land would be transferred to K-RIDE for a nominal fee of INR 1/Acre. The details of the same are given in civil engineering section in the FPR. About 233.09 Ha is required for the proposed project corridors, depots and Stations. Corridor wise land requirements including private land acquisition is tabulated in **Table 8.2**. Corridor wise land free stretches and land acquisition stretches are presenten in **Figure 8.1**.

Table 8.2. Corridor wise Land Requirements including Private Land Acquisition

S.No.	Corridor/ Depot	Government Land, Ha					Private Land, Ha	Total
		Railway Land	GoK Land	Forest land	Other Govt. Land	Total Govt Land		
1	Corridor- 1	46.80	0.83	0.00	0.00	47.62	4.90	**52.52**
2	Corridor- 2	34.70	2.83	0.00	3.63	41.16	2.07	**43.23**
3	Corridor- 3	17.05	1.03	0.00	0.00	18.09	8.39	**26.47**
4	Corridor- 4	46.75	1.94	0.00	0.00	48.69	16.31	**65.00**
5	Depot - 1 (Devanahalli)	0.00	2.03	18.62	0.00	20.65	4.16	**24.81**
6	Depot - 2 (Soladevanahalli)	0.00	0.00	0.00	0.00	0.00	21.05	**21.05**
7	**Total**	**145.30**	**8.66**	**18.62**	**3.63**	**176.21**	**56.88**	**233.09**
8	**Percentage**	**62.34%**	**3.71%**	**7.99%**	**1.56%**	**75.6%**	**24.4%**	

Source: BSRP - Feasibility Report & details from Land Acquisition team

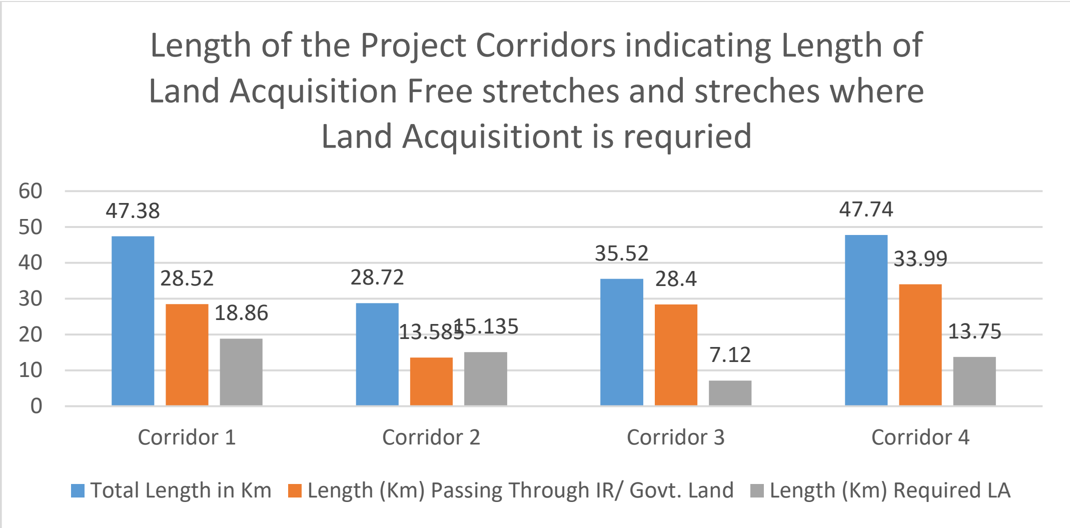


Figure 8.1. Corridors - Land Acquisition Free Stretches & Land Acquisition Stretches

Corridor – 1: The comprehensive walk-through survey conducted by the SIA team shows that around 88.28% of land is government land and about 11.72% is private land. The structures in the private land that are affected are Residential (54.12%), Commercial (4.71%), residential cum commercial (1.18%) and CPRs (1.18%), while 38.82% are non-responsive.

Corridor – 2: The comprehensive walk-through survey conducted by the SIA team shows that around 76.46% of land is government land and about 23.54% is private land. The structures in the private land that are affected are Residential (61.25%), Commercial (18.69%), residential cum commercial (14.88%) and CPRs (5.19%), while all PAHs were responsive.

Corridor – 3: The comprehensive walk-through survey conducted by the SIA team shows that around 68.3% of land is government land and about 31.7% is private land. The structures in the private land that are affected are Residential (35.56%), Commercial (10.37%), residential cum commercial (2.96%) and CPRs (4.44%), while 46.67% are non-responsive.

Corridor – 4: The comprehensive walk-through survey conducted by the SIA team shows that around 74.91% of land is government land and about 25.09% is private land. The structures in the private land that are affected are Residential (43.57%), Commercial (3.57%), residential cum commercial (0.00%) and CPRs (3.57%), while 49.29% are non-responsive. The outcome of the comprehensive walk-through survey is shown in Figure above.

Status of Land Acquisition: Joint Measurement Survey has been completed in Corridor 2, and the same is in progress in other project corridors. The ownership of the land, extent of loss of land, asset loss and any other losses due to the land acquisition will be assessed and confirmed during joint measurement survey by the Special Land Acquisi-tion Officer, KIADB and the land acquisition notice to the landowners would be issued. The concerned land owners will also participate in the survey. The joint measurement survey will be conducted after the de-signs are finalized and the land requirement is finalized. It is expected that the joint measurement surveys will be taken up sequentially for all corridors; these are expected to be completed by June 2024.

Mitigation Measures : The compensation for land is detailed in Social Impact Assessment Study Report. Impact on Private land comprises of residential land, commercial land and vacant land. As per

RAP notice shall be given in advance to the encroachers (and squatters, if any) present in the Corridor of Impact, who need to be relocated. All R and R activities shall be undertaken as per the relevant acts and also comply with WB's ESS 5 and EIB's ESS6. Entitlements as per K RIDE entitlement framework shall be completed before construction starts.

8.3.3. Risks & Impacts on Diversion of Forest land

BSRP project requires diversion of 18.6 Ha Forest land for the construction of Akkupete (13°14'50.40"N & 77°41'26.37"E) Depot. Forest land shall be diverted in accordance with the Forest (Conservation) Act, 1980 and WB's ESS 6 & EIB's ESS 4. Compensatory afforestation is one of the most significant conditions stipulated by the Central Government for diversion of forest land for infrastructure projects such as Suburban Railway Project in Bengaluru. Obtaining Forest Clearance is still under progress at K RIDE level. Compensatory afforestation land has been identified by K RIDE in consultation with Forest Dept. & deposit amount in Compensatory Afforestation Fund Management & Planning Authority (CAMPA), which is required to carryout compensatory afforestation. Concerned Divisional forest department will prepare compensatory afforestation scheme and undertake afforestation using CAMPA fund.

Clearing of vegetation in proposed Akkupete depot site shall be undertaken manually through Bengaluru Rural Forest division as per statutory guidelines laid out under Karnataka Preservation of Tree Act, 1976 and amendments and Forest Conservation Act, 1980. Further, compensatory afforestation and its maintenance for loss of trees will be undertaken by Bengaluru Rural Forest division as per these Acts/guidelines. Hence, preparation of separate Pest Management Plan does not required.

Total number of trees to be felled in forest land is 17,323. The number of trees to be transplanted depends on the site condition and root condition & health of tree. This will be ascertained by forest dept. Maximum effort will be done to save trees and transplant with all required measures. Those trees which cannot be transplanted at all will only be removed. The total area required for afforestation of these trees comes out to about 18.6 ha, which is identified by K RIDE in consultation with Forest Dept. The proposed CA land is located in survey no. 65 (13°24'24.08"N & 77°24'21.09"E) of Sasalu Village of Doddabalapura Taluk. The identified land is approx. 35km from the proposed Akkupete Depot land. As per the preliminary interaction of forest officials and site visit, the identified CA land is suitable for compensatory afforestation and has no thick vegetation in it. Topography of the CA land is plane to undulating and has katcha road available to access the land. From the prima facies, there will not be any adverse impact on existing vegetation cover and fauna due to undertaking CA. Google imagery of the CA land identified for diversion of forest land is presented in **Figure 8.2**. Photographs of the CA land is presented in **Figure 8.3**.

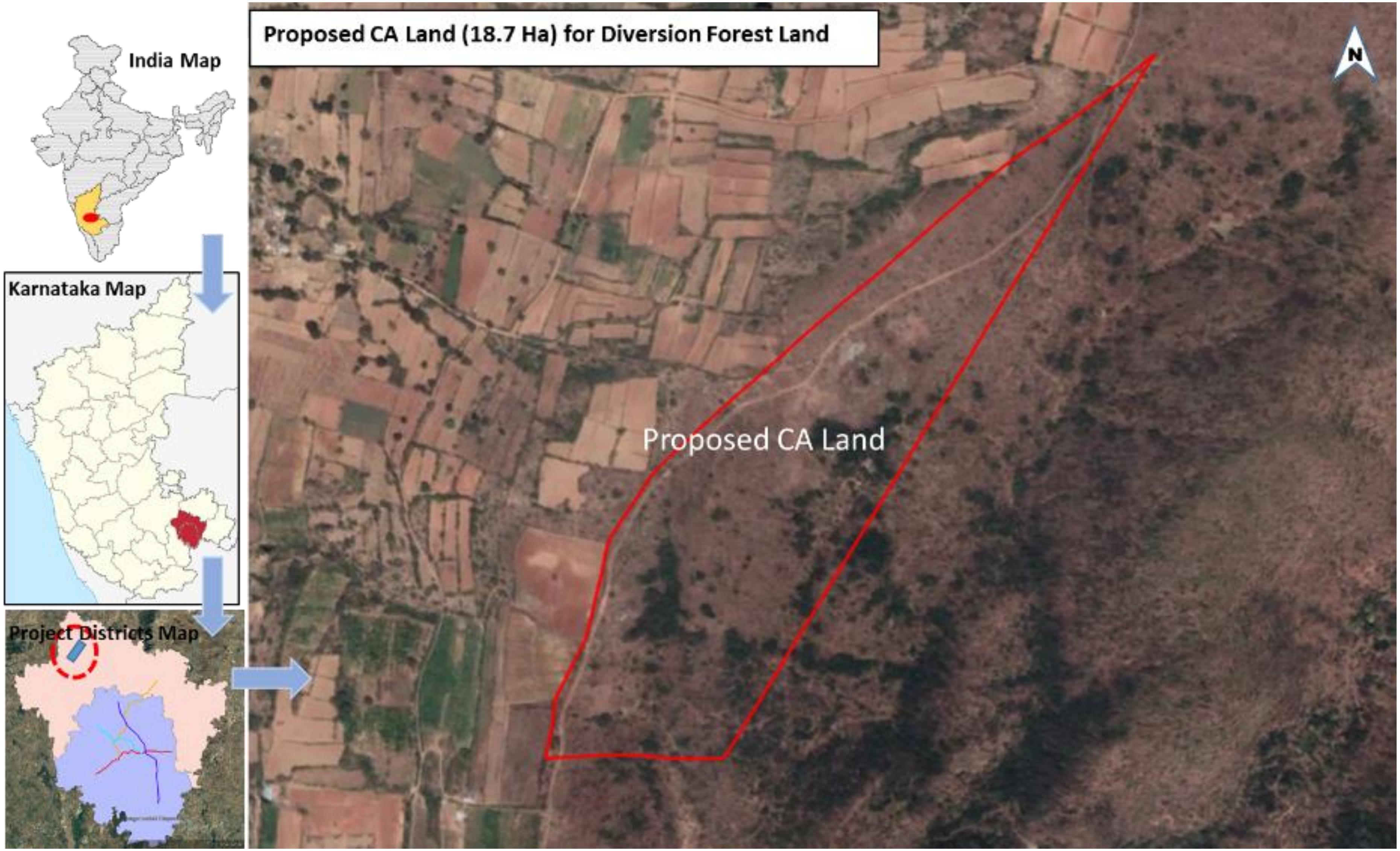


Figure 8.2. Google Earth image Showing Proposed Compensatory Afforestation Land Identified for Diversion of Forest Land

Figure 8.3. Photographs of the Compensatory Afforestation Land Identified for Diversion of Forest land for Depot in Akkupete

8.3.4. Risks & Impacts on Biological/Ecological Environment

8.3.4.1. Risks & Impacts and Mitigation Measures on Flora

The proposed project runs within the city limits and the surrounding a few village limits. A Tree inventory for the total project has been carried out. As per the assessment the total number of trees likely to be affected as a result of the proposed project is about **32,572 trees**. Most of the trees affected are at median of the existing road along the corridor and on either side of the existing road and railway lines for the proposed Suburban Railway stations and corridors. Shrubs and small tress under Social Forestry are affected due to establishment of Depots at Akkupete and Soledevanahalli. The inventory of trees for Corridors including stations and Depot is summarised in the **Table 8.3.** There are no rare or endangered tree species as per site observation and condition.

Table 8.3. Number of Trees along the Corridor/Depots

Sl. No.	Alignment/Depot		Total No. of Trees
1.	Corridor 1 (KSR Bengaluru City - Devanahalli)		7198
2.	Corridor 2 (Baiyyappanahalli Terminal – Chikkabanavara)		3469
3.	Corridor 3 (Kengeri – B'lore Cantonment – Whitefield via SBC)		2072
4.	Corridor 4 (Heelalige – Rajanukunte)		2306
Sub-Total along the Alignment & Stations (A)			**15,045**
5.	Akkupete Depot	Forest land	17323
		Non – forest land	182
	Sub total		17505
6.	Soladevanahalli Depot		22
Sub-Total at Depots (B)			**17527**
Total Trees (A+B)			**32,572**

It is observed during field survey that most of the tree species are common trees, particularly ornamental or horticulture trees/plants. As per the field study, except *Aegle marmelos* (near threatened) there are no rare endangered endemic and threatened (REET) species were noticed to be present in the proposed project area. IUCN Categorization of trees present in BSRP Corridors are presented in **Table 5.44**.

Depot Areas : The land for establishing the depot is at Akkupete and Soledevanahalli. It is proposed to mobilize the Akkupete land of about 18.6 Ha by the Forest Dept. Whereas soledevanahalli depot is proposed in private land. Akkupete Depot is identified on Forest land where compensatory Afforestation has been taken-up forest dept. in the year 2001 and the land diversion to Railway Authority is under process. The project area is covered largely with shrubs of *Melia dubia* (wild neem – Hebbevu in Kannada), Eucalyptus and Acacia species. Tree enumeration and identification of plant species is under progress, whereas the same for plants in the proposed project coming under forest area need to be carried out by the Bengaluru Rural Forest Division, Devanahalli.

Mitigation Measures : Transplantation of trees shall be carried out by the BBMP Forest Wing and Forest Authority in consultation with K RIDE. Tree removal shall be carried out in accordance with the Karnataka Forest Act, 1963 (Karnataka Act 5 of 1964) amended with Karnataka Forest Rules, 1969, The Karnataka Preservation of Trees Act, 1976 and The Karnataka Preservation of Trees (amendment) Act, 2014, Forest Conservation Act 1980 and ESS 6 of World Bank & EIB's ESS 4.

The trees considered for removal & Translocation in BBMP Limit for the project needs to be compensated with afforestation by tree planting ten trees for every tree cut i.e. in the ratio 1:10 (considering at least survival of 5 trees per a tree removed) by the BBMP Forest Wing in coordination with K RIDE. However, Trees to be removed in Forest land shall be carried out by Forest Dept. in coordination with K RIDE and in accordance with the Compensatory Afforestation Fund Management & Planning Authority (CAMPA). The Forest Department will be responsible for the Afforestation Programme and Tree Maintenance during project implementation.

Residual Impacts: Loss of Flora leading to reduction in absorption of CO2 and release of O2 along the project areas for initial few years, may be upto 5 years at the maximum. This will be overcome in due course of time by the Tree Plantation and Tree Maintenance through Afforestation Programme by the Forest Department during project implementation.

8.3.4.2. Compensatory Afforestation for Felling on Trees along Existing Railway Alignment

There are about 32572 trees are affected due to BSRP Rail alignment and stations. Transplantation of trees will be carried out by the BBMP Forest Wing and Forest Authority in consultation with K RIDE. Tree removal shall be carried out in accordance with The Karnataka Preservation of Trees Act, 1976 and The Karnataka Preservation of Trees (amendment) Act, 2014 and ESS 6 of World Bank & EIB's ESS 4.

The trees consider for removal & Translocation in BBMP Limit for the project needs to be compensated with afforestation by tree planting ten trees for every tree cut ie., in the ratio 1:10 by the BBMP Forest Wing as per the statutory guidelines in coordination with K RIDE.

At present, manual clearing of vegetation along the railway tracks is practiced by Indian Railway. It is proposed to adopt same method to clear the vegetation for BSRP. Vegetation (shrubs, climbers and small plants) along the proposed BSRP tracks will be cleared manually without using weedicide and herbicides. Due to this, there is no contamination of soil or nearby water bodies.

Clearing of trees along railway side shall be undertaken through BBMP forest wing/ Forest as per statutory guidelines laid out under Karnataka Preservation of Tree Act, 1976 and amendments and Forest Conservation Act, 1980. Further, compensatory afforestation and its maintenance for loss of trees will be undertaken by BBMP forest wing/ Forest dept. as per these Acts/guidelines. Hence, preparation of separate Pest Management Plan does not required.

8.3.4.3. Risks & Impacts and Mitigation Measures on Fauna

As per the interaction with forest officials, there are no wildlife crossings present in the project corridors. There are no impact on aquatic life, since construction activity will not take place inside the lakes. And as mentioned in Section 5.6.3 and outcome of Surface water quality test results, storm water drainages/Rajakaluves are polluted by sewage and industrial discharges. There is no aquatic fauna observed in these storm water drains/ rajakaluves.

As mentioned in above section, there will be considerable impact on avifauna due to felling of trees along the existing railway alignment, stations and depots locations. Even though, trees will be felled only on one side of the existing railway alignment, impacts can be avoided by translocation of the trees to adjacent vacant railway land.

It is observed that, the birds identified in the lake are having plentiful of forage and roost in the lake vicinity compared to rather than surrounding urbanised and built-up areas. They are not observed to fly to areas where there is high pollution and disturbance from anthropogenic activities.

Lakes in the side of the project site will not be disturbed due to project, some birds especially those which are native/residents and/or residents will not leave or leave for a time, but may eventually come back.

Most of the avifaunal species observed during monitoring are observed to be already acclimatized to anthropogenic activities such as fishpond operations, construction of buildings, disturbance near residential areas, etc. If these species will be displaced by the activities of the BSRP, it is surmised that in time, they will come back to their old haunts and habitats near the project site.

Hence, it is advised to carryout following few pre-construction measures to avoid/minimize the impact on avifauna, forage, roost/nesting and disturbance to young ones in the region.

- Tree felling should not be undertaken during night time.
- Tree felling should be minimized as far as possible, if unavoidable importance should be given for translocation to nearby vacant locations.
- Tree felling should be avoided during nesting and breeding time especially in April and May months.

Residual Impacts: There is no residual impacts anticiapted.

8.3.5. Risks & Impacts on Climate Change

This Section is concerned with the Assessment of associated risks on climate due to project (which is positive through predicted reduction of GHG emissions) as well as Vulnerability of project to Climate Risks and their management.

8.3.5.1. Climate Change Risks due to Project

The Climate change includes both the global warming driven by human emissions of greenhouse gases and the resulting large-scale shifts in weather patterns. The development and operation of the BSRP has the potential to contribute to the greenhouse effect through emissions produced by various activities throughout the construction and operation of the Project. The 3 main GHGs include carbon dioxide (CO_2), Hydrocarbons (HC) and nitrous oxide (N_2O).

An initial screening process was conducted as part of the project preparation to analyze the possibility of any potential to reduce GHG emissions or increase the reduction of GHG emissions. Also it included the potential to sequester carbon in soils and in vegetation. Risk Assessment study has been conducted focusing on the project approach to reduce GHG emissions and to avoid excess GHG emissions.

Based on the initial screening study relevant possibilities for adaptation have been identified, analyzed and assessed. The methodology followed is based on the methodology for analysis of Climate Risks as described in the Fifth Assessment Report (AR5), 2014 and Sixth Assessment Report (AR6), 2022 of United Nation's Intergovernmental Panel on Climate Change (IPCC).

Risk of climate-related impacts result from the interaction of climate-related hazards (including hazardous events and trends) wherein associated with vulnerability and exposure of human and natural systems, including their ability to adapt. Their identification is based on large magnitude or high probability of impacts: irreversibility or timing of impacts; persistent vulnerability or exposure; or limited potential to reduce risks.

High emissions leading to increased magnitudes of warming which in turn increase the likelihood severity, pervasive and irreversible impacts for people, species and ecosystems. Continued high emissions would lead to mostly negative impacts on biodiversity, ecosystem services and economic development and amplify risks for livelihoods; and risks for food and human security.

Climate change is a major threat to equitable and sustainable development infrastructure Projects such as the proposed Suburban Railway Project. Amongst all climate change consequences, the following may impact on the proposed Suburban Railway operation: (i) increase in Air temperature with increase in amplitude of temperature fluctuation during the year and (ii) changes in distribution of precipitations during the year. However, adaptation, mitigation and sustainable development are closely interrelated with potential synergies and trade-offs.

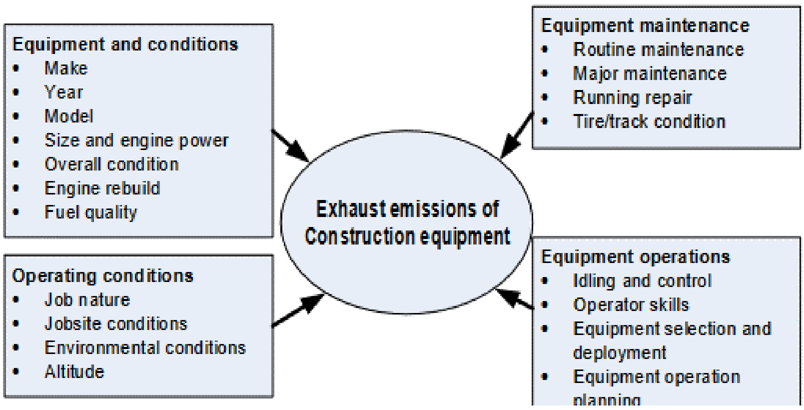
8.3.5.2. Assessment of Carbon Foot Print (GHG Emissions) during Construction Phase

During the construction of the Project (BSRP) the GHG emissions will result from pollutants generated during vegetation removal, wastewater treatment, transport, manufacturing and construction of building materials and energy usage. These GHG emissions will be relatively low, produced over a short time period and are therefore unlikely to contribute significantly to overall GHG emissions from BSRP.

- Due to tree felling and vegetation clearance (along alignment and for depots), increase in Carbon Emission during pre- construction and construction phase is 710 tonnes of CO2e for one year of activities. This contributes to 31% of the GHG emissions.
- Compensatory afforestation will be done for the tree felling, resulting in about 7,100 tonnes of CO2e per year reduced for the year 2025 (compensation of new trees for trees felled in the ratio of 10:1) (Ref. Section 9.1.9 of EIA Report)
- Construction equipment and vehicular emissions account for major contribution of about 69% towards GHG emissions, particularly 1566.81 tonnes of CO2e for a total period of 3 years of construction.

Factors affecting the construction equipment emissions

There are a large number of factors affecting the exhaust emissions of construction equipment or machinery or vehicles, many are difficult to measure and quantify their degree of impact on the rate of emissions. Overall the factors can be categorized into four groups as shown in **Figure 8.4**. **Table 8.4** depicts net GHG Emission from BSRP construction equipment, Machinery and vehicles during project Construction phase.



Source : H. Fan, 2017 - A Critical Review and Analysis of Construction equipment emission factors

Figure 8.4. Factors of impact on construction equipment exhaust emissions

Table 8.4. Net Carbon Foot Print as GHG Emissions during Construction Phase (for a period of 3 Years)

GHGs	Emission in g/Km	Emission in g/Km for total Project	Emission in Tonnes/Km	Emission in Tonnes/Km for total Project
CO	75,54,525.00	4,51,46,74,794.30	7.55	4,514.67
HC	4,72,901.40	28,26,11,551.46	0.47	282.61
NOx	1,14,86,736.00	6,86,46,11,274.43	11.49	6,864.61
CO_2	95,58,53,230.80	5,71,22,93,60,964.85	955.85	5,71,229.36
PM	15,32,002.80	91,55,43,257.31	1.53	915.54

Source: Estimate prepared for the CRVA Report based on" Carbon Emission factors from CPCB/MoEF, 2008 (for HCV Construction Vehicles) and BSRP Feasibility Report (for Personal Vehicles)"

Construction Phase Mitigation Measures

Mainly Construction Phase Mitigation Measures are required to save CO2 emission. Adverse impacts of GHG emissions arising from the construction of the proposed Rail Project (BSRP) have been addressed according to the hierarchy of avoidance, mitigation and efficiency in management of adverse impacts, implemented where possible through the planning and design process and the development of on-going standard practices.

Reduction and Avoidance

Implementation of vehicle operating guidelines to encourage correct and efficient operation of vehicles

- The implementation of a traffic management plan, that:
- Reduces the number of vehicles and/or trips required for transport
- Uses buses for transportation of large numbers of personnel to minimise number of vehicles operating
- Implementation of a wider fuel management strategy which encourages use of more efficient plants and vehicles, planning, logistics, driver education and maintenance
- Efficient management of procurement and product supply
- Reduction on the amount of waste disposed to landfill and reuse of waste on site as much as possible, which will subsequently reduce the amount of vehicle movements and therefore fuel usage
- Use of teleconferencing and video conferencing to reduce travel to and from offices and associated gaseous emissions from fuel combustion
- GHG emissions and energy consumption will be measured in accordance with current legislative requirements
- Fuel consumption, energy use and GHG emissions will form part of reporting requirements to K-RIDE
- GHG emissions and energy consumption will be reported to relevant authorities in accordance with current legislative requirements
- A more comprehensive GHG emissions inventory will be addressed by the Contractor with approval by Environmental Specialist of General Consultant prior to construction that provides greater detail on construction emissions.
- The next step will be to set achievable and realistic reduction targets and identify and investigate potential reduction opportunities to realise these targets. A site specific marginal abatement cost curve for identified reduction opportunities will be developed to assist K-RIDE to prioritise these opportunities and be useful in determining what particular opportunities can be employed to reach a specific carbon reduction goal. Activities such as vegetation clearing will be restricted to the required footprint only through the implementation of the EMP which will identify clearing limits. The concept design also re-uses excavated spoil material onsite as fill for the Suburban Rail line embankment, thereby reducing transport distances and heavy vehicle trips to an offsite disposal area. While fuel usage is a necessary

requirement for construction of the BSR Project, so far as to reduce GHG emissions the following measures will be implemented as far as practicable:

- Adopting vehicle pooling for transport of construction personnel to minimise the number of vehicles operating
- Procurement of generators which use biodiesel or natural gas, where possible

The preventive measures detailed in the EMAP (EMAP Table 10.2, Section 10.9 of Chapter 10 – Environmental Management Plan of EIA Report), will be followed by the Contractor during Construction to avoid reduce the GHG emissions to the environment to the maximum possible and thereby, avoiding or reducing any significant impact on climate change.

Mitigation

On 10.08.2015, Government allowed direct sale of Biodiesel (B100) for blending with diesel to Bulk Consumers such as Railways, State Road Transport Corporations. On 29.06.2017 Government allowed sale of biodiesel to all consumers for blending with diesel. India's Ministry of Petroleum and Natural Gas published its "National Policy on Biofuels" in 2018, and further amended it in June 2022. The policy's objective is to reduce the import of petroleum products by fostering domestic biofuel production (MoPNG, GoI Guidelines, 2018).

Biodiesel blends (diesel that has a percentage of the fuel replaced with biodiesel) may reduce greenhouse gas emissions due to fuel consumption. However, this is dependent on a number of factors including the origin of the biodiesel feedstock. When sourced from appropriate feed-stocks, the reduction in emissions is approximately equivalent to the percentage of biodiesel in the blend (for example diesel with 20 per cent biodiesel will reduce greenhouse gas emissions by approximately 20 per cent). Opportunities for the use of biodiesel will be further examined and used where possible on the BSRP.

The application of technical efficiencies in construction plant and equipment will also provide more efficiency. These options will be further investigated, including any new technologies available, expected benefits, potential risks and costs.

Through the EMAP (EMAP Table 10.2, Section 10.9 of Chapter 10 – Environmental Management Plan of EIA Report), appropriate management will be integrated into all construction activities and processes and GHG emissions will be monitored. Through assessment and review, the BSRP will seek continuous improvement in compliance and emissions reduction.

Energy Efficiency and Management

Given that energy is the largest source of GHG emissions, appropriate mitigation measures will be implemented to reduce energy use as far as practicable through the following:

- Identification of the significant energy consuming equipment and recognising opportunities where technical efficiencies in plant and equipment can be applied. To improve fuel efficiency, an understanding of energy uses and corresponding fuel consumption would help K-RIDE to identify further opportunities where reduction in sources is most feasible and effective
- Site offices and accommodation buildings will be designed and constructed so as to include energy and water efficient equipment

- Implementation of a Construction EMP which establishes the baseline water, materials and energy use objectives and targets with the aim of introducing resources and emissions reductions targets through the construction phase
- The EMP will set out appropriate management and encourage integration of key activities and processes so as to effectively monitor GHG emissions

Implementation of mitigation measures such as resource efficiency, adoption of less carbon-intensive or renewable energy sources to reduce fugitive emissions will be followed as per the EMP to save CO2 emission (EMAP Table 10.2, Section 10.9 of Chapter 10 – Environmental Management Plan of EIA Report).

8.3.5.3. Assessment of Carbon Footprint with Mitigation

Trees play a significant role in reduction of CO2 by sequestering it from the atmosphere during photosynthesis to produce carbohydrates that are used in plant structure/function and return O2 back into the atmosphere as a by-product. Roughly half of the greenhouse effect is caused by CO2. Therefore, trees act as carbon sinks, alleviating the greenhouse effect. As per the project study, the process for CO2 conversion will get affected as a result of removal of trees for the project. The total loss due to tree removal is evaluated as given in the **Table 8.5**.

Table 8.5. Assessment of Carbon Footprint due to Tree Loss

Si. No.	Description	Quantity
1.	Total no. of Trees to be cut	32572
2.	Increase in CO_2 in the atmosphere (or Decrease in CO_2 absorption by tree) @ 21.8 Kg/year/tree	710069 Kg/Year (710 Tons/Year)
3.	Decrease in Oxygen production @ 49 Kg/year/ tree	1596028 Kg/Year (1596 Tons/Year)

Source: EIA Survey & Study

Mitigation Measures:

The climate change mitigation activities to avoid or reduce any impact on Climate particularly during Construction Stage include the following :

- to avoid or reduce air pollutants causing raise in Temperature and
- to avoid or reduce activities leading to Flooding during rains.

The biosphere does have an impact on global CO2 levels by tree removal or planting trees. Tree planting helps to tackle climate change. The combination of CO2 removal from the atmosphere, carbon storage in wood and the cooling effect makes trees extremely efficient tools in fighting the greenhouse effect. Planting trees remains one of the most cost-effective means of drawing excess CO2 from the atmosphere. The tree removal for the project needs to be compensated with afforestation by tree planting in the ratio 1:10 by the Forest Department in consultation with K RIDE and in accordance with CAMPA. Carbon Credits are discussed in Chapter 9 – Project Benefits.

Trees also remove other gaseous pollutants through the stomata in the leaf surface by absorbing them with normal air components. It is also observed from the study (Coder and Kim, 1996) that Tree cover removed 48 lb or 21.77 Kg (22 Kg) of particulates, 9 lb or 4.08 Kg of nitrogen dioxide, 6 lb or 2.72 Kg of sulfur dioxide, 0.5 lb or 0.226796 Kg or 227 g of carbon monoxide and 100 lb or 45.36 Kg of carbon – daily.

Assessment of Carbon Foot Print (GHG Emissions) during Operation Phase and Mitigation Measures

According to a 2007 estimate, electricity generation in India contributes 37.8% of CO2 eq. emissions – CO2, SO2, NO2 (MOEF, 2010) and is mainly by coal-based thermal power plants. Since the coal in India has a higher fly ash content (30–40%), electricity generation leads to the formation of particulate matter (PM10 /PM2.5) – a source of air pollution in the form of fly ash (Senapati, 2011). Therefore, the BSRP has no direct emissions from its operation as the source of energy is electricity from power plants. However, it contributes to carbon emissions at power plants during the generation of electricity used for its operation. BSRP operations will save time and distance for commuters and avoid or reduce the need for other forms of travel (for eg. diesel buses, cars, motorbikes), thus avoiding CO2 emissions. CO2 predicted for the proposed project is given in **Table 8.6**.

Table 8.6. Predicted CO2 Emission due to Project (in Crore Tons)

CO_2 Emission Source	2025	2031	2041	2051
Plying Vehicular Emission during Construction of BSRP implementation	0.02	0.02	0.03	0.04
Emission due to Power generation during operation stage (from power source source)	0.02	0.02	0.02	0.02
Emission due to Construction Equipment, Machinery & Vehicles during Construction stage	0.06	0.00	0.00	0.00
Total CO_2 Emission with BSRP Implementation	0.10	0.04	0.05	0.06

The climate risk mitigation measures are provided in the Environmental Management Action Plan (EMAP) and Environmental Pollution Monitoring, Section 10.9 of Chapter 10 – Environmental Management Plan of EIA Report. The Cost of EMP includes the Climate Mitigation cost also. Through the EMAP appropriate management will be integrated into all construction activities and processes and GHG emissions will be monitored and measures such as resource efficiency, adoption of less carbon-intensive or renewable energy sources to reduce fugitive emissions will be followed as per the EMP to save CO2 emission. Through assessment and review, the BSRP will seek continuous improvement in compliance and emissions reduction.

8.3.5.4. Operation Phase Risks and Adaptation Measures

The project involves the running of electrical energy based suburban rail cars during operation. GHG emissions during project operation, while running of the BSRs are negligible. However, CO2 Emission will be mainly during the production of electricity at base source i.e. at Power Plants. Annual CO2 emission at base source during electricity generation for running of BSRs is presented in the **Table 8.7**.

Table 8.7. Assessment of Annual Carbon Foot Print (GHG Emissions) due to power consumption at Base Source during Operation Phase

Prediction Years	Energy Consumption (in Crore KWh)	GHG Emission					
		CO_2		SO_2		NO_2	
		kg	Tonnes	g	Tonnes	g	Tonnes
2025	25.5	242250000	242250	1836000000	1836.00	1116900000	1116.900
2026	26.08	247760000	247760	1877760000	1877.76	1142304000	1142.304

Prediction Years	Energy Consumption (in Crore KWh)	GHG Emission					
		CO_2		SO_2		NO_2	
		kg	Tonnes	g	Tonnes	g	Tonnes
2027	26.65	253175000	253175	1918800000	1918.80	1167270000	1167.270
2028	27.23	258685000	258685	1960560000	1960.56	1192674000	1192.674
2029	27.81	264195000	264195	2002320000	2002.32	1218078000	1218.078
2030	28.39	269705000	269705	2044080000	2044.08	1243482000	1243.482
2031	28.97	275215000	275215	2085840000	2085.84	1268886000	1268.886
2032	29.35	278825000	278825	2113200000	2113.20	1285530000	1285.530
2033	29.75	282625000	282625	2142000000	2142.00	1303050000	1303.050
2034	30.14	286330000	286330	2170080000	2170.08	1320132000	1320.132
2035	30.54	290130000	290130	2198880000	2198.88	1337652000	1337.652
2036	30.92	293740000	293740	2226240000	2226.24	1354296000	1354.296
2037	31.3	297350000	297350	2253600000	2253.60	1370940000	1370.940
2038	31.68	300960000	300960	2280960000	2280.96	1387584000	1387.584
2039	32.06	304570000	304570	2308320000	2308.32	1404228000	1404.228
2040	32.46	308370000	308370	2337120000	2337.12	1421748000	1421.748
2041	32.84	311980000	311980	2364480000	2364.48	1438392000	1438.392
2042	33.24	315780000	315780	2393280000	2393.28	1455912000	1455.912
2043	33.63	319485000	319485	2421360000	2421.36	1472994000	1472.994
2044	34.03	323285000	323285	2450160000	2450.16	1490514000	1490.514
2045	34.41	326895000	326895	2477520000	2477.52	1507158000	1507.158
2046	34.79	330505000	330505	2504880000	2504.88	1523802000	1523.802
2047	35.18	334210000	334210	2532960000	2532.96	1540884000	1540.884
2048	35.57	337915000	337915	2561040000	2561.04	1557966000	1557.966
2049	35.96	341620000	341620	2589120000	2589.12	1575048000	1575.048
2050	36.35	345325000	345325	2617200000	2617.20	1592130000	1592.130

Note : CO2 =0.95 kg/kWh, SO2 = 7.2 g/kWh; NO2 = 4.38 g/kWh: Traction Energy Consumption is 66%
Source : Estimated for the Climate Change Study of BSRP, 2022-23

Adaptation Measures

As mentioned earlier under Construction Phase mitigation measures Energy efficient system will be adopted at stations and depots. Energy efficient lighting and ventilation will be implemented at Stations, depots and trans-modal cars. Additionally, Solid Waste Management and Waste water recycling systems will be adopted at stations and depots (Section 8.11.7 – Risks and Impacts due to Depots and Stations for Solid Waste and Waste water Management during Operation Phase).

In future, there is possibility of BSRP to switch on to total harnessing of natural sources of energy, such as solar power for lighting and ventilation, which will further contribute to savings in CO2 emission during maintenance facilities at stations and Depots. Additionally, the application of technical efficiencies in construction plant and equipment will also provide opportunities for greater efficiency; expected benefits, reduction in potential risks and costs.

Table 8.8 presents total savings in reduction in CO2 Emission due to reduced plying Vehicles as positive impact because of BSRP implementation along with annual projected estimate. **Table 8.9** presents net savings in CO2 emission during operation of BSRP after 5 Years (includes plying vehicular CO2 emission and CO2 emission during operation of Suburban Rails). Net saving is approximately 710.45 Cr Tonnes of CO2 emission due to BSRP.

Table 8.8. Net Savings in plying Vehicular CO2 Emission (in Tonnes/Year) due to Project Implementation

CO_2 Reduction due to BSRP	2025	2031	2041	2051
Reduction in CO_2 Emission with BSRP	1,50,598.58	2,05,183.65	2,69,340.17	3,53,557.05
CO_2 Emission without BSRP	21,16,764.97	25,06,695.54	29,94,108.38	35,76,296.27
Overall Reduction in CO_2 Emission	19,66,166.38	23,01,511.89	27,24,768.21	32,22,739.22
Reduction in CO_2 Emission in %	92.89	91.81	91.00	90.11

Source : Feasibility Report, 2019 and EIA Report of DPR for BSRP, 2022

Table 8.9. Savings in CO2 Emission during Operation of BSRP after 5 Years

Savings in CO_2 Emission during BSRP Implementation	2031	2041	2051
Savings of CO_2 Emission	7,10,49,63,677.88	7,10,53,86,934.26	7,10,58,84,905.30
Total CO_2 Emission with BSRP Implementation (in Tons)	4,47,433.60	5,11,590.18	5,95,807.00
Net Savings in CO_2 Emission (in Tons)	7,10,45,16,244.28	7,10,48,75,344.08	7,10,52,89,098.30
Net Savings in CO_2 Emission (in Million Tons)	7,104.52	7,104.88	7,105.90
Net Savings in CO_2 Emission (in Crore Tons)	710.45	710.49	710.53

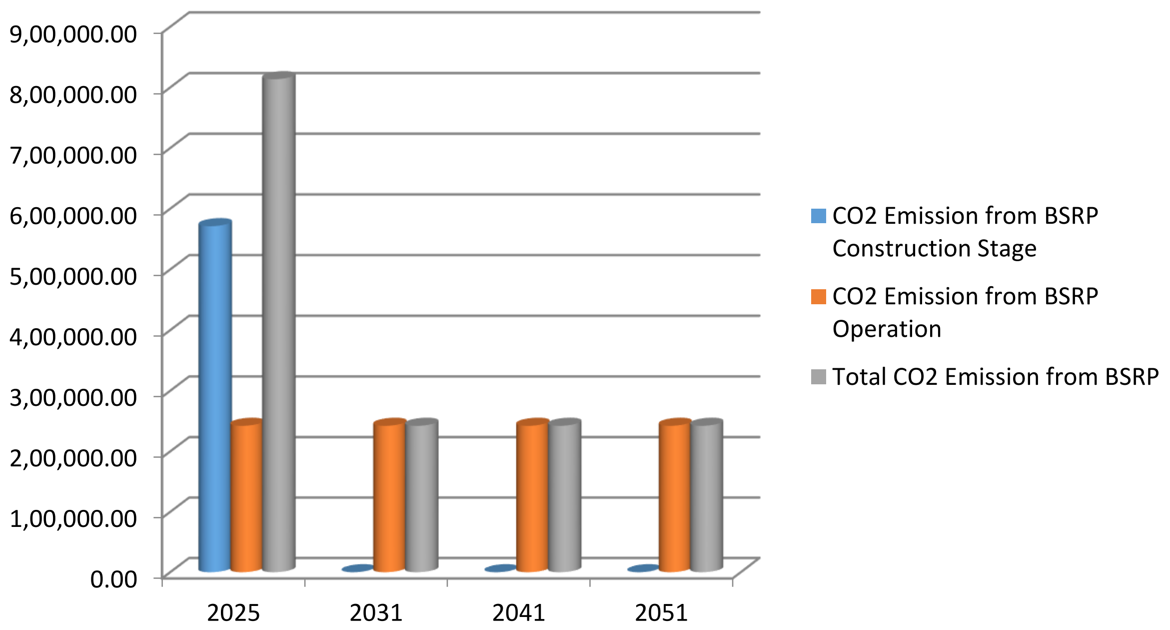


Figure 8.5. CO2 Emission during BSRP Execution

Figure 8.5 depicts the CO2 emission during the Construction and Operation Stages of BSRP. Emissions from power generation necessary for Suburban Rail operation have been deducted from the CO2 emission savings. Electricity consumption of the train operation depends on the Specific Electricity Consumption of the train (0.045 kilowatt hour per gross ton kilometer), the total line length, the number of trips per day, the composition of the train, the number of persons transported, and the amount of electricity regenerated by the train itself (30% regeneration as per DPR). Electricity consumption of stations and depots is calculated with a 50% increase over the lifetime of the project, corrected for the expected amount for electricity generated by solar power at stations and depots.

Gross CO2 emissions from the operations of WB-EIB funded proposed rail transport project were estimated as 4,47,433.6 tons, or an decadal average of 5,18,276.93 Tons. CO2 emission and Savings in CO2 Emission for decadal predictions is presented in Tables 8.10 and 8.11 and depicted in **Figure 8.6** and **Figure 8.9**.

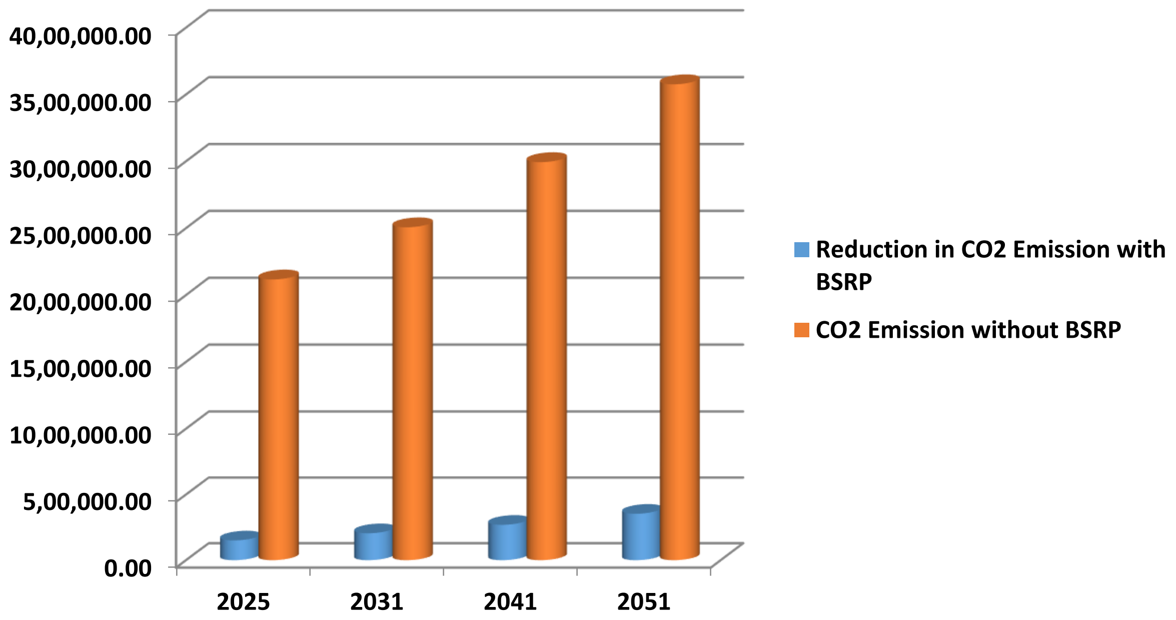


Figure 8.6. CO2 Emission with and without BSRP Implementation

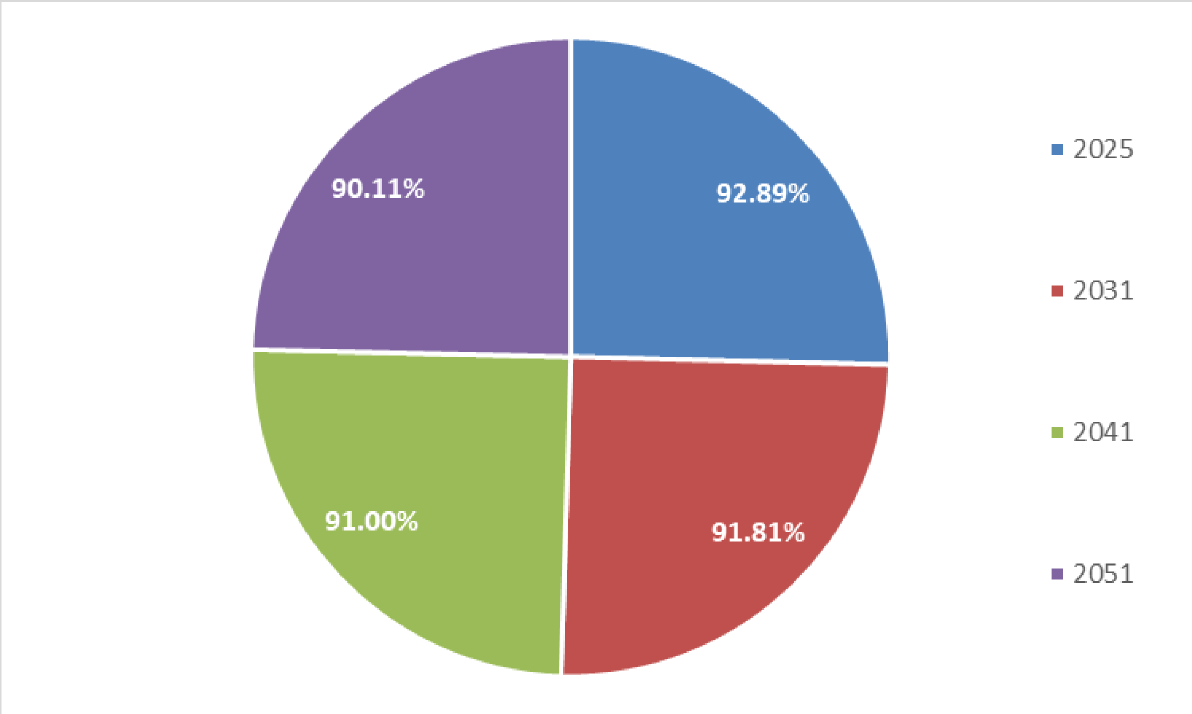


Figure 8.7. Savings of CO2 Emission during BSRP Implementation

8.3.5.5. Climate Change Risks and Vulnerability Assessment (CRVA)

The methodology for CRVA study is based on the Desk Study & Reviews and on-line Consultations with stakeholders, Engineers and Experts.World Bank (WB ESS 3 – 'A' Management of air Pollution under Resource Efficiency and Pollution Prevention and Management) and EIB Guidelines (EIB ESS 5 – Climate Change) have been followed during this study for Climate Change Risks Vulnerability Assessment (CRVA). The summarised Assessment is presented in this Section. A detailed CRVA Report is enclosed as **Annexure 10.41**.

8.3.5.6. Climate Change in the Project Area (Bengaluru)

Over the past decade, the climate of Bengaluru is observed to have changed as a result of rapid urbanization and heat island effect, increasing pollution, and obliteration of vegetation and water bodies. The maximum temperature in Bengaluru Urban has risen to as high as 38°C to 39°C during April–May while in earlier decades it hardly exceeded 35°C. The summer season extends from March to May and the winter extends from January to February.

Average Annual rainfall in Karnataka is 1,151 mm. About 80% of rainfall is received during the southwest monsoon, 12% in the post-monsoon period, 7% during summer, and 1% in winter. The mean annual rainfall is around 875 millimeters (mm) spread over about 50 days in a year. Over half of the rainfall comes during the late monsoon months of August to October. Cyclonic rains occur during November and December while there is virtually no rainfall during January–March. Bengaluru receives both southwest as well as northeast monsoons.

8.3.5.7. Baseline Natural Hazards

In the name of development and demand for land, low- lying flood plains as well as the city's numerous lakes are transformed for urban infrastructure with previous lessons unaccounted. The conversion of natural land to impervious surfaces has resulted in faster rainfall–runoff processes and reduced recharge. The city was affected by recent flood in 2022 due to intense rainfall. Flood waters entered into buildings, leaving people stranded in knee-deep water. The recent flood affected the city with inundation of water, particularly low lying areas and roads without proper draining facilities. The overflowing drains inundated roads and low-lying areas of the city, took 6 days to recede due to inadequate storm water drain infrastructure. The municipality has taken required action to improve the storm water drain infrastructure. Currently, necessary measures have been adapted by the Municipality i.e. Bruhat Bengaluru Mahanagara Palike, to climate change aspects such as urban floods.

Climate change raises very concrete challenges for the project. With majority of the lines being elevated, structures are exposed to excessive heat, causing damage and disruption of rail operations. Increased temperature, heavy precipitation and risks of fluvial flooding are the common Climate change concerns along with cyclonic winds and showers. It is to be remarkably noted that cyclone wind risks cannot be totally mitigated, and damages are not limited to wind but also include cyclone-induced heavy rainfall and subsequent flooding.


Source: rainmanspeaks.blogspot.com. (2012)

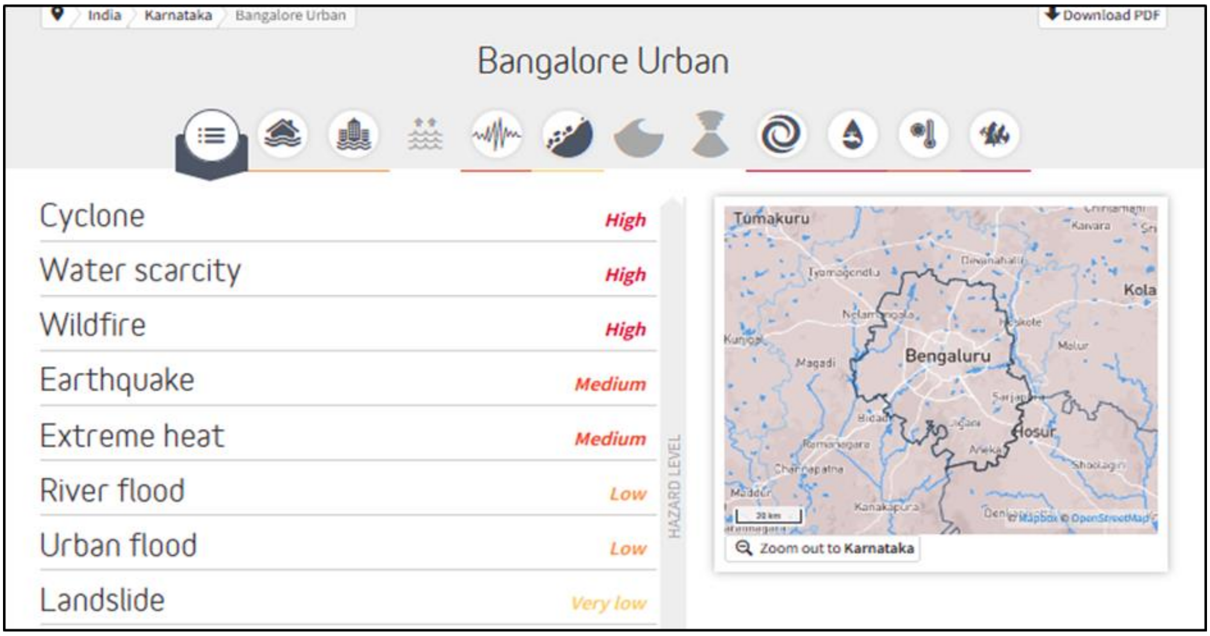

Source: driverspark.com. (2016)


Source : downtoearth.org.in (2022)


Source : REUTERS (2022)

Figure 8.8. Exhibits of Flood impacts on Bengaluru's Transport System

By using the web based tool and applying it specifically to Bengaluru, the likelihood of natural hazards such as cyclones, water scarcity, earthquake, extreme heat, river flood, and urban flood is identified with risk levels categorized as very low, low, medium, and high. The screenshot shown in **Figure 8.9** is reproduced from the ThinkHazard webpage for Bengaluru Urban.



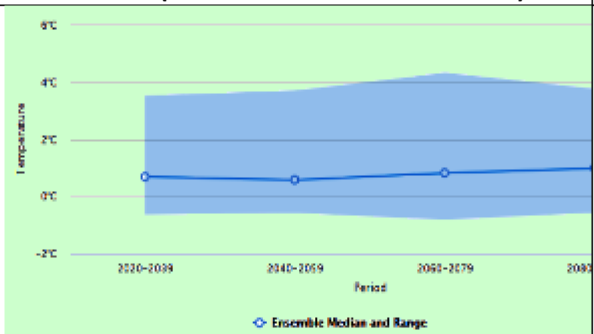
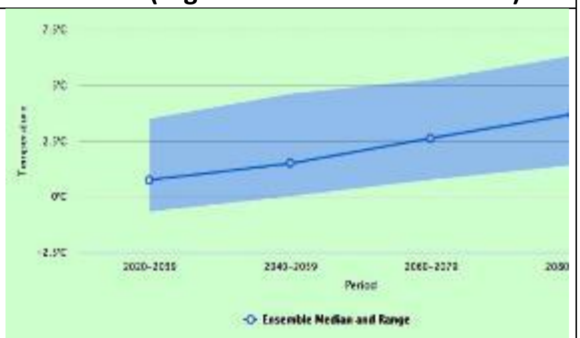
Source: ThinkHazard

Figure 8.9. Likelihood of Natural Hazards in Bengaluru

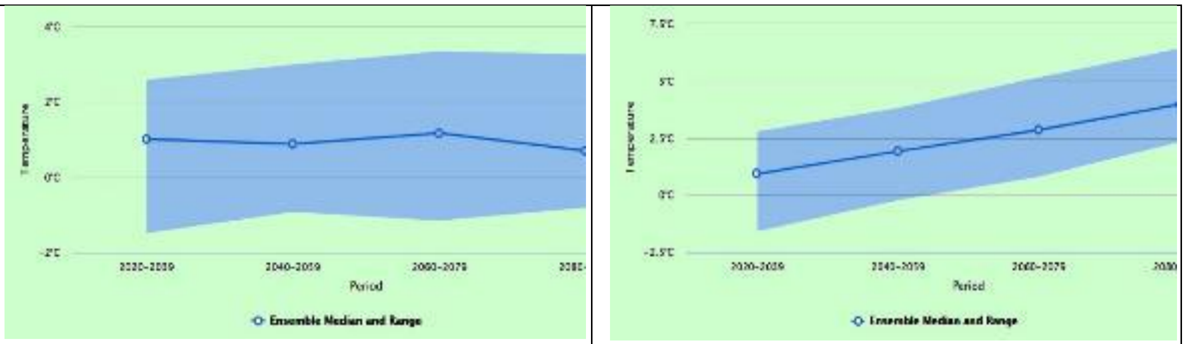
8.3.5.8. Future Climate Projections

Temperature

A set of worldwide climate models are cradled in the World Bank's Climate Change Knowledge Portal (CCKP) (World Bank Group) to help decision makers understand the projections of future climate change and related impacts. The significant variables in the design of various civil elements of land transport infrastructure include mainly temperature extremes with their diurnal ranges rather than average temperatures. The projected changes (anomalies) in daily maximum temperature (Tmax) and daily minimum temperature (Tmin) over the period of interest and relative to the reference period (1986–2005) for Bengaluru located at around 77.59°E, 12.97°N, are illustrated in **Figure 8.10**. The contrast in temperature anomalies estimated under lower and upper representative concentration pathways (IPCC, 2014) RCP2.6 and RCP8.5, respectively, are presented in the charts below.

	RCP 2.6 (Low GHG Emissions Scenario)	**RCP 8.5 (High GHG Emissions Scenario)**
Daily Maximum Temperature,	 **(A) Projected Change in Maxima of Daily Maximum Temperature, ΔTmax**	 **(B) Projected Change in Maxima of Daily Maximum Temperature, ΔTmax**

Daily Minimum Temperature,



(C) Projected Change in Minima of Daily Minimum Temperature, ΔTmin

(D) Projected Change in Minima of Daily Minimum Temperature, ΔTmin

Location: 77.59°E, 12.97°N

GHG = greenhouse gas, RCP = representative concentration pathway, Tmax = daily maximum temperature, Tmin = daily minimum temperature.
Source: World Bank's Climate Change Knowledge Portal.

Figure 8.10. Projected Changes in Temperature for Various Timeframes

The **Table 8.10** presents the midterm (2021–2050) projections of temperature and precipitation for the districts of Bengaluru Urban and Bengaluru Rural.

Table 8.10. Projected Increase in Mean, Maximum, and Minimum Temperatures, 2021– 2050

Districts	Projected Increase in Mean Temperature		
	Tav,°C	Tmax,°C	Tmin, °C
Bengaluru Urban	1.96	2.06	1.88
Bengaluru Rural	1.97	2.06	1.91

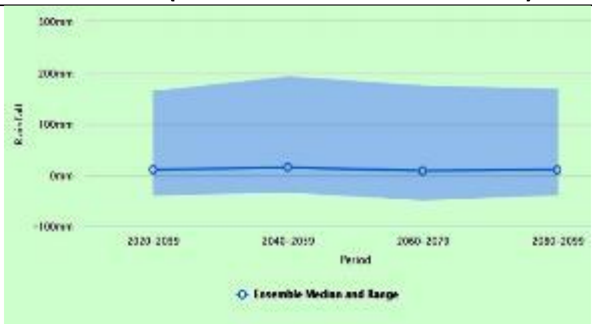
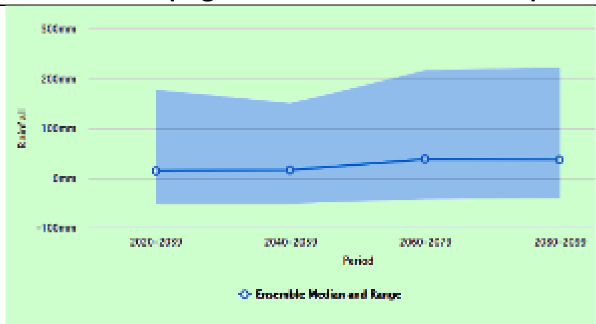
Tmax = mean maximum temperature, Tmin = mean minimum temperature, Tav = mean temperature.
Source: Karnataka Climate Change Action Plan.

Heat Waves

It is predicted that extreme heat waves will become more and more common worldwide because of raise in average global temperature. The mean maximum temperature in Bengaluru is projected to increase by around 2.06°C in the 2030s, which means the extreme upper temperature is also progressively pushed up.

Rainfall

Usually changes in extreme precipitation are analyzed based on the evolution of the percentiles of the daily precipitation. However, in engineering design application, the magnitude of daily maximum rainfall or return level and the associated frequency of extreme rainfall event or return period, are imperative. The projected rainfall changes for 25-year return periods under lower RCP 2.6 and upper RCP 8.5 scenarios are illustrated in **Figure 8.11**. A 25-year return level of daily precipitation is the maximum daily rainfall that can be expected once in an average 25-year (i.e., 4% chance) period with the possibility that two or more events of that magnitude can occur in much shorter intervals.

RCP 2.6 (Low GHG Emissions Scenario)	RCP 8.5 (High GHG Emissions Scenario)
 (A) Projected Change in Annual Maximum DailyPrecipitation, (25 yr Return Level)	 (B) Projected Change in Annual Maximum Daily Precipitation, (25 yr Return Level)
Location: 77.59°E, 12.97°N	

GHG = greenhouse gas, RCP = representative concentration pathway.
Source: World Bank's Climate Change Knowledge Portal.

Figure 8.11 Projected Change in 25-year Return Level of Maximum Daily Precipitation (mm)

As per Karnataka Climate Change Action Plan, the climate change projections are given for mean change in annual and seasonal precipitation and are compared with the reference period (1961–1990) for Bengaluru Urban and Bengaluru Rural. The same is illustrated in **Table 8.11**. In general, the value of seasonal precipitation change varies between -15% and +36%.

Table 8.11. Projected Change in Annual and Seasonal Rainfalls, 2021–2050 (SRES A1B Emissions Scenario)

No.	Districts	Projected Change for				
		JFMonths (%)	MAM Months (%)	JJAS Months (%)	OND Months (%)	Annual Mean (%)
1	Bengaluru Urban	-15.11	29.92	-2.89	10.14	3.66
2	Bengaluru Rural	3.05	36.30	-2.31	9.61	3.56

JF = January/February, JJAS = June/July/August/September, MAM = March/April/May, OND = October/November/ December.
Source: Karnataka Climate Change Action Plan

8.3.5.9. Climate Change Risks and Adaptation Measures

The potential impacts of climate change on BSR infrastructures/assets are compiled and briefly outlined here. These impacts call for careful consideration of rail design, construction, and maintenance to achieve lasting benefits.

Weather-related hazards are already among the factors most frequently causing disturbances for railways. Temperature, rainfall along with Flooding, storm and humidity are the major climate parameters that could impact the suburban railway infrastructure in Bengaluru, whereas snow, permafrost, storms and sea-level rise factors are not applicable to BSRP as the city is far away from Sea and snow falling regions. Climate risks are summarized as given below :

- Primary climate change risks that can impact the project in the short to medium term are temperature increase and variability of rainfall, particularly the increases during the monsoon seasons.

- Observed trends in the state show a slight increase in annual maximum and mean temperatures, which are also reflected in future projections (SRES A1B and RCPs 2.6 and 8.5) of annual and monthly average temperature, and minimum and maximum temperatures.
- Long-term climate change risks that could impact projects are flooding from extreme rainfall events, particularly during monsoon periods, and increases in annual average temperature in the project area that could increase the risk of extreme hot days. Heat waves and flooding appear as priority threats, particularly urban flooding as a result of increase in impermeable surfaces due to rapid urbanization.
- Storms and more frequent strong cyclones can bring about increased flooding, greater probability of infrastructure failures, erosion of rail track foundation and bridge supports, bridge scour, reduced clearance under bridges, wind damage to roofs of stations, lighting, overhead cables, rail signals, and other tall structures. Power outages during such events will also hamper operations.
- The increase in frequency and magnitude of extreme heat conditions in turn increases the risk of failures due to track expansion. Pervasive changes induced by extreme heat may also lead to deformations and failure of reinforced cement concrete structures. Abrupt temperature changes can cause cracking and spalling of concrete due to thermal shock, and aggregate expansion can also produce distress within the concrete.

Overall Climate Change Risk Assessment is presented in a Matrix, as given below in **Table 8.12**.

Table 8.12. Impact Matrix of Climate Change on Vulnerable Assets of BSRP

Vulnerable Infrastructure/Assests		Climate Variation/Change			
	Temperature	Rainfall	Flood	Wind	Storm/ Cyclone impact
Bridges	√	√	-	√	√
Drainage Systems	-	√	√	-	√
Railway Tracks	√	√	√	-	√
Culverts	-	√	√	-	√
Slip Slopes	-	√	√	-	√
Signalling, telecommunication and solar panels	√	-	-	√	√

Based on the Overall Climate Change Risk Assessment Results the Climate Risks of BSRP are categorised as Medium Risks.

The consequences of these failures can lead to risks such as inconvenience, economic losses due to disruptions, and an increase in carbon emissions due to additional transportation effects to reach the destination; also including serious consequences such as train derailments, damage to the railway infrastructure, and danger to human life.

Other Risks due to Climate Change

Other risks due to climate change include Risks on Biodiversity, Food Safety and Nutrition, Health and Transition climate risks are addressed in the CRVA Report (**Annexure 10.41**).

Consequences of Climate Risks on Project Infrastructure

The impact of these climate change parameters on vulnerable railway assets leading to several consequences are as follows : track movement, track buckling, track washout, erosion of track bed, over-flooding, falling of trees, higher winds, visibility, drainage system clogging, landslips, disruption of bridge foundations, settlement of edifices, arcing of conductive components, wayside fires, vegetation, etc.

These above events have extreme consequences for the dependability of railway infrastructure and the acceptable level of services by the executing agency - K-RIDE and other stakeholders. Severity of risks may lead to the following :

- Stoppage and / or cancellation of Rail services
- Inefficient acceleration and braking, slower speeds and delays
- Accidents
- Material damage to Rail fleet, equipment and infrastructures

Risk assessment Matrix

Figure 8.12 shows that Risk assessment Matrix with different colours based on likelihood and severity. High risks are highlighted in red, moderate risks in yellow (amber) and low risks in green. Adaptation measures will reduce the high risks to moderate and low risks. Color-coding for a 5×5 risk assessment matrix is to represent the combination level of probability and impact of the identified risks.

		Severity				
		Negligible	Minor	Moderate	Major	Catastrophic
Likelihood	Almost certain	5	10	15	20	25
	Likely	4	8	12	16	20
	Possible	3	6	9	12	15
	Unlikely	2	4	6	8	10
	Rare	1	2	3	4	5

Figure 8.12. Risk Assessment Matrix (5 X 5)

The performance of adaptation measures depends on their robustness against various possible futures, with varying climate change impacts. Residual impact is associated for each adaptation measures due to the heavy rains, temperature & Wind speed etc. **Figure 8.13** shows that Residual Risk assessment Matrix with different colours based on likelihood and severity.

	Severity			
Likelihood	Residual impacts	Minor	Moderate	Major
	Likely	3	6	9
	Possible	2	4	6
	Unlikely	1	2	3

Figure 8.13. Residual Risk Assessment Matrix (3 X 3)

8.3.5.10. Climate Risk Adaptation Measures of BSRP

The Bengaluru Suburban Rail Project (BSRP) comprises many different interacting infrastructures including earthworks and civil structures, rapid rail track structure, signalling, and many interconnected installations. After understanding the climate change vulnerability of location of BSRP as discussed in previous sections, it is known that BSRP assets are sensitive and vulnerable to critical climate risks. The project specific potential risks by identified significant long term impacts and its management through proper care, concern and pro-actions or potential Adaptation measures are comprehensively assessed and presented in **Table 8.13**.

Table 8.13. Climate Risk Assessment and Adaptation Plan for Construction and Operation Phase including Maintenance of BSRP

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
1	**Precipitation / Rain fall**												
A	Low / Medium Rainfall	Medium to Moderate	-	Increased risk of earthwork failures due to desiccation.	4	3	12	De-vegetation programme, Re-ballasting and tamping interventions	1 to 2	Section-8B: Technical Specifications. Chapter-2 Suitability of Subsoil & Ground Improvement Techniques	570 – 578	The cost of work is included in the respective construction activity.	Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE
										Section-8B: Technical Specifications. Clause 3.4 Cross Slope of Formation	580		
										Section-8B: Technical Specifications. Clause 4.3.1 Geotextile Clause 4.3.2 Geogrid	595 - 597		
B	High Rainfall	Major	Flooding (surface water, fluvial, groundwater); infiltration and Landslides	Increased risk of earthwork failure and groundwater content in low-lying areas; landslides in wet weather landslide. Infrastructure slope failure; bridge scour;	4	4	16	**Construction Phase :** **(i) Usage of Protection boxes** to shield equipment that can't be moved or require protection and ventilation. **(ii) Adopting Equipment protection systems** safeguard essential equipment and items that cannot be	3 to 4	Section-8A Employer's Requirement Clause 14 Turfing/ Planting Clause 15 Provision of Jute Geo Textile	 277 277	The cost of work is included in the respective construction activity.	Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
				flooding of track, depots, buildings; water damage to electronic equipment. Track buckling/washout line closure Reduced operating speeds				relocated from flood-prone areas. (iii) **Flood panels** serve as door barriers during hurricanes, offering excellent defense against flooding and water damage and for protection of construction materials. (iv) **Usage of Compression panels** for glass during emergency, to create a sealed flood protection barrier around openings, preventing water entry. (v) **Flood barriers** offer a strong, long-term solution to protect buildings. (vi) Conducting Awareness programs for working staff and local Community.					

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
								Flood Preventive and Control Measures shall be in compliance with IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020. **Operation Phase :** Planting of 'protection Trees' Slope stabilisation programmes including installation of retaining walls, soil nails and sheet piles Counterfort retaining drains in slopes and crest drain refurbishment.. Regular monitoring during rainy season. Review and update Asset Risk Assessment and Action Plan in line with implementation timetable with identification of standards to be updated to take account of climate change.					

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
								Conducting Awareness programs for working staff and local Community. Flood Preventive and Control Measures shall be in compliance with IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020.					
		Moderate	Inland erosion	Over flow from Culverts and Cross Drainages Disruptions from blockages affecting track stability	3	4	12	Applicable Measures for High Flood Control as provided above shall be followed during construction and operation phases. Periodic cleaning of drainages with the cooperation of BBMP and Local Authorities.	1 to 2	Section-8B: Technical Specifications. Chapter 8: Erosion Control of Slopes	641 - 649	The cost of work is included in the respective construction activity.	Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE
		Moderate		Increased risk of bridge scour arising from flood events.	4	3	12	Bridge scour protection programmes shall be followed.	3 to 4	Drainage Arrangement Drawing	-	The cost of work is included in the respective construction activity.	Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
		Minor	Flooding	Infrastructure slope failure; track misalignment; misalignment of poles supporting overhead lines Reduced operating speeds	2	5	10	Increase capacity of spillways and culverts. Embankment protection through tree plantings, Vegetation. Improvement of longitudinal ditches and drains Green planning. Increasing height of Station Entrances. Increase road embankment level to at least 0.5 m over the maximum flood level	1 to 2	Section-8B: Technical Specifications. Chapter 1: Soil Exploration & Survey	564	The cost of work is included in the respective construction activity.	Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE
										Section-8B: Technical Specifications. Clause 3.11 Height of Embankment and Formation Layer Thickness	592		
										Section-8B: Technical Specifications. Chapter 8: Erosion Control of Slopes	642		
		Moderate		Failure of other structure supports due to increased risk of scour Standing water fouling track ballast.	3	4	12	Applicable Measures for High Flood Control as provided above shall be followed during construction and operation phases. Expanding drainage capacity , Discharge	1 to 2	Section-8B: Technical Specifications. Clause 6.2.5 Drainage Arrangements in Embankments and Cuttings	628 - 631		

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
				Reduced operating speeds				Capacity for infrastructure including culvert size, design for new flood event thresholds, Increasing maintenance including clearing debris from culverts to reduce flooding Installation of emergency culvert etc., Installation of pumped drainage solutions.Double twisted hexagonal woven steel wire mesh		Section-8A Employer's Requirement Clause 44: RoB Drainage	277		
		Minor		Voluminous Mud flow causing structural damage to infrastructure. Reduced operating speeds	2	5	10	Installation of containment channels and dikes, Revetments using riprap, gabion mattresses and concrete facings Anchors, geo-grids and micro-piles	1 to 2	Section-8B: Technical Specifications. Chapter 8: Erosion Control of Slopes	642	The cost of work is included in the respective construction activity.	Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE
2	**Temperature**												
A	High Temperature	Medium	Heat waves; wildfire (very rare)	Track buckling line closure; thermal expansion in structures and/or	3	4	12	**Construction Measures :** Change Rail installation procedure to increase temperature threshold for thermal expansion.	1 to 2	Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020)			

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
				associated misalignment problems. • Track stability may be affected. Dis- position of high-risk track segments may lead to incidences of high temperatures. • Reduced operating Speeds.				During extreme winter and summer, ambient temperature should be monitored and necessary steps shall be taken to cold/hot weather concreting as applicable. Using measures such as preventive grinding and milling to minimize the effects of temperature variation. **Measures during Concreting in Hot Weather:** **DOs:** • Depute competent inspection personnel at site to anticipate the need for requirements during hot weather concreting and ensure them. When temperature conditions are critical, carry out concreting during evening or night. • If ambient temperature is likely to exceed 40 degree Celsius during period of concreting, start					

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
								concreting only if arrangements for hot weather concreting are in place. ● Plan the locations of construction joints ahead of time with hot weather contingencies in mind. ● Do not add water to pre-mixed concrete at the job site unless it is part of the amount required initially for the specified maximum water-cement ratio and the specified slump. ● Use all available means to maintain the materials at as low temperatures as practicable. ● Provide shades on stockpiles to protect them from direct rays of the sun. ● Sprinkle water on the coarse aggregate piles & apply moisture correction accordingly. ● Use cold water in concrete and keep it cold by protecting pipes, water storage tanks, etc.					

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
								● Mix ice directly into the concrete as part of the mixing water. ● Design the mix with minimum cement content consistent with other functional requirements. ● Use lower heat of hydration cements instead of that with greater fineness and high heat of hydration. ● Check concrete temperature frequently using a metal clad thermometer by embedding it in concrete. ● Keep the mixing time to the minimum as required to ensure adequate quality and uniformity. ● Paint the exposed mixer surface yellow or white, cover it with hessian cloth and spray cool water. ● Keep the period between mixing and delivery to an absolute minimum.					

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
								● Coordinate the delivery of concrete with the rate of placement to avoid delays in delivery. ● Sprinkle forms, reinforcement, and subgrade with cool water just prior to placement of concrete. ● Wet the area around the work to cool the Surrounding air and increase its humidity. ● Deploy ample personnel to place concrete immediately on delivery to minimise the delay losses. ● Place concrete in thin layers and small areas to reduce time interval between consecutive placements. ● Moist fresh the concrete by means of fog sprays, wet hessian cloth, cotton mats, or other means if cold joints or cracks tend to form, especially shortly after placement and before finishing.					

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
								• Protect the concrete from evaporation of moisture, preventing ingress of external water, by means of wet (not dripping) gunny bags, hessian cloth, etc., immediately after consolidation and surface finish. • Commence the moist curing once the concrete has attained some degree of hardening sufficient to withstand surface damage (approximately 12 hour after mixing). • Sprinkle water on formed surface while forms are still in place. Keep the vertical and steeply sloping formed surfaces moist by applying water to the top surfaces prior to and during form removal. • Keep the exposed surfaces moist by wet curing & Provide wind breaker wherever possible.					

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
								● Spray the covering material with water to keep them soaked. ● Heavily reinforced area should be given special attention. **DONTs:** ● Use such large chunks of ice that do not melt down completely before mixing is completed. ● Use concrete if its temperature is above 40 degree Celsius ● Rely on the protection afforded by forms for curing in hot weather. ● In initial stages of hardening, temp of curing water should be approximately equal to that of concrete. ● Remove wet covers until they are completely dry. ● Delay in finishing air entrained concrete in hot weather. ● Let the concrete surface dry during curing causing					

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
								alternate drying and wetting conditions. ● Prolong mixing. ●Finish slabs prematurely, e.g. While bleed water is still on the surface. **Operation Measures :** Change Rail installation procedure to increase temperature threshold for thermal expansion. Replacement of jointed track with continuously welded Rail. Painting Rails white in areas of known high risk to thermal expansion by direct sunlight. ● Regular monitoring during summer season at extreme temperatures. ● Review and update Asset Risk Assessment and Action Plan in line with implementation timetable					

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
								with identification of standards to be updated to take account of climate change To overcome the same, provision of thermal joint/ expansion joint is required to be provided. Eventually, sensors may be installed directly on the tracks to monitor rail stresses in real time and implement an early warning system.					
		Minor		Expansion of moveable assets such as swing bridges hindering operation. Reduced operating speeds	2	4	8	Sprinkler systems Replacement of bridges with heat resistant materials with lower thermal expansion coefficients	1 to 2	Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020)			
		Low		General increase in failure rate of assets in high temperatures.	3	2	6	Use of coolers, fans and air conditioning to improve tolerance of signaling equipment. Double-skinned	1 to 2	Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020)			

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
				Reduced operating speeds				equipment casing to assist cooling					
		Low		Sagging of the overhead line equipment. Reduced operating speeds	2	3	6	Removal of fixed termination overhead line equipment Improved balance weight and head span technologies. Provision of Counter weights	1 to 2	Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020)			
		Low		Increased fire risk. Reduced operating speeds	2	4	8	Vegetation management along tracks	1 to 2	Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020)			
B	Low Temperatures	Low	-	Rail fracture, weld failure, cracks and/or associated misalignment problems. Reduced operating speeds	1	2	2	Proper Supervisions and Inspections Only ornamental trees will be planted at embankments, slope etc.	1	Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020)			
3	**High Wind Speed – Wind Storms**	Moderate	Tree fall; wind-blown objects	Increased risk of leaf fall leading to low track adhesion Rolling stock instability	3	4	12	Leaf Removal and partly de - vegetation programmes. During Operation & Maintenance Stage,	3 to 4	Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020)			

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
			Severity of gusts at higher wind location					periodic cleaning will be carried out.					
		Moderate	Tree fall; wind-blown objects	Damaged trees and debris falling onto track Downed power lines; structural damage and/or track misalignment by fallen trees/wind-blown objects. Reduced operating speeds	3	4	12	De-vegetation programmes Establishment of tree-free zones in Rail corridor and control measures to avoid debris falling.	3 to 4	Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020)			
		Major	Tree fall; wind-blown objects	Excessive wind loading on structures such as masts and towers. Reduced operating speeds	3	5	15	Strengthening of existing equipment, build in resilience to design of new equipment. Improved overhead wire tensioning systems.	3 to 4	Measure considered under good engineering practice (Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020)			
		Moderate	Tree fall; wind-blown objects	Increased risk of damage to	2	5	10	Install damping devices	1 to 2	Measure considered under good engineering practice (Ref. : IRBM : 1998 and			

Sl. No.	Climate Change Phenomenon	Scale	Predicted hazards	Predicted Risks/Impacts on Vulnerable Asset or Activity	Likelihood	Severity	Risk Level	Potential Adaptation Measures/ Activities	Residual Risk Level	Section/ Clause in Tender Document (Annexure enclosed)	Page No.	Budget Considered in INR	Implementation Stage/ Implementing agency/ monitoring Agency
				bridges in high winds. Equipment destruction Reduced operating speeds						Handbook on Railway Construction, Second Edition, June 2020)			
4	**Lightning and electrical storms**	Minor	Risk to line workers Outages of power	Damage to buildings and structures from lightning strikes	2	4	8	Install lightning conductors / arresters. Fitment of surge protection.	1 to 2	Station tender: SECTION-8A-Part-2-Employers-Requirements Clause 12.1. (h)	396	The cost of work is included in the respective construction activity.	Implemented during the construction stage/ Implemented by the Contractor/ Monitored by GC to BSRP & K RIDE
*Management (or non-structural) adaptation measures: e.g., changing the timing of maintenance to account for changing patterns of energy demand and supply, investment in early warning systems or purchasing insurance to address financial consequences of climate variability. These measures can also include enhanced monitoring of existing assets to reduce the risk of failure as climate conditions change. Adaptive management approaches also include provisions to include flexibility from the outset to monitor and adjust to changing circumstances over the assets lifetime.													
Ref. : IRBM : 1998 and Handbook on Railway Construction, Second Edition, June 2020 and other relevant Indian Railway guidelines													

In addition to the above Adaptation Measures towards Climate Risks, the following are the essential measures to be considered to protect railway assets against specific weather hazard events :

- switch protection,
- pile construction for buildings with technical equipment,
- cooling of signals and installation of fans to keep electronic equipment functional during periods of extreme heat,
- increased (preventive) maintenance activities (infrastructure and existing protection systems),
- vegetation clearance and land use regulations along rail tracks,
- installation of (automatic) monitoring systems such as anemometer, water and rain gauge, rail temperature gauge, landslide detectors.
- Boost energy-efficiency programmes – such as efficient provision for natural lighting and Solar lighting (at least one-third of all lightings)
- Adopt efficient lighting such as usage of LED based lighting
- Adopting to updated communication technology for Management of Emergency situations or any other risky situations during operation
- Awareness and Orientation Training to government and local authorities and public

Other asset infrastructures, such as drainage systems, catenary systems, and vegetation management shall be maintained by K RIDE, to reduce their impact due to climate change. Further, K RIDE will follow the guidelines and Preventive measures as per Indian Railway Manual to handle Monsoon Preparedness, Flood events, regular checking of Retaining walls, Rail affecting Tanks, drain cleaning and slope stability in BSRP.

8.3.5.11. Climate Adaptation /Mitigation Plan and Budget

Climate Adaptation Plan for BSRP includes Adaptation measures as follows:

1) implementation of Head-hardened 1080 grade steel rails, 60 UIC (at Design Stage itself) to overcome high temperature risks,
2) Elevated Rails avoid the impact of Floods on Rail network assets,
3) Utilization of Concrete mix materials increased durability, high strength and resistance to overcome flood and erosion impacts.
4) Installation of Rainwater harvesting systems at all stations in the viaduct sections of Corridors to overcome high rainfall run-offs and flood
5) Construction of Central Water Board approved recharge pits along the median at each pier location to facilitate percolation of runoff into the ground
6) Installation of Standby diesel generator sets in case of emergencies, including flooding in BSRP stations
7) Provision of Support equipment and plant necessary for maintenance to carry out preventive, restorative, and adaptive maintenance

8) Construction of at-grade and elevated medium capacity rail lines in BSRP with implementation of Specific Environmental Management Action Plan (EMAP) to mitigate impact of pollutants on Climate.

As per estimate, the Cost of Rainwater harvesting/Construction of Recharge Pits is ₹ 312.9 Lakhs. Other costs are included under civil works cost. The main mitigation activity includes Construction of at-grade and elevated medium capacity rail lines in BSRP along with implementation of mitigation measures to reduce CO_2 emission during construction stage of the BSRP. Estimated cost is included in the EMP budget. Estimated Savings in GHG Emissions of the project is 7,104.52 tCO_2e/year and overall estimated mitigation cost is $ 19,450.52 million. Out of $ 19450.52 Million total cost of the project the KfW-EIB is financing 60% of the total civil works cost equivalent to $11,670.31 million. K-RIDE, a special purpose vehicle formed by the Union Ministry and Gov. of Karnataka is executing authority. Gov. of Karnataka and Union Ministry will bear 20% (i.e. $ 3,890.10 Million) each of the project cost.

8.3.6. Risks & Impacts on Utility/Drainage System

Risks and Impacts : The proposed Suburban Railway Corridors are planned to run through the urban area at grade (at ground level) in less densely populated and along the existing Railway corridors and above the ground (elevated) in populated and sensitive areas.

As per the Field Study of the proposed project, a large number of sub-surface, surface and Overhead Utility services viz. sewers, water mains, storm water drains, gas pipe lines, telephone/ communication cables, overhead power transmission lines, power cables, traffic signals, etc. exist all along the proposed alignment. Apart from these utilities, South Western Railway's huge network of Traction Power cables, Traction Power Installations, DC and AC traction substations, SPs and SSPs, Signal & Telecommunication cables, traction OHE masts and structures, Signal posts, power supply cubicles, location boxes etc. are spread along and across the entire alignment.

The proposed corridor has been planned to the maximum within Railway's ROW and the some of the utility services and Railways vital installations are encountered at number of locations.

These utility services are very essential and need to be maintained in working condition during different stages of construction, by either temporary or permanent diversions and relocation or by supporting in position. Any interruption to these will have serious repercussions on sensitive Suburban services and direct impact on the commuters, besides setback in construction and project implementation schedule. Meticulous planning, therefore, will be necessary in tackling the issue of.

Mitigation Measures : Since these impact on project implementation and completion time and cost, instigation of required meticulous pre-planning/ action shall be taken for the protection / diversion of these utility services and as well as Railway's vital installations, prior to the commencement of the project activities.

Drains running parallel/across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location. Sewer lines running parallel/across the alignment are not proposed for diversion. But due care will be taken to avoid any damage to above lines. The related Plans and cost of such shifting/diversions are covered in the section on Civil Engineering aspects of Design in DPR.

All community utilities and properties i.e. hand pumps, open wells, water supply lines, sewer lines, telephone cables, buildings and health centers shall be relocated before only when construction of corridor activities commence. This will be in line with ESS 10 of World Bank & EIB ESS 2.

Residual Impacts: Not applicable.

8.3.7. Potential Social Impacts

8.3.7.1. Risks and Impacts : The following are the risks and impacts on socio-economic environment at the project area.

(i) Loss of Land

The proposed Suburban Rail Project shall require land for different purposes. Land is mainly required for stations, running section and depot. Acquisition of land shall make affected families landless, houseless, and jobless in most of the cases.

The data collection in the affected slum could not be completed, due to the reason of non-disclosure of Compensation and Resettlement and Rehabilitation Entitlements related information, as it was not ready and approved by then. The people demanded to disclose the entitlement ma-trix prior to the census and socio-economic survey. However, the Socio-Economic Survey will be done before the timeline provided in RAP Implementation Schedule.

Table 8.14. Overall Social Impacts of the Project

S. No.	Impact	Corridor-1	Corridor-2	Corridor-3	Corridor-4	Total
1	Land Requirements					
A	Private Land (in Sqm)	9.06 (including Depot)	23.12 (including Depot)	8.39	16.31	56.88
2	**Total Structures/buildings Affected**					
A	Affected structures/ buildings – details received/ provided	51	274	66	66	457
B	Affected Common Property Resources	1	15	6	5	27
C	Affected structures/ buildings – details not received/ provided*	33	0	63	69	165
	Total	**85**	**289**	**135**	**140**	**649**
3	**Project Affected Households**					
A	Affected PAH – Titleholders Owners	94	267	106	150	617
B	Affected PAHs- non Title holders -squatters	34	44	43	26	147
C	Affected PAHs- non title holders -Slum dwellers	0	109	0	0	109
D	Affected PAH - Tenants (These are tenants living in	11	156	31	30	228

S. No.	Impact	Corridor-1	Corridor-2	Corridor-3	Corridor-4	Total
	the properties of titleholders)					
E	Affected Households, details not received/ provided	33	0	63	69	165
F	Affected Workers	0	2	0	0	2
	Total	**172**	**578**	**243**	**275**	**1268**
4	Number of displaced employees	9	11	27	17	64
5	Affected buildings of Titleholder	44	196	65	66	371
6	Affected Residencial Buildings	46	177	48	61	332
7	Affected Commercial Buildings	4	54	14	5	77
8	Affected Resi/Comm Buildings	1	43	4	0	48
9	Affected Vulnerable PAHs	47	116	46	8	217

*Details not available due to House closed, Owner not willing to provide to provide, Owner not available.

***Source**: iDeCK survey Feb – July 2022*

Mitigation Measures : Every effort has been made to keep land requirements to the barest minimum by realigning the alignments away from private property / human habitation. After planning, the land requirement is kept at minimum and particularly, acquisition of private land was avoided. The total land requirement for the project is 233.09 Ha in which 56.88 Ha are private land.

8.3.7.2. Number of Affected Structures

Out of the total 649 affected structures identified; 332 are residential, 77 are commercial, 48 residential cum commercial buildings and 27 are Common Property Resources (CPRs); while 165 have not responded. The table below indicates the impact of project on the different types of structures i.e. residential, commercial, residential cum commercial and other minor structures, such as portion of boundary wall, toilet, car shed, lean to roof etc. Out of these, 282 structures are fully affected and 202 are partially affected.

A total of 85 structures are affected in Corridor-1, 289 structures are affected in Corridor-2, 135 structures are affected in Corridor-3 and 140 structures are affected in Corridor 4. In all the corridors the majority of affected structures are the residential, i.e., 51.16%. The ownership status would be known only after the joint measurement is conducted by the land acquisition team of BSRP and Joint Measurement Certificate is issued.

Photographs of the major structures (Residential, and residential cum commercial) and CPRs are attached as Annexure C (Except for Corridor 2, as it is resurveyed and photographs are yet to be taken). The identification of structures for Corridor-2 is based on available design, which is under finalization, while for other corridors the alignments/ designs are yet to be finalized, and therefore results presented in the table should be considered preliminary for all corridors.

Table 8.15. Number of Affected Structures

Partially & fully affected structures	C1	C2	C3	C4	Total	Percentage
Residential	46	177	48	61	332	51.16%
Commercial	4	54	14	5	77	11.86%
Resi cum commercial	1	43	4	0	48	7.40%
CPRs	1	15	6	5	27	4.16%
Non – responded	33	0	63	69	165	25.42%
Total	85	289	135	140	649	100.00%

Note: Number of affected structures presented in this table is preliminary. The results of final census for all corridors will be available at a later stage (see Section 1.18).

Table 8.16. Extent of Impact of Affected Structures

Name of the corridor	Number of Structures					
	Fully	Percentage	Partially	Percentage	Total	Percentage
Corridor 1	43	82.69%	9	17.31%	52	100
Corridor 2	135	46.71%	154	53.29%	289	100
Corridor 3	64	88.89%	8	11.11%	72	100
Corridor 4	40	56.34%	31	43.66%	71	100
Total	**282**	**58.26**	**202**	**41.74**	**484**	**100**

In case of partially affected buildings, a stability assessment would be done by a qualified engineer during the valuation of the structure in consultation with the project affected family, to assess if the remaining part of the building is safe after repairs and renovations. As of now, no preventive demolition, due to structural damage caused by vibration is expected. The exact number of displaced and affected will be finalized after the verification by the engineer. Category wise preliminary impacts are discussed under chapter 7 of this report.

8.3.7.3. Number of Project Affected Tenants and Employees Households

Apart from the structures affected households 228 tenants and 64 employees would also be affected. Tenants are found in both titleholder's and non-titleholders' buildings. The corridor wise affected tenants and employees is presented in below table. The number of open land (land only) affected households would be identified during joint measurement survey and the RAPPIC would do the socio-economic survey during RAP development phase. As mentioned in previous sections, the surveys are yet to be concluded; these surveys will be updated once the designs are finalized and Joint Measurement Certificate (JMC) is issued. The Joint Measurement Surveys for Corridor 2 are in progress.

Table 8.17. Corridor Wise Number of Affected Tenants and Employees Households

Corridor	Number of Tenants			Employees
	Residential	Commercial	Total	
C 1	7	4	11	9
C 2	109	47	156	11
C 3	24	7	31	27
C 4	26	4	30	17
Total	**166**	**62**	**228**	**64**

Note: (165 to be surveyed structures are not considered for this assessment)

8.3.7.4. Vulnerable Households

As regards vulnerability among surveyed (excluding the 165 to be surveyed HHs) PAHs, there are 217 PAHs belonging to vulnerable category out of 845 (please see below table). Out of these 59 PAHs are women headed households, 68 PAHs are below poverty line, 21 PAHs having disability and old age persons. Apart from that, 54 and 15 PAHs belong to Scheduled Caste and Scheduled Tribes respectively. Both Scheduled Castes and Scheduled Tribes are considered as vulnerable groups because the Scheduled castes (SCs) and Scheduled Tribes (STs) falls under the provisions of Constitution of India and get preferential treatment in the government benefits because these people are traditionally vulnerable.

Table 8.18. Corridor Wise Affected Vulnerable Households

Vulnerability	Number of Households					
	C1	C2	C3	C4	Total HH	Percentage
Women Headed Household	0	54	3	2	59	27.19%
Below Poverty Line	7	47	13	1	68	31.34%
Family with disability or old age	7	12	1	1	21	9.68%
Scheduled Castes	23	70	29	2	54	24.88%
Scheduled Tribes	10	3	0	2	15	6.91%
Total	47	116	46	8	217	100.00%

Note: (165 to be surveyed structures are not considered for this assessment)

8.3.7.5. Number of Affected Community Property Resources

Corridor wise details of the affected common property resource are listed shown in below table. No heritage building is affected due to development of BSRP. Majority (66.7%) of the affected CPRs are religious structures.

Table 8.19. Corridor Wise Affected CPRs

Description	CPRs					
	C1	C2	C3	C4	Total	Percentage
School & Collage (private)	0	2	0	0	2	7.41
Community Toilet	0	0	0	0	0	0.00
Religious centers (shrines and small temples, boundary wall of the religious centers, etc)	1	11	4	2	18	66.67
Railway Gate, Water Tank, CW, Shed/ Building	0	2	2	3	7	25.93
Total	1	15	6	5	27	100

Note: (165 to be surveyed structures are not considered for this assessment)

8.3.7.6. Displacement

Those households who are fully affected due to land acquisition for the project and they are considered for relocation can be referred as Project Displaced Households (PDHs). Out of the total displaced 457 (Residence, commercial and residential cum commercial) households 332 households would be displaced physically (loss of residence), and 77 PAHs would be displaced economically (Source of livelihood), and 48 households will lose their both residence and livelihood due to proposed suburban rail project.

8.3.7.7. Impacts from Loss of Access to Forest/Agricultural areas

The SIA study reveals that there are no impacts such as loss of access to forest resources or to agricultural areas. The Depot 1 at Akkupete requires 18.62 Ha of forest land. The Forest land to be acquired is within the city (Akkupete). This area does not offer any ecosystem services to nearby communities. This area was used for compensatory afforestation plantation; mostly dominated by Eucalyptus fibrosa and Acacia mangium tree species. No firewood collection, wild fruit collection or any other timber or non-timber forest produce is taking place as this is mostly social forestry; and does not impact any livelihoods. However, no agricultural activity takes place in any of the corridors.

8.3.7.8. Temporary Impacts Because of Construction Disturbance

The SIA study has not identified any temporary impact in relation to loss of income or livelihood due to the construction activities.. There will be temporary impacts due to construction, such as impacts on the Mathikere slum. The EPC contractor will identify temporary land requirements for workers camps, stores, yards, etc. and enter into rental/ lease agreements with land owners. These lease agreements will be submitted to the promotor. Presently, the designs are under process, once these are approved, temporary land requirement for working space will be assessed, impacts due to such temporary land requirement will be included in the corridor wise RAPs to be developed.

8.3.7.9. Impacts on Mobile and Semi-mobile Vendors

The SIA study has not identified any mobile/ semi-mobile vendors at any informal markets crossed by the alignment or stations or depots. However, when the surveys are updated by the RAPPIC, if any such impacts are identified, then they will be included in the corridor wise RAPs to be developed. These are eligible for relocation assistance.

8.3.8. Risks & Impacts on Religious Structures /Archaeological / Historical and Cultural Monuments/ Heritage Sites

Impact on religious structures present along the project corridors were assessed. As mentioned in the **Table 8.18**, there are few religious structures such as temple, shrine, tree shrine, church, mosques, etc., directly affected either a portion of the structure or entire structure. In corridor 1 – 1 structure, in Corridor 2 – 11 structures, Corridor 3 – 4 structures and Corridor 4 – 2 structures are affected due to proposed project improvements. Most of these structures such as tree shrines, shrines, few minor temples are encroachments falling within Indian Railway RoW. However, the affected structures shall be translocated to nearby locations in consultation with local community and Urban Local Body. There are no impacts on burial ground present along the project corridors.

In accordance with the Ancient Monuments and Archaeological Sites and Remains (Amendment) Bill, 2017, the proposed development project under infrastructure projects can be implemented within prohibited areas around protected monuments. As per the field study and assessment, two legally protected Archaeological Monuments / Heritage structures near Corridor 1 – KSR to Devanahalli (Devanahalli Fort - at 228m from the Project Site and Tippu's Birth Place, Devanahalli - at 271m from the Project site) were noticed to be affected (within in 300ms from the archaeological Sites) due to the proposed Suburban Rail project. There will be no construction within the radius of 100m from the above said monuments/heritage centres. Other than these no other archaeological/ historical/ cultural monuments or heritage centres are in the vicinity of the project corridors.

Risks and Impacts on Tangible and Intangible Cultural Heritage Assets : There is no risk and impact on tangible cultural heritage assets such as visual art, food, clothing, and styles of architecture along and intangible assets such as legends, music, and values like generosity or respect. However, access shall be restricted to the Archaeological heritages at Corridor 1 during construction and operational phases of the project. Alternative access to local community shall be provided to make it convenient to reach to their residence or market or work place, etc.

Mitigation Measures :

Archaeological and Historical/Cultural Properties

As per the base line study and impact analysis, no damage to Archeological Monuments is predicted. However, during construction, archaeological or historical structures may get affected by direct or indirect construction activity. It shall be ensured that no impact is predicted on the ASI Monuments due to project activities.

A prior survey shall also be conducted before construction to identify if there is any historical structure nearby construction sites, which may get impacted. Necessary measures shall be undertaken accordingly, if any. Devanahalli Fort and Tippu Sultan birth Place at Devanahalli are the Archaeological Survey of India Protected monuments located at 228m and 271m respectively to the alignment – Corridor 1, for which necessary procedure will be followed to obtain the necessary construction permit from ASI. Prior to the initiation of construction, K RIDE will inform the ASI authority. The management plan will include ground vibration monitoring during construction and operation of project.

It is therefore specifically mentioned that the proposed project shall be executed with all required mitigation measures with utmost care and concern and particularly, in accordance with the stipulated guidelines of ESS 8 of World Bank; & EIB's ESS 10 and the Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 and the Ancient Monuments and Archaeological Sites and Remains (Amendment) Bill, 2017.

Corridor 1: Measures shall be implemented to avoid any risks and impacts on legally protected Archaeological Monuments (Devanahalli Fort and Tippu Sultan's Birth Place at Devanahalli) in line with The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI) and WB ESS 8 & EIB's ESS 10.

ASI Stipulations to be followed are as follows -

1. Interpretation panels/signage must be provided for the monument.
2. Drainage system should be checked so that the corridor level should not be higher than the monument and water should not enter inside the monument complex.
3. Prior intimation should be given to ASI authority to monitor the site and also to check the impact on monument during /post digging (excavation) process.
4. Prior permission must be obtained from the Competent Authority for any construction or increase in height.
5. A certificate should be furnished to the Competent Authority on completion of proposed construction to effect that it has complied with all conditions of the permission.
6. The compliance must be with the heritage bye-laws of the protected monument concerned as and when the bye-laws are approved.

Residual Impacts and Measures: No residual impacts are anticipated because it will be ensured by the Contractor during construction stage to follow diligently the guidelines of The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI); and in line with WB ESS 8 and EIB Standard 10.

Chance Find Procedures

All fossils, coins, articles of value of antiquity, structures and other remains of archaeological interest discovered on the sites shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation - The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI) and in line WB ESS 8 & EIB's ESS 10.

The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He shall, immediately upon discovery thereof and before removal acquaint the Environmental Specialist of GC of such discovery and carry out the GC's instructions for dealing with the same. Works shall be resumed once approval is obtained from the GC and K RIDE. The GC shall seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work in the site. The Archaeological structures/ materials identified along the project corridors, if any, shall be protected/ preserved or enhanced and handed over to ASI as per the law. The details regarding Chance Find procedure is given in **Annexure 10.5**.

Residual Impacts: No residual impacts are anticipated. The project will be implemented with these above mentioned measures related to Archaeological and Cultural Heritages; and thus, comply with the Indian regulations and WB's guidelines ESS 8 and EIB Standards 10.

8.3.9. Risks & Impacts on Environmental Sensitive Receptors

As mentioned in the **Table 8.18, t**here are no direct impact on environmental sensitive features such as educational institutes, Health Centers and court premises except one Health center in Corridor no. 2. There are about 67 environmental sensitive receptors present along the BSRP Corridors. Out of 67 receptors, Corridor 1 is having 8 receptors, Corridor 2 – 24 receptors, Corridor 3 – 23 receptors and Corridor 4 – 12 receptors. Corridor wise detailed list of Environmental Sensitive receptors present along the project is presented in **Table 5.48**. As per the social impact assessment study, there are no affected due to proposed project improvements.

8.3.10. Risks & Impacts on Local Transport Facilities

Risks and Impacts : The proposed project BSRP has been proposed only to gratify the surplus demand of present and future traffic requirement and for the access to essential destinations and metro stations. Therefore, there is no prediction of loss of either facilities or employment to the existing transport facilities and the people concerned. Instead, it supports the additional local transport facilities to cater to the requirement of transport to and fro work place/residence to Suburban stations and vice-versa. As a supplementary impact employment opportunities are predicted due to the proposed project.

Mitigation Measures : Not applicable here as the project has positive/beneficial impacts on local transport facilities.

Residual Impacts and Measures : Not applicable here as the project has positive/beneficial impacts on local transport facilities.

8.4. Risks & Impacts Due to Project Design & its Mitigation Measures

The potential impacts enlisted due to project design are as given below :

The above issues are highlighted in the following sub-sections.

- Platform Inlets and Outlets
- Risks & Impacts of Noise and Vibration
- Right of Way, Alignment, Track design and Architecture
- Spatial Planning of Stations and Inter Modal Integration
- Consumption of Energy for Illumination, Ventilation and Water at Stations and Depots
- Risks due to Natural Hazards
- Robust Design with Provisions for Green Buildings
- Efficient Material Re-use and Conservation
- Conservation of Flora/Preservation of Trees
- Utility Plan
- Design Improvement to Minimise the Vibration

8.4.1. Risks & Impact of Noise and Vibration

Noise impact at grade line is anticipated in trade off with visual intrusion resulting from elevated line.

Necessary mitigation measures shall be employed during project construction and operation phases. Details are provided under section 8.6.5 and 8.6.6 for construction phase and section 8.7.1 & 8.7.2 for operation phase.

Residual Impacts : There will be insignificant residual impact on the environment. No adverse impact on the ecosystem is anticipated.

The project will be implemented with the above mentioned measures related to avoid impact of noise and vibration; and thus, comply with the Indian regulations and WB's guidelines ESS 8 and EIB Standard 3.

8.4.2. Consumption of Energy for Illumination, Ventilation and Water at Stations and Depots

The proposed project impacts on the Energy consumption as it is required for illumination/lighting and ventilation and water for drinking, sanitation and cleaning purposes, which will affect climate change, if due care is not provided.

Mitigation Measures : The illumination and ventilation system shall be adopted at Suburban Railway Stations and Depots as per the stipulated norms and guidelines of Manual for Standards and Specifications for Railway Stations, June 2009. Proper illumination and aeration/ventilation shall be implemented at required locations at Suburban Railway Stations and Corridors to ease out the public congestion.

As per Indian Green Building Council (IGBC) Standards, BSRP stations / Depots are proposed to be designed and constructed with all possible energy/ resource efficient measures. As per contract in an

EPC bares, all the sustainable issues, energy conservation requirements are the requirements of design & construction contracts & proper tender conditions are included.

Natural source of energy such as solar energy and natural ventilation or open aeration shall be aimed as prime concern while considering the provision for proper natural lighting and ventilation at Suburban Stations and Depots. Required electricity shall be harnessed with natural source for lighting and ventilation facilities and Power Utilities such as HVAC, Lifts and Escalators etc. The electricity is sourced from existing BESCOM / KPTCL.

As per the DPR estimate, Total power demand in BSRP project is estimated as 50 MVA. Detailed Power supply study is being taken up through simulation study of the project to optimize the power consumption and detailed design shall be carried out. The power consumption is also proposed to be augmented through non-renewable energy sources viz. solar energy. The Rolling stock specification is proposed to be with energy regenerating braking system.

The bulk power supply is proposed to be taken from the state power grid in coordination with the state authorities at one or two project locations and distributed through various sub stations to ensure reliable and uninterrupted power supply. K RIDE also intends to follow up with the concerned authorities, regulatory commissions to provide concessional power tariffs as BSRP is a public project.

The project envisages to generate solar energy to the maximum extent as per the Govt. of India policy published by Ministry of Non – Conventional energy. The depots & Station roof design are being proposed with proper orientation / inclination to harness maximum Solar energy. The exact quantum of energy depends once the detailed design is finalised along the corridor.

Resource efficiency measures such as LED lighting, timer for high mast lamps at depots, minimum lightings at stations and parking areas, out operation of water pumps, use of Resistance Temperature Detector (RTD) sensors in axial fans, use of split AC, etc.,

Additionally, consumption of water for drinking and sanitary facilities is significantly attained by proper design of passenger flow inside stations, space & facilities inside stations and multimodal integration facilities outside stations and by required measures and maintenance. The main source of water utilization shall be from Water supply.

Residual Impacts: There will be no residual impact on the environment.

8.4.3. Robust Design with Provisions for Green Buildings

Engineering design of BSRP is as per codal provisions. Application of green concepts during design, construction, operation, maintenance, renovation and demolition enhances to reduce or eliminate negative impacts on environment and creates positive impacts on environment. The "green Building" which is also referred as "Sustainable building" preserves precious natural resources; and improves total quality of life.

Green Building concept is adopted in K RIDE's Bengaluru Suburban Railway Project in terms of structural design and provisions for better saving of energy and water; and reduction in emission of CO_2. All stations and Depots are designed as green buildings.

The Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII) was formed to enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025. IGBC has launched green Mass Rapid Transit System (MRTS) rating system for all stations and green Factory Building rating system for Depots. These rating systems are tools to enable new rail based MRTS to apply green concepts during design & construction, so as to further reduce environmental impacts that are measurable.

The proposed Bengaluru Suburban Railway Project addresses green building features in the following categories Design and Construction - Site selection, Planning and Maintenance, Energy Efficiency, Water Efficiency, Material Conservation and Indoor Environment and comfort. Design and Construction - Site selection, Planning and Maintenance Energy and water efficiency are discussed below. Material conservations during project execution are dealt under the sub-section Mitigation Measures during construction stage. Indoor Environment and Comfort will be considered while providing aesthetics to the Stations. All required care and measures shall be taken while providing comfortable Indoor Environment at Stations during operation, as well as Technical rooms and laboratories at Base Camp and plant sites during construction.

Residual Impacts: No residual impact is anticipated and there will be no impact on ecosystem. Positive impact on environment is predicted.

The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1, 3, 4 and 5.

8.4.3.1. Design and Construction Stage

The proposed project requires storage yard, casting yard, assembly yard for building and storage of materials and equipment required temporarily during construction and will be removed or cleared after construction stage, but before operation stage. The site selection and planning during design and construction has a major role in contributing for Green Building features. In this line the criteria to be followed are as follows :

- 500m away from the right of way of National Highway
- 500 m away from habitat and settlements
- 250 m away from flood plains, water bodies and State Highways

Away from the Notified Areas- Reserved Forests, Nature Protection, Sanctuary, Wildlife Sanctuary, Eco-sensitive zones, Historical Monuments, places of tourist interest, etc.

Maintenance of the yards is an important aspect to avoid emission of dust and other particulates into the ambient atmosphere.

Residual Impacts: Insignificant residual impact is anticipated and there will be no impact on ecosystem.

The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1, 3, 4, 5 and 10.

8.4.3.2. Utilization of Solar Power

Utilization of Solar power through Solar panels for lighting and aeration at Stations and Depots will not create harmful greenhouse gas emissions. The carbon foot print of solar panels is already quite small, as they last for 25 years plus with no loss in efficiency. Also the materials used in the panels are increasingly recycled. Hence, carbon foot print will continue to reduce.

For the utilization of renewable energy, wherever feasible, installations for solar power can be implemented on the roof of elevated stations and in Depots. It is assumed that 75% of roof area of each station can be considered for solar power generation. Energy potential and cost for installations in Depots has not been estimated in this report because amount of land/structure surface area available for this purpose can be estimated up on evaluation of the Depots layouts. However cost of this is not included in estimated cost of EMP since installation and maintenance of solar power infrastructure is proposed here and it shall be taken up only after the project is awarded to developer along with Power Purchase Agreement.

The project envisages to generate solar energy to the maximum extent as per the Govt. of India policy published by Ministry of Non – Conventional energy. The depots & Station roof design are being proposed with proper orientation / inclination to harness maximum Solar energy.

The exact quantum of energy depends once the detailed design is finalised for the project.

Residual Impacts: No significant impact of residues on the environment is anticipated.

8.4.3.3. Energy and Water Efficiency

The maximum utilization of natural day light and design of passenger flow inside railway stations and on roads outside stations and optimal utilization of electrical energy, climate control, lighting and other facilities at stations will enhance energy efficiency. For this purpose installations for solar power can be implemented at stations and Depots where feasible.

Water supply in stations for air conditioning, cleaning and use of staff and passengers will be procured from municipal supply. Water for Depots will be sourced from municipal supply: this will be supplemented by re-use of used water from coach wash.

8.4.4. Efficient Material Re-use and Conservation

Construction and demolition (C&D) waste includes building materials such as insulation, concrete, wood, gypsum wall board, PVC, steel, bricks, etc. and some hazardous materials such as asbestos, lead, mercury, and arsenic treated lumber contained in building related debris.

Mitigation Measures : The hazardous materials are not generally considered with the C&D waste and must be disposed of according to regulations and practices.

Proper storage, avoidance of spillage, re-use as far as possible and proper maintenance shall be carried out to conserve materials of use in construction. There are several strategies that can be employed to insure less Construction waste, and consequently less disposal-off materials in landfills.

Residual Impacts: No significant impact of residues on the environment is anticipated. The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1, 3 and 4.

8.4.5. Conservation of Flora/Preservation of Trees

Conservation of flora during Suburban Rail Network Development at regional scale is a key to avoid exploitation or degradation of natural resources. Moreover, conservation of Flora with longer time horizons is intrinsically valued as beneficial tool for society and source of national pride.

Mitigation Measures : Maximum efforts were made to save and preserve trees at the project area during study. The alignment is designed in such a way that realignment and elevated corridor option were considered during design to preserve and save existing trees along the proposed alignment. It is ensured that only those trees which seem to affect project with no other alternative are proposed to be cut.

All efforts shall be made to preserve/save trees. Specific attention shall be given for protecting large trees, green tunnels and locally important trees (religiously important etc.). Details of the trees affected due to the proposed project corridors are given in (Section 5.9.2 of EIA Report) Tree cutting shall be proceeded only after all the legal requirements including attaining of In-principle and Formal Clearances from the Forest Dept. are completed and subsequently a written order is issued to the Implementing Agency. Tree preservation will be line with Karnataka Preservation of Trees Act, 1976, Forest Conservation Act 1980 and ESS 6 of World Bank & EIB's ESS 4. A Tree Management Plan is prepared in line with the State's Tree Act and World banks guidelines and is attached as **Annexure 10.44**.

Residual Impacts: No significant impact of residues on the environment is anticipated. The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1, 3 and 4.

8.4.6. Utility Plan

The proposed Bengaluru Suburban Railway Project alignment passes along major roads of the city and it is required to shift the sub-surface, surface and overhead utility services prior to construction. A detailed investigation of all utilities is undertaken and proper strategic plans shall be prepared for their retention *in-situ* or for temporary or permanent diversions with required precautions and approval shall be obtained in advance from concerned authority/organization before project construction. The stakeholder engagement and information disclosure for shifting of utilities should be planned in line with ESS 10 of World Bank to maintain the constructive relationship throughout the project construction stage. By implementing these measures, the project is expected to comply with the WBESF guidelines.

Table 8.20. Organizations Responsible for Utilities and their Services

Sl. No.	Organization/Department	Utility/Services
1.	BBMP/PWD/NHAI	Roads
2.	BWSSB	Sewerage and drainage lines. Water mains and their service lines Water treatment plants, pumping stations, Roads, surface water drains, nallahs, sewer lines,
3.	Telephone Operating Agencies – State Govt. and Private	Telecables, junction boxes, telephone posts, O.H lines

Sl. No.	Organization/Department	Utility/Services
4.	Power Grid Corporation of India Ltd.	HT towers, cables
5.	Irrigation Dept.	Canal
6.	Oil Corporations	Gas pipelines
7.	BESCOM	HT/other overhead Power lines Street lights, high mast lights etc.

8.4.7. Design Improvement to Minimise the Vibration

In order to suppress and/or reduce the negative effects of ground-borne noise and vibration, different mitigation measures were tested in the past years. To reduce the ground borne vibrations, design level changes are being practiced rather than typical operational level arrangements. Engineering control measures are in place to limit the vibration levels to the acceptable minimum.

These improvements can be applied to new infrastructure and/or existing ones. Different methodologies are to be compared both with their feasibility and the costs to be able to use them most conveniently. In this section, the major available technologies will be illustrated and discussed exhaustively.

The mitigation systems can be applied in all three parts of the railway system, on the vehicle, on the track and on the transmission path (that is generally soil). It is also possible to make improvements directly at the receivers (i.e., buildings). The parts of the railway environment (where the mitigation measure are possible) are subdivided into four main subsystems: vehicle, track, transmission path, and receiver. Based on the different rail systems, the characteristics of the components change from one to another.

8.4.7.1. Improvement in the Vehicle

The vehicle dynamics play a crucial role in the generation of the ground-borne effects, principally when irregularities are present at the wheel-rail contact. Rail vehicles are constructed using bogie system technology, with a single and double suspension, for the freight and passenger trains, respectively. Primary suspensions connecting the wheelsets to the bogie frame and are made with coil or rubber springs. Secondary sus- pension systems, located between the bogie and the car body, consist of elastomer elements, air spring or metal spring, a proper design of the bogie suspension can significantly reduce the levels of ground vibration. In general, vehicles with soft primary suspension produce lower levels of vibration than vehicles equipped with stiff suspensions. It is also important to highlight that the way in which the vehicle affects the generation of the vibrations depends on the type of train and the technology that is used. The importance of improvement of the vehicle is crucial for the ground-borne vibration since this effect is arising between the track and wheel contact, with the latter being a component of the train. The principal measures to control and/or mitigate the ground-borne vibration coming from the vehicles will be presented in the sub-section and are the following:

- Improving wheel roundness,
- Reduction of the unsprung mass,
- Reduction of speed,
- Resilient wheels.

When the main contributor in the vehicle is identified, it is possible to design the vehicle so as the dynamic forces acting on the track are reduced. It should be noted that wheel out of roundness and the unsprung mass of a single wheel are often the dominant excitation mechanisms.

8.4.7.2. Improving Wheel Roundness

Wheels out of roundness are one of the main causes of excessive vibration. This can be the result of the manufacturing process or repeated loading at high frequencies.

The most common manifestation is the formation of wheel flats, caused primarily by train breaking/deceleration. The most common manifestation is the formation of wheel flats, caused primarily by train breaking/deceleration, and this results in high-frequency impact force whenever the corners of the wheel flat impact the rail during the rotation. **Figure 8.14** shows an example of wheel polygonalization in the first-, second- and third-order.

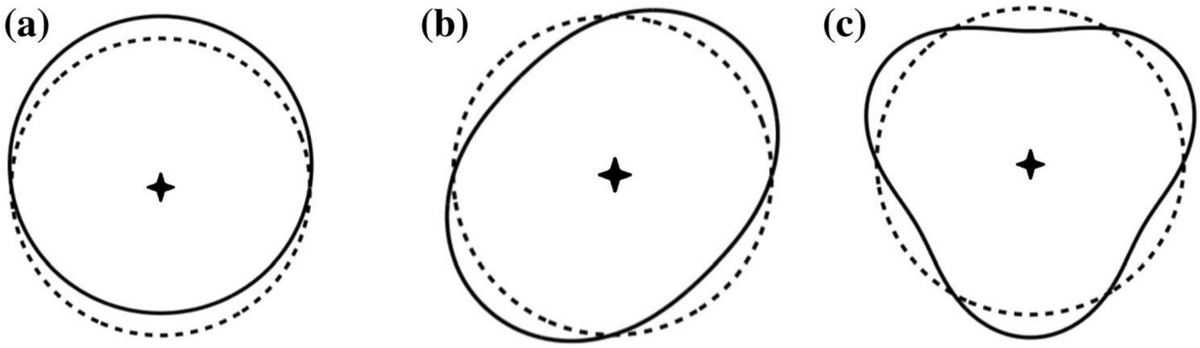


Figure 8.14. Wheel Polygonization to Mitigate Vibration

This can be achieved with good maintenance of the wheels, improvement of the sliding protection and steel quality. In particular, re-profiling, a high-quality wheel grinding program ensures the reduction of noise levels in the range of 5 to 10 dB.

8.4.7.3. Reduction of the Unsprung Mass

The unsprung mass is defined as the set of the loads generated by suspensions, wheels and bogies frames. This mass laying directly on the rail beams is the main cause of the damage to the tracks. Therefore, its reduction becomes relevant in terms of track and infrastructure damage and consequently with respect to the reduction of the vibrations level. However, the decrease of this mass is difficult to achieve due to safety criteria, wheels life and the vehicle dynamics design.

The wheel-set mass is generally in the range of 700–3500 kg, from small-diameter wheels on freight wagons to large diameter locomotive wheels. Its reduction can be obtained by the optimization of the cross-section in its shape and/or material and is generally limited to 5%– 10% of the nominal wheel mass, with which is possible to achieve a vibration reduction of 2–4 dB in the long-term. In addition, the reduction of the radial thickness would reduce wheel mass significantly but at the same time influence the number of re-profilings, wheel life and production costs.

8.4.7.4. Reduction of Speed

Vehicle speed plays central role in the generation of ground-borne noise and vibration. By reducing the train speed by a factor of two it is possible to reduce vibration levels approximately up to 6 dB.

In general, when the train speed is approaching the Rayleigh wave speed of the transmission path it is possible to have considerable growth in the track vibration and consequently an increase in the ground-borne effects. In addition to the speed of the train, many other factors influence the vibration propagation, such as types of railway vehicles, transport type (passenger or freight), track type and others. In order to get advantages from the reduction of the speed, it would be necessary to find the less impacting speed during the motion, depending on the type of train, type of transmission path and other components. Even if vibration levels can be reduced up to 6 dB, speed reduction is not a favourite choice when developing mitigation systems. On the other hand, a disadvantage of this approach is that it has a high cost in a long time as the line capacity is reduced.

8.4.7.5. Resilient Wheels

Resilient wheels are more effective in eliminating wheel squeal on tight turns and is possible to have a reduction in vibration in the range of 3–6 dB.

With respect to the transmission of vibrations to the track, the use of resilient wheels significantly reduces the energy transmitted to the track.

With respect to the transmission of noise to the environment, the sound power emitted by the resilient wheels is clearly lower than that emitted by the monobloc wheel.

8.4.7.6. Improvement in the Track

Before introducing the improvements that can be applied to the track, it is worth to briefly present the track system and its components.

- Rail is the main part of railway track, acts as two parallel lines.
- Rail pad is designed between the sleeper plate and foot of the rail, generally made by an elastic polyurethane mat. Together with spikes and the fasteners joining the steel rails to the sleepers.
- Sleepers is laid perpendicular to steel rail. Railway sleeper can be properly deformed to trimmer pressure when the train passes through and are generally of three types (wooden, steel and concrete sleeper).
- Ballast bed is a layer of free-draining coarse aggregate used as a bed elastic support for sleepers.

An important factor for the ground-borne effects is the overall track stiffness. A low track stiffness can result in an increase in the deformation of the soil and ballast, while on the contrary when the stiffness is too high a corrugation is easier to be generated. Additionally, if the stiffness has radical fluctuations over the track section, track deterioration and vibration is resulted. The values of stiffness may change based on types of traffic that are expected (e.g., freight or passenger transport), consequently it is difficult to fix an ideal value of the stiffness since generally, the lines host various types of trains. Therefore, track imperfection and degradation (not only due to track stiffness) are crucial to the track vibrations.

Therefore, a correct selection of these elements (rail, fastening, sleepers, ballast) plays a central role in diminishing the formation and propagation of vibration. Increasing the flexibility of the superstructure components raises their ability to damp (dissipate) vibration generated at wheel-rail interface.

8.4.7.7. Rail Track Enhancements

The irregularity in the track and the ballast can be an important source of vibration. Indeed, a good track alignment can provide a 10 dB reduction for the ground-borne vibration, therefore, maintenance to the rail plays an important role in the vibration mitigation.

Embedded rail systems are also an alternative, typically used in urban lines. In these systems, the rail is embedded in a concrete slab which is then either filled by pouring out elastic embedding material (at the bridges steel moulds are applied) or by the installation of prefabricated rubber parts around the rail web, with a wedge on either side to keep the rail in place which showed that the elimination of metal-to-metal contact contributes to a reduction up to 8 dB in the frequency range 5–200 Hz;

Rail dampers can also be used for vibration mitigation. These are prefabricated passive elements in steel material, which are fixed to both sides of the rail web serve to reduce the vibration of the rails. Rail dampers are usually installed between every sleeper in problematic areas of the track. Studies conducted by German (DB) and French (SNCF) Railways, at the rail track sections with rail dampers installed, showed a reduction of vibration up to 9 dB.

8.4.7.8. Fasteners Enhancements

Use of rail fasteners can significantly reduce the vibration levels. Use of fasteners will help to reduce the vibration levels through the following enhancements.

- Hold rails securely in the rail seat.
- Limit the rotation of the rail about the outer edges of the rail foot.
- Minimise longitudinal movement of rails through creep and thermal forces.
- Assist in retention of track gauge.
- Not cause damage to the rail.

8.4.7.9. Sleepers and Ballast Enhancements

The sleeper can be installed in concrete or wood. Concrete sleepers are the most used type because of economic advantages (simpler installation, greater durability, lower maintenance, and operation costs). Wooden sleepers present a higher vibration damping capacity. The studies showed a vibration reduction by 5 dB when using wooden sleepers. At the same time, there are also other important improvements that can be done just under the track in order to achieve vibration attenuation, such as by placing the elastomeric pads between the sleepers and the ballast bed. This elastomeric pad is usually composed of two layers of different material, the upper made by viscoelastic rubber with high vibration damping ability and the lower layer is a coarse geotextile that serves to prevent possible upper layer damage from impressing of crushed ballast material. Elastomeric pads under the sleepers can provide a reduction of 8–20 dB. The ballast mats (that can be applied to both the surface and under- ground systems) offers a reduction of 3 to 15 dB. However, if a ballast mat is too soft there is a risk that the ballast layer becomes more feeble when solicited to the vibration produced by the passing train. Therefore, this could compromise the ride quality unless rigorous maintenance is performed (increase in costs).

8.4.7.10. Alternative Track Technologies

In the track improvements, the technology of the track itself plays a crucial role and, in addition to the classical ballasted track, there are other approaches with different track design concepts projected to mitigate the ground-borne noise and vibration.

8.4.7.11. Ballast Bed with concrete slab

Track structures with ballast bed are better vibration reducers than the track structures on special reinforced concrete slabs. The main disadvantage of this type of track construction, compared with tracks laid in ballast bed, is its greater rigidity, which results in increased vibrations. Further reduction of the vibration propagation can be achieved by increasing the height of the ballast bed.

8.4.7.12. Floating- slab tracks.

Another alternative to ballasted tracks is the floating- slab tracks. These are special types of slab tracks with the so-called mass-spring systems principle, here the track is mounted on a thick concretes lab that rests on rubber bearings, glass fiber or steel springs. With such designs, the highest possible mass is added above the track spring to form a system with a very low resonance frequency. Floating-slab tracks are typically used to manage the vibration and ground-borne noise from underground trains where a large reduction is required.

8.4.7.13. Dynamic Vibration Absorber (DVAs)

An additional measure, that plays an important role when dealing with ground-borne vibration and noise mitigation, is the dynamic vibration absorber (DVAs). DVA is a vibration system that combines dampers and springs, to absorb and dissipate the vibration energy, the rubber layers bonded with the rail waist are mainly used to perform as the distributing elastic components of the DVA; the steel plates are used as the quality layer and the constraints layer to form the distributing power quality of DVA, together with the rubber damping layer. Then the distributing elastic components and distributing power quality can jointly constitute a set of distribution parameters of the dynamic vibration absorber. The DVA can absorb the vibration and prevent the noise radiation when the rail waist is vibrating . The DVA system can be an effective measure to address the ground- borne effects and can reduce between 5.3 and 6.6 dB depending on the type of soil and the train speed.

8.4.7.14. Improvement along the Path

Another important part of the rail environment, where it is possible to intervene in order to mitigate the effects of rail traffic, is the transmission path. Here, the elastic waves travel from the source to the receiver. In most cases, when referring to the transmission path the project has soil and/or rock materials.

Measures in the transmission path are typically applied in the surface train, where surface waves are the main contributor for the ground-borne effects, because for the P- and S-waves and the parts of the buildings those are below the ground level these measures would not be worthwhile. The aim of the measures insert between the track and the adjacent building is to act as a barrier, diverter or damper of the vibration waves that travel from the source with the scope of minimizing and/or cancel their effects at the receiver.

8.4.7.15. Increasing the Distance

An obvious and effective way to reduce ground-borne noise and vibration is by augmenting the distance between the track and the receiver. However, this measure is applicable only in some cases when urbanization permits it, and the cost of the free land is cheaper than other mitigation measures. At a distance of 500 m from the rail track, people no longer perceive the rail traffic vibrations.

8.4.7.16. Embankment

Embankments are constructions that allow railway lines to pass at an acceptable level and gradient over low lying ground.

Placing rail tracks on an embankment, a reduction of vibration and noise at the point of emission for up to 5 dB(A) can be achieved if the height of the embankment is at least 3 m. Embankment with specific material stiffness can play the role of a waveguide by trapping energy within it.

8.4.7.17. Soil stiffening

Soil stiffening methods will mitigate the ground vibration. By reducing the coherence of the soil, it is possible to reduce the vibration by 14 dB within the frequency of 4–32 Hz. In addition to all the mitigation measures that can be applied within the transmission path, one should consider the exact soil characteristics since these have a direct relationship with the propagation of the waves.

Residual Impacts: By strictly adopting the aforesaid mitigation measures and regular and diligent monitoring during project implementation, residual impacts anticipated are insignificant.

The project will be implemented with the above mentioned measures and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1 and 3.

8.5. Risks Due to Natural Hazards

Mild Earthquakes / Tremors and Flood due to unprecedented rains are the two main natural disasters predicted for this BSRP.

Seismicity : The proposed project lies in Seismic Zone II (least active zone) as per revised Seismic Zoning Map of India corresponding to least seismic hazard or low-damage risks. Mild tremors are predicted once a while.

Mitigation Measures: Engineering construction shall be done in accordance with provisions specified in Code of Practice. K RIDE's Bengaluru Suburban Railway project area lies in Zone II as per revised seismic zone classification of India IS1893 (Part I):2002 corresponding to minimum seismic hazard. It is less prone to earthquakes. Engineering construction shall be as per codal provisions.

Flood: Causal factors include combinations of loss of pervious area in urbanising landscapes, inadequate drainage systems, blockade due to indiscriminate disposal of solid waste and building debris, encroachment of storm water drains, loss of inter connectivity among lakes, housing in floodplains and natural drainage and loss of natural flood-storages sites.

Mitigation Measures: This includes engineering measures and flood preparedness with the understanding of ecological and hydrological functions of the landscape.

Other than these, there is no other natural hazard due to climate change as per the forecast.

Embankment Stability, Erosion control and Drainage: The formation work is proposed to be constructed as per RDSO (MoR) guidelines. All the precautions of slope stability, erosion control, drainage etc. are the tender conditions to be implemented by the EPC contractor. BSRP corridor predominantly runs parallel to the existing Railway line and there are no deep cuttings and high embankments along the corridor.

There are no reported cases of either of soil erosion, embankment settlement or slope failures in the cuttings along the existing Railway lines as per the records maintained by Indian Railways.

Residual Impacts: As there will be proper implementation and stringent monitoring by K RIDE, there will not be any residual impacts anticipated.

The project will be implemented with the above mentioned measures related to Natural Hazards; and thus, comply with the Indian regulations and WB's guidelines ESS 1 and EIB Standard 1.

8.6. Risks and Impacts Assessment during Project Construction & Mitigation Measures

Potential temporary negative environmental impacts have been foreseen during project construction. The required mitigation measures shall be adopted for the predicted impacts during project construction, which will reduce the overall magnitude of impacts on the environment and community. The potential negative Environmental impacts are discussed below:

- Preconstruction Activities, related issues and Mitigation Measures
- Construction Material Management and House Keeping
- Risks & Impacts on Land/Soil Quality
- Risks & Impacts on Air Quality
- Risks & Impacts on Noise Level
- Risks & Impacts on Vibration
- Risks & Impacts on Water Resources & its Quality
- Risks and Impacts on Flora & Fauna and their Protection
- Risks and Impacts due to Solid Waste
- Risks & Impacts on Traffic
- Energy Management
- Risks & Impacts due to Labour Camps
- Occupational Health Risks
- Occupational Safety Risks
- Community Health and Safety
- Risks and Impacts on Cultural Heritage and Archaeological and Historical/Cultural Properties
- Risks & Impacts of Plastics

Environmental mitigation measures during construction stage are provided here to mitigate observed potential negative impacts on environment. These mitigation measures shall be implemented by the Contractors in accordance with the approved Environmental Management Plan and monitored by the Environmental Consultant of Supervision Agency or the project Proponent. The cost of Environmental Management during construction is included in Cost Estimate/Budget provided at the end of this

Chapter and it forms the part of Engineering Cost. The Sub-sections below will enlighten on the envisaged potential impacts along with necessitated appropriate mitigation measures.

8.6.1. Preconstruction Activities, related issues and Mitigation Measures

8.6.1.1. Establishment of Plants, Equipment and Machinery

All construction plants shall be sited sufficiently away (500ms) from settlements and agricultural operations or any commercial establishments. Such plants shall be located at least 100m - 500m away from the nearest dwelling preferably in the downwind direction.

The Contractor shall submit a detailed layout plan for all such sites and approval of Environmental Specialist of GC, prior to the establishment and obtain approval. Guidelines and reporting format for siting of Construction Camp is presented as **Annexure 10.2** and **Annexure 10.17** respectively. Specifications for crushers, hot mix plants and batching plants with required Equipment and Machinery shall comply with the requirements of the relevant emission control legislations. Consent for the Establishment and Operation from KSPCB shall be obtained before establishment.

Arrangements to control dust pollution through provision of windscreens, water sprinklers, and dust extraction systems shall have to be provided at all Plant work sites.

At present, contractor in place for Corridor 2 and he has identified the three camp sites near Benaganahalli Station, Hebbal Station and Jalahalli Station. These land are level land and free from vegetation and encroachment present within Indian Railway RoW. Hence, there is no impacts observed due to establishment of these camps.

8.6.1.2. Preparation for procurement/Supply of Construction Materials

Risks & Impacts : Construction materials such as quarry materials – aggregates; and borrow earth required for the project shall be procured from approved quarries and borrow areas, as per the guidelines stipulated by Dept. of Mining & Geology.

Mitigation Measures: Contractor shall finalize the quarry or borrow areas for procurement of construction materials after assessment of the availability of sufficient quantity of materials, quality and other logistic arrangements or he can directly procure crusher materials from the supplier.

The Sand shall be procured from approved sand mines. As a substitute, M-Sand may be used, wherever feasible. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the Indian regulations. Procurement shall be in compliance with WB ESS 1, 3 & 6 and EIB ESS 1, 3 & 4.

8.6.1.3. Risks and Impacts due to Pre-casting yards and Material stockpiling

Risks and Impacts : Sites for casting of structural concrete elements and material stockpiling can result in air and water pollution, noise, diversion of open areas like green parks and temporary displacement.

Mitigation measures : Mitigation measures include careful planning, timing of casting operations and storage in casting yards and camps. Pre-casts will be properly stock piled in Cast yards.

Sites for casting of structural concrete elements and material stock piling and storage will be identified by the Contractor and decided by the K RIDE before start of construction. This helps to avoid any issues related to displacement of people, if any.

The Construction materials such as steel, bricks, concrete materials, etc. will be stock piled and stored properly in a fenced or closed Store yard. Precautionary measures shall be taken to reduce and mitigate dust generation at Store and Cast yards. The unwanted or unused balance materials will be removed for use, if required; if not will be disposed properly after the completion of works. The unwanted or unused balance materials, if suitable will be utilized for borrow areas or open pit or trench filling.

Residual Impacts: Residual impact to the environment is insignificant.

8.6.1.4. Labour Procurement and Protection of Work Force

Labour procurement shall be in accordance with labour laws and Contract Document - The Contract Labour (Regulation & Abolition) Act and Rules, 1970, The Building and Other Constructions Workers (Regulation of Employment and Conditions of Service) Act, 1996 (BOCW Act, 1996), The Industrial Relations Code 2020, The Code on Social Security 2020, The Occupational Safety, Health and Working Conditions Code, 2020 and The Code on Wages 2019, The Minimum Wages Act, 1948, The Equal Remuneration Act, 1976, The Child Labour (Prohibition & Regulation) Act and Rules 1986, The Payment of Bonus Act, and Rules 1976, The Interstate Migrant Workmen (RE &CS) Act and Rules, 1979, The Payment of Wages Act, 1936, The Maternity Benefit Act, 1961, Labour Law (Exemption From Furnishing Returns & Maintaining Registers by Certain Establishments) Act, 1988, The Factories Act, 1948 and other related regulated.

The project workers may be direct, contracted or community workers. The Contractor shall preferably use unskilled labour drawn from local communities to give maximum benefits to the local community.

A. Working conditions and management of primary supply chain and contract workers relationships

Labour management procedure will be developed by the Contractor and approved by K RIDE in due course when once the Contract is signed.

(i) Terms and conditions of employment

The project workers will be with information and documentation that is clear and understandable regarding their terms and conditions of employment. This will be in line with worker's rights related to hours of work, wages, overtime, compensation and benefits, as per applicable regulations.

(ii) Non-discrimination and Equal Opportunity for Workers

There shall be no discrimination among project workers based on personal characteristics unrelated to inherent job requirements. The employment of project workers will be based on the principle of equal opportunity and fair treatment and there will be no discrimination with respect to any aspects of employment relationship.

(iii) Worker's organizations

The project will not require a separate worker's organization during project implementation.

B. Protecting Work Force

(i) Protection to Female Workers

Protection shall be provided for women workers of project against sexual harassment and grievance shall be redressed with necessary actions, in accordance with the Act - Sexual Harassment at the Workplace (Prevention, Prohibition and Redressal) Act, 2013 and amendments.

(ii) Child labour and minimum age

The Child Labour is totally prohibited in the project. No child under the age of 18 shall be employed or permitted to work in any sort of works related to project, as per the Child Labour (Prohibition and Regulation) Act, 1986. Whoever employs any child or permits any child to work in contravention of the provisions of section 3 shall be punishable with imprisonment for a term which shall not be less than three months but which may extend to one year or with fine which shall not be less than ten thousand rupees but which may extend to twenty thousand rupees or with both, as per Section 14 of the Child Labour (Prohibition and Regulation) Act, 1986. If the Contractor is found guilty of breaching the Act, he shall be treated as per the Child Labour (Prohibition and Regulation) Act, 1986 and the relevant procedure shall be followed by the K RIDE.

(iii) Forced Labour

Labours engaged or inducted either through contract basis or through paper notifications complying local labour law. Further, there is no scarecity of skilled and unskilled man power in project district. Hence, forced labour issue will not be raised in the project.

C. Grievance mechanism pertaining to project labour

A grievance mechanism will be in place during project construction stage for all types of workers such as direct workers and contracted workers to raise work place concerns and grievances. Workers will be informed regarding grievance mechanism at the time of their recruitment. Measures will be taken to make the grievance mechanism easily accessible to all project workers. The grievance mechanism will be proportionate to the nature and scale and the potential risks and impacts of the project. It will be an easily understandable and transparent process.

Based on the above labour aspects and in compliance with ESS 2 of World Bank's Guidelines & EIB's ESS 8 the Contractor will prepare Labour procurement procedure and Management Plan for the Approval from Sr. Environmental Specialist/Sr. Social Specialist and K RIDE, prior to labour procurement and commencement of Construction activities. Overall labour procurement will be in line with ESS 2 of World Bank's Guidelines & EIB's ESS 8.

8.6.1.5. Obtaining of Temporary Land for borrow Areas and temporary camps at work sites

The Contractor as per prevalent rules shall carry out negotiations with the landowners for obtaining their consent for temporary use of lands for construction camp at work sites and borrow areas, etc. in line with Occupational Safety and Health Standards, Part 1910.142, WB ESS 6 and EIB Standards 1 and 3.

8.6.1.6. *Procurement of Construction Materials*

The procurement of qualitative construction materials by the Contractor shall be from the licensed supplier. This will be decided by the Contractor with the approval from the Supervision Consultant/General Consultant or the Project Proponent.

Quarry materials – Quarry materials shall be procured by Contractors from approved and licensed Quarries. Contractor shall finalize the quarry for procurement of construction materials after assessment of the availability of sufficient quantity of materials, quality and other logistic arrangements. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the regulations and WB ESS 1 & 3 & EIB's ESS 3. Contractor shall also work out haul road network and report to Environmental Specialist of GC/IE and GC/IE shall inspect and in turn report to K RIDE, before approval. In case, if approved quarry is owned or leased by the Contractor, following are the measures to be undertaken during Blasting operations :

- Except as provided in the contract or ordered or authorized by the Engineer, the Contractor shall not use explosives. In case, explosives are the dire requirement for the construction purpose, it shall be procured by the Contractor from the authorized agencies by complying with the requirements of the Explosives Act, 1884 and Explosives Rules, 1983 and in line with WB ESS 2 and 4 and EIB Standards 8 and 9.
- The Contractor shall at all times take every possible precaution and shall comply with appropriate laws and regulations relating to the importation, handling, transportation, storage and use of explosives. The contractor shall at all times when engaged in blasting operations, post sufficient warning flagmen, to the full satisfaction of the Engineer.
- The Contractor shall at all times make full liaison with and inform well in advance and obtain such permission as is required from all Government Authorities, public bodies and private parties whomsoever concerned or affected or likely to be concerned or affected by blasting operations.
- Blasting shall be carried out only with permission of the Engineer. All the statutory laws, regulations, rules etc., pertaining to acquisition, transport, storage, handling and use of explosives shall be strictly followed.
- Controlled Blasting shall be carried out during fixed hours (preferably during mid- day) or as permitted by the Engineer. The timing should be made known to all the people within 1000m (200m for pre-splitting) from the blasting site in all directions.

Contractor shall also work out haul road network and report to Environmental Specialist of GC and GC shall inspect and in turn report to K RIDE before approval.

Borrow Earth – Finalisation and procurement of Borrow earth from approved borrow areas and all logistic arrangements as well as compliance to environmental requirements, as applicable, shall be the sole responsibility of the Contractor and shall be in line with EPA 1986 and ESS 1 & 3 of World Bank and EIB Standards 1 and 3.

The Contractor shall not start borrowing earth from selected borrow area until the formal agreement is signed between landowner and Contractor and a copy is submitted to the GC.

Locations finalized by the Contractor shall be reported to the Environmental Specialist of GC for approval and he/she shall report to K RIDE.

Planning of haul roads for accessing borrows areas shall be undertaken during this stage. The haul roads shall be routed to avoid agricultural areas as far as possible and shall use the existing village roads wherever available.

The environmental personnel of the GC shall be required to inspect every borrow area location prior to approval. The GC should include the Request for Inspection form for borrow area approval from the environmental point of view. Guidelines and reporting format for siting, operation and re-development of borrow area is presented as **Annexure 10.4.** Reporting format for borrow area management plan is presented as **Annexure 10.19**.

Sand / M-Sand - The Sand / M – Sand shall be procured from approved sand mines. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the amended Sand Mining regulations and WB ESS 1 & 3 and EIB Standards 1 & 3.

As a substitute, M-Sand may be used, wherever feasible. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand.

Risks and Impacts of Construction Materials : During construction dust generations, noise pollution, loss of natural resources and personal safety issues are the major hazards in operational quarry and borrow regions which lack necessary mitigation measures. Improper or negligent management of unwanted or surplus construction materials and waste materials at Construction camps cause the dumped and left over waste materials to enter in to nearby/adjoining water courses. Approximately 10-15% of the construction materials will be left over at Construction camps as construction waste/spoils. Dumping of construction waste/spoil in haphazard manner at construction sites or camps may cause surface and ground water pollution near the construction sites.

Mitigation Measures during Construction : All required environmental and safety mitigation measures such as sprinkling of water to control dust emission, cordoning of work area, provision of dust screens, etc., need to be adopted during construction to minimize or avoid dust particles and other emissions due to operation of equipment and entry of waste materials into nearby natural resources. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the amended regulations and WB ESS 1 & 3 and EIB Standards 1 & 3.

8.6.1.7. Procurement of Water for Construction

The contractor shall use ground/surface water as a source of water for the construction and may set up own bore well facility for construction work. If construction water is procured from common or public source, it may lead to disruption/disturbance to other water users in the nearby locality.

Mitigation Measures : The Contractor shall need to comply with the requirements of the State Ground Water Department for the extraction of Water for Construction and shall follow stipulations as per the contract document and EPA, 1986 and in line with ESS 1 & 3 of World Bank and EIB Standards 1 & 3.

To avoid disruption/disturbance to other water users, the Contractor shall extract water from fixed locations and consult Environmental Specialist of GC before finalizing the locations. The Contractor shall provide a list of locations and type of sources from where water for construction shall be extracted.

8.6.2. Construction Material Management and House Keeping

The project related construction materials include coarse aggregates, cement, coarse sand, reinforced steel, structural steel, water supply, drainage and sanitary fittings, etc. The loading and unloading activities involve labourers employed by the Contractor at Material site/s and construction sites.

Mitigation Measures The Contractor shall be solely responsible for regular management of Construction Materials from storage to loading, unloading, usage and maintenance to ensure to maintain quality and quantity of materials and stringently follow approved Environment, Health and Safety (EHS) guidelines. Procedures for storage, handling and transport of construction materials and their reuse shall be prescribed in EHS guidelines. The EHS guidelines shall be prepared in line with World Bank ESS guidelines and National regulations.

House Keeping : Housekeeping at Base Camp, Storage Yards, Plant sites and Construction sites is to maintain cleanliness and hygiene at working areas. This keeps the working environment cleared of all unnecessary waste, thereby providing a first-line of defense against accidents and injuries. It is the responsibility of Contractor and all site personnel.

Mitigation Measures : Some of the preventive and mitigation measures are listed below:

- Full height fences, barriers, barricades etc. shall be erected around the site in order to prevent the surrounding area from excavated soil, rubbish etc, which may cause inconvenience to and endanger the public.
- All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exits fire doors, break-glass alarm points, fire-fighting equipment, first aid stations, and other emergency stations shall be kept clean, unobstructed and in good working order.
- All surplus earth and debris shall be removed/disposed-off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials, etc. shall be covered while moving.
- Unused/surplus cables, steel items and steel scrap within the working areas shall be removed to pre-identified locations.
- All wooden scrap, empty wooden cable drums and other combustible packing materials shall be removed from workplace to identified locations.
- Empty cement bags and other packaging materials shall be properly stacked and removed.
- Proper and safe stacking of material is of paramount importance at yards, stores and such locations for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.

Following of EHS Guidelines during Construction till handling of the project to the project proponent, is the sole responsibility of the contractor, which should be clearly mentioned in the contractor’s agreement.

By implementing these EHS guidelines, the project is expected to comply with the Indian Standards and WBESF guidelines – WB's ESS 1, 2 & 4 and EIB Standards 1 & 9.

8.6.3. Risks & Impact on Land / Soil Quality

8.6.3.1. Soil Erosion, Fugitive dust generation and Land Subsidence

The fugitive dust generation due to clearing of land, cutting of trees, excavation of borrow areas are likely to trigger soil erosion. The movement of vehicles/machinery/equipment and work forces is also likely to cause soil erosion. Loosening of top soil and loss of vegetative cover from the ROW along the detour and parallel section due to excavation, land cut and back filling could lead to soil erosion.

There will be minor impact on soil causing erosion due to run-off from unprotected excavated areas which can result in soil erosion, especially when erodibility of soil is high. The clearing of land, cutting of trees, excavation of borrow areas are likely to trigger soil erosion. The movement of vehicles/machinery/equipment and work forces is also likely to cause soil erosion. Loosening of top soil and loss of vegetative cover from the ROW along the detour and parallel section due to excavation, land cut and back filling could lead to soil erosion. Denudation of vegetation from soil slopes or the lack of vegetative cover on embankment slopes is often responsible for formation of rills and rain-cuts, eventually leading to a surficial slide or to an undermining of the edges of the railway structure.

The problems anticipated include mainly the Surface and ground water pollution due to dumping of unwanted or surplus construction soils (concrete and bricks), waste materials (from Contractor's Camp), etc.

The borrow areas are likely to cause soil erosion and affect agricultural areas. Loss of productive soil may result from uncontrolled opening up of borrow pits. However, embankment slopes made from earthen material as well as exposed surfaces of hills will be protected for preventing soil erosion in areas which have high soil erodability or high intensity rainfall.

Land subsidence is not predicted as there is no underground construction. The construction of stations is at grade only.

Mitigation Measures : Measures to mitigate the Soil Erosion and dust generation include careful planning, timing of cut and fill operations and re-vegetation in accordance with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 1, 3 and 6 of World Bank. In general, construction works shall be stopped during monsoon season.

As far as practicable, top soil removed from the construction sites will be used for construction of embankment to enhance growth of vegetation on the embankment surface and its consolidation. Besides, adequate temporary or permanent drainages are planned to be provided before slope construction begins with lagoons to allow silt to settle out. As for the borrow areas, appropriate measures for the management of borrow areas will be taken. Top soils of the borrow pit sites will be conserved and restored after excavation is over.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures. It is suggested to utilize Ready Mix Concrete (RMC) at site directly from batching plant to avoid spillage. The Construction materials such as steel, bricks, etc. will be stored in a fenced stored yard. The unwanted or unused balance materials will be removed for use, if required; if not will be disposed after the completion of works.

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of temporary berms, temporary mulches, seeding or other methods as necessary to control erosion shall be implemented.

The pre-identified disposal location shall be part of Comprehensive Waste Disposal Plan Solid Waste Management Plan to be prepared by the Contractor in consultation and with approval of Environmental Specialist of GC.

Guidelines for preparation of Comprehensive Waste Management Plan are provided in **Annexure 10.9**. Guidelines on topsoil conservation and reuse and slope stabilization measures are provided in **Annexure 10.1** and **Annexure 10.3**.

Cumulative Impacts on Soil erosion : Soil erosion may take place near cutting areas, at steep and uncompact embankment slope, and wherever vegetation is cleared. Soil erosion may have cumulative effect viz. siltation, embankment damage, drainage problem etc. Loss of soil due to run off from earth stock-piles may also lead to siltation.The consequences of soil erosions are far wider than repair and maintenance of the project corridor. Along the project corridor 1, the inflow of water into lake during rains causes erosion of the embankment besides seepage of water into embankment and subgrade resulting in softening of the subgrade. This may also increase siltation in water bodies.

Mitigation Measures : Project corridors are with elevated stretches near the lakes. Project design includes provisions of retaining walls/retaining walls for the protection. Regular checks shall be made to ensure its effectiveness.

Following are the some of the important control measures considered during project implementation:

- Bank protection measures shall be taken at erosion prone areas.
- Provision of side drain shall be provided to guide the water to natural outfalls.
- When soil is spread on slopes for permanent disposal, it shall be buttressed at the toe by retaining walls.
- Side slopes of the embankment shall not be steeper than 2H: 1V. Turfing of embankment slopes shall be done along the at grade stretches.
- IRC: 56 -1974 recommended practice for treatment of embankment slopes for erosion control shall be taken into consideration for this suburban Rail project also.

The project will implement these above mentioned vegetation protection measures and thus, comply with the Indian regulations and WB ESS 1, 3 & 6 and EIB Standards 1 & 3.

8.6.3.2. Preservation of Top Soil

The topsoil from all areas of cutting and all areas to be permanently covered shall be stripped off to a specified depth of 150 mm and stored in stockpiles. A portion of the temporarily acquired area and/or Right of Way shall be earmarked for storing topsoil. The locations for stock piling shall be pre-identified in consultation and with approval of Environmental Specialist of GC. Topsoil is rich in organic content and is essential to establish new vegetation. The stored topsoil may be used as finished grade for planting areas or to rehabilitate borrow areas.

Mitigation Measures : The preservation of Top soil shall be in accordance with EPA 1986 and ESS 1 & 3 of World Bank & EIB's ESS 3. The following precautionary measures shall be taken to preserve them till they are used:

Stockpile shall be designed such that the slope does not exceed 1:2 (Vertical to horizontal), and height of the pile is restricted to 2 m. To retain soil and to allow percolation of water, silt fencing shall protect the edges of the pile.

Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum to ensure that no compaction shall occur. The stockpiles shall be covered with gunny bags or vegetation.

It shall be ensured by the Contractor that the topsoil shall not be unnecessarily trafficked either before stripping or when in stockpiles. Such stockpiled topsoil shall be utilized for –

- Covering all disturbed areas including borrow areas, only in case where they are to be rehabilitated.
- Dressing of slopes of embankment/agricultural fields of farmers acquired temporarily land.

Guidelines on topsoil conservation and reuse and slope stabilization measures are presented in **Annexure 10.1** and **Annexure 10.3** respectively.

8.6.3.3. Embankment or Slope Protection Measures

All temporary sedimentation control works and maintenance thereof shall be deemed as incidental to the earth work or other items of work and as such no separate payment shall be made for them in compliance with WB ESS 3 & EIB's ESS 3.

Mitigation Measures : Contractor shall ensure the following measures :

- After construction of railway embankment, the side slopes shall be covered with grass and shrubs (refer **Annexure 10.3** and **Annexure 10.25**) as per design specifications.
- Turfing works shall be taken up as soon as possible provided the season is favorable for the establishment of grass sods. Other measures of slope stabilization shall include mulching netting and seeding of batters and drains immediately on completion of earthworks.
- In borrow pits, the depth shall be so regulated that the sides of the excavation shall have a slope no steeper than 1 vertical to 2 horizontal, from the edge of the final section of the bank.
- Along sections abutting water bodies, pitching as per design specification shall protect slopes.
- The formation work is proposed to be constructed as per RDSO (MoR) guidelines. All the precautions of slope stability, erosion control, green cover, drainage etc. are the tender conditions to be implemented by the EPC contractor. BSRP corridor predominantly runs parallel to the existing Railway line and there are no deep cuttings and high embankments along the corridor.
- There are no reported cases of either of soil erosion, embankment settlement or slope failures in the cuttings along the existing Railway lines as per the records maintained by Indian Railways.

- As far as possible, cutting soil is proposed to be reused in the embankment in case the soil is found to be suitable for the Railway embankment. Alternatively, suitable blending materials, soil improvement techniques, blanketing materials for proper drainage, geo-grids are proposed to be used.

Guidelines on slope stabilization, sediment control and Embankment/slope protection measures are presented in **Annexure 10.3, Annexure 10.6** and **Annexure 10.25** respectively. Typical cross section of Silt trap is presented in **Annexure 10.31**.

8.6.4. Risks & Impacts on Air Quality

Respirable Particulate Matter (PM10) would be the predominant pollutant affecting air quality during the construction phase as it is likely to generate considerable quantities of dust, especially during dry conditions due to excavation, backfilling, concreting, hauling, dumping of earth materials, construction spoils and vehicular movement along unpaved routes. Deterioration of air quality due to gaseous emissions from construction equipment and vehicular traffic will also occur.

The assessment of air pollution during construction phase has been undertaken based on the principles of Air pollution Health Risk Assessments (AP-HRA). Construction and decommissioning activities may generate emission of fugitive dust caused by combination of on-site excavation and movement of earth materials, contact of construction machinery with bare soil and exposure of bare soil and soil piles to wind, during construction phase. A secondary source of emission includes exhaust from diesel engines of earth moving equipment and open burning of solid waste on-site. During operation of the proposed project ambient air quality gets affected only at Stations and Depots.

The Air quality gets affected due to the potential sources of emission of dust and particulates during overall project activities as mentioned below:

- Fugitive Dust emission during earth works – excavation during site preparation and loading and unloading of construction materials;
- Emissions from construction equipment, DG Sets and Machinery during their operation;
- Fugitive emissions from the vehicles plying on the road;
- Fugitive emissions during transport of construction materials;
- Dust, particulates and hydrocarbon pollutants due to combustion during the operation of RMC Plant and at casting yard;
- Dust and particulate emission due to traffic congestion at construction sites along the corridors
- Dust emission at muck disposal, debris disposal and pre-casting yards and
- Burning of garbage or solid waste materials

As mentioned above, the air emission will be mainly in the form of coarse and fine particulate matter at construction sites and will settle down in the close vicinity of active sites whilst the air emission at RMC Plant and casting yard sites during operation of equipment/plants/machinery dust and particulate matters, NO_x and SO_x. This air emission with pollutants as specified, will affect the ambient air quality in the vicinity of the construction activities. Discharge from low stack height may also be one of the main causes for air pollution. As per KSPCB Standards stack height should be 30m from the ground. However, with all the above facts it is required to mention here that the air pollution temporary and localized around stations and construction sites which can be mitigated by adopting proper measures diligently.

The quantification of generated Air pollutants due to transportation of construction material and excavated/fill material has been attempted considering the BS III vehicles in usage by the Contractors. Trucks and Backhoe loaders/excavators are direly required to transport civil construction material from pre-cast yards and batching plants to construction sites and between construction sites and soil disposal sites.

The particulate matter 10 (PM_{10}) and 2.5 ($PM_{2.5}$) generated from excavation activities particularly and from other construction activities, are considered as critical pollutants. In this situation, the pollution emission sources shall be distributed throughout the project site and shall be considered under the category of area source.

The impact of project on air quality during the construction period will be mainly due to increase in Suspended Particulate Matter (SPM) along haul roads and emission from vehicles and construction machinery. The mitigation measures proposed for air pollution reduction are in line with Air (Prevention and Control of Pollution) Act, 1981 & its amendments and ESS 3 of World Bank and EIB Standards 1 & 3.

Mitigation Measures : The land for the proposed project construction is relatively more level plateau (plain terrain) with rare and minor undulations in east portion of Bengaluru. Therefore, extensive earth work activities are not anticipated during this phase. Moreover, as far as possible, environment friendly and technologically upgraded construction equipment/vehicles of BS V norms shall be preferred.

Mitigation measures which shall be adopted to reduce the air pollution are highlighted below:

Control of Dust Pollution :

- The Contractor shall take every precaution to reduce the level of dust from construction plants, construction sites involving earthwork by sprinkling of water, encapsulation of dust source.
- The Contractor shall take all mandatory precautions to minimise fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste and from processes such as pneumatic filling of silos, transportation by road, drilling and blasting, crushing, screening, bulk/bag unloading, etc.
- The Contractor shall not allow emissions of fugitive dust from any transport during handling of materials, construction or storage activity. The emission should not remain visible in atmosphere beyond the property line of emission source for any prolonged period of time.
- The Contractor shall use cover for materials of dust generating like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free-board to reduce spills and avoid fugitive dust.
- Contractor shall install barriers around the open construction sites before commencing the work.

- The temporary dumping areas shall be maintained by the Contractor at all times until excavated materials are reutilized for backfilling wherever necessary or as directed by Employer. Dust control activities shall continue even during any work stoppage.
- The Contractor shall place material in a manner that will minimize dust production. Material shall be wetted each day, to minimize dust production. During dry weather, dust control measures must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.
- The Contractor shall sprinkle water at construction sites to suppress dust, during handling of excavation soil or debris or during demolition.
- The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use.
- Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.
- In case of water scarcity in certain areas or periods, Contractor may limit water sprinkling once in the early morning hours and should erect warning boards on dust nuisance to the road users and limit the dust emanating activities.
- Contractor shall carry out periodic check of machinery and vehicles; dust collectors and physical barriers at bulk.
- The concentration of suspended particulate matter at a distance of 40m from a construction plant located in a cluster of industries should be less than 500 µg. The environmental monitoring is to be conducted as per the monitoring plan.

Control of Emission from Construction Vehicles, Equipment and Machinery :

- The Contractor shall procure the construction plants, equipment and machinery, which shall conform to the pollution control norms specified by MoEFCC/CPCB/KSPCB. This will control air pollution.
- He shall maintain evidence of design and equipment to make these available for inspection by Employer.
- Contractor shall ensure that all vehicles, equipment and machinery procured for construction are regularly maintained and confirm that pollution emission standards and comply with the relevant statutory requirements of CPCB such as The Air (prevention and control of pollution) Act, 1981 and EPA, 1986 and/Motor Vehicles Rules 2000 with amendments and WB ESS 3 and EIB Standards 3.
- The Contractor shall properly maintain and periodically check all construction / haulage vehicles, machinery and Equipment so as to comply emission in accordance with National Ambient Air Quality Standards stipulated by Statutory Agencies of Government of India or the State Government from time to time.
- Stack height of equipment/ Plants and D. G. sets at plant site should conform to KSPCB Standards – minimum 30 meters from the ground level.
- The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.

- The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction Depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.
- The Contractor shall submit PUC certificates for all vehicles/equipment/machinery used for the Project.

Summarizing the above mitigation measures, it can be the following techniques considered for the reduction and control of air emissions from construction and decommissioning sites :

- Minimizing dust from material handling sources, such as conveyors and bins, by using covers and /or control equipment (Water suppression, bag house or cyclone)
- Minimizing dust from open area sources, including storage piles, by using control measures such as installing enclosures and covers, and increasing the moisture contents
- Dust suppression by water sprinkling to minimize dust emission from vehicular movements
- Managing emissions from mobile sources
- Avoiding open burning of solid wastes such as waste papers, clothes, tyres, etc.

The project will implement above mentioned Air Control Measures proposed comply with the Indian regulations and WBESF and EIB E&S guidelines.

Residual Impact: After implementation of the mitigation measures described above residual impacts are expected to be minor and no significant impact is anticipated on the ecosystem.

8.6.5. Risks & Impacts on Noise Level

A significant impact of Noise pollution from the proposed project is mainly on public health. Noise is a contributing factor to the degradation of human health. The effects may be due to direct or indirect impacts of Noise. The most common health issue in persons exposed to noise pollution is Noise Induced Hearing Loss (NIHL) such as abnormal loudness perception, tinnitus (high pitched ringing in ears) and paracusis in very rare cases (distorted hearing leading to hallucination). Other potential mental health impacts of noise pollution include increased stress/tension levels, sleep disturbances, etc. leading to uncontrolled emotions and mood shifts, lack of concentration, dizziness and loss of balance, and in extreme cases nervous disorders; and potential physical health impacts include high blood pressure, heart disease, increased respiration rates, fatigue, etc.

Source: Noise pollution during construction is mainly due to movements of construction vehicles for transportation of material and equipment. The impact of noise on surrounding community is assessed considering the following factors :

In order to mitigate noise pollution with necessitated measures Noise level has been assessed based on the following criteria and factors :

Criteria for noise level assessment :-

- The existing ambient noise levels;
- The expected construction noise levels;
- The criteria relating the existing noise environment and the predicted construction noise levels to human responses and
- Mitigation strategies that can be used to control the construction noise.
- Factors considered for assessment include the following :-
- Characteristics of noise source (instantaneous, intermittent, or continuous in nature)
- The difference between the existing noise level and the anticipated construction noise levels;
- The absolute level of expected construction noise;
- The adjacent land uses;
- The time and duration of construction;
- Location of noise source with respect to noise receptor

Day time Noise Levels : Ambient Noise levels during day time were found to be in the average range of 48.8 to 60.8 dB (A). The maximum noise level was observed as 60.8 dB (A) at Yeshwanthapur RS and a minimum of 48.8 dB (A) was observed at Nirmithi Kendra near Akkupete Depot.

Night time Noise Levels : Ambient Noise levels observed to fall in the range 37.6 to 48.2 dB (A) during the night time. A maximum of 48.2 dB (A) was observed at Yeshwanthapur RS and a minimum of 37.6 dB (A) was observed at Nirmithi Kendra near Akkupete Depot.

The forecast of the at source noise levels at varied distances are presented in **Table 8.21**.

Table 8.21. Noise Level Prediction For Construction Equipment

S. No.	Machine	Noise Levels in dB(A) without Noise Controls		
		At Source**	At 15 m*	At 45 m**
1	1.5 cum capacity Excavator / Loader	109	85	65
2	8.33 cum capacity rear end dumper	108	84	64
3	Crawler Dozer	109	85	65
4	Heavy Duty jack Hammer	109	85	65
5	Compressor	104	80	60
6	Crane	107	83	63
7	Generator	105	81	61
8	Rock Drill	122	98	78

Source : FHWA – Noise Hand Book - Data taken from "construction equipment noise levels and ranges report" of Federal Highway Administration, ** Calculated using logarithmic equation.*

It is understood from the above table that construction activities are expected to produce noise levels in the range of 104-109 dB (A) at source which decreases with increase in distance.

Whilst predicting noise emissions due to proposed project the sources of noise generation have been examined for construction phase.

The proposed Suburban Rail construction project would involve placing ballast, and installation of new tracks and establishment of stations. Construction period may be for 2 -3 years. The construction will take place at different distinct locations at different period. It will not be continuous throughout the entire alignment a time. And employment of vehicles vary based the type of construction activities. The production of noise varies with the type of construction vehicle/s operated for a particular activity.

The construction activities of the proposed project will be associated with Maximum Environmental Noise Levels (MENL) applicable to Construction Noise. Construction noise is temporary, intermittent and localized; vary extensively both spatially and in time/duration; and with location and distance of the equipment/machinery from sensitive receptors.

The construction activities which emit highest construction noise levels include pile driving activities, in association with construction of walls and bridges. The most prevalent noise source at Project construction sites would be internal combustion engines. Earth-moving equipment, material-handling equipment, and stationary equipment are all engine-powered. Mobile equipment operates in a cyclical fashion, but stationary equipment (e.g. generators and compressors) operate at sound levels that are legitimately constant over time. Because the trucks cannot be confined to a particular Project site and their movement will be there during most of the time for transportation of construction materials, thereby leading to noise generation and may impact sensitive receptors nearby. Other noise sources may be impact equipment and tools such as pile drivers for pile foundations. Impact tools could be pneumatically powered, hydraulic, or electric.

The analysis and assessment of construction noise is dependent on above mentioned criteria and factors; and typical activities with types of equipment used for demolition, excavation, erection works and other related activities. The **Table 8.22** highlights assessed typical values of noise level generated from major noise generating sources – Vehicles and Equipment/Machinery envisaged during construction phase.

Table 8.22. Average Noise Levels Generated from Construction Equipment

Sl. No.	Name of Source	Noise Level at in dB (A) Lmax @ 15m(DBA, Slow)
1	Batching Plant	83
2	Concrete Pump Truck	82
3	Dumpers	84
4	Cranes	85
5	Dozer	85
6	Generators	82
7	Excavator	85
8	Trailer	84
9	Jackhammer	85
10	Hydraulic Hammer	90
11	Compactor (ground)	83
12	Compressor (air)	78
14	Impact Pile Driver	95
14	Vibratory Concrete Mixer	80
15	Auger Drill Rig	85

Source: Federal Highway Administration's (FHWA), national model for the prediction of construction noise.

The Construction activities shall be between the hours of 7:00 a.m. to 10:00 p.m. near sensitive locations, residential areas and other restricted areas, as instructed by the Railway authority. Construction of noise barriers, such as temporary walls between noisy activities and receivers reduces noise by up to 15 dB (A). Vegetation cover act as noise pollution shields and supports to reduce the noise level.

Careful planning with proper maintenance of machinery and their operation and scheduling of operations can however reduce noise levels. The overall noise during construction will be for short-term (for day time only) and can be mitigated.

For modeling purpose, terrain is considered to be plain and there are no sound absorptive materials present in the direction of the sound wave propagation so as to formulate the worst-case scenario.

8.6.5.1. Noise Modeling During Construction Phase

To estimate the typical noise generated during the construction process, model studies was done considering one piling rig, one construction crane and one concrete mixer truck. This setup will give a typical noise generation during piling and concreting activities. From the study it was observed that, 70 dB(A) noise was observed up to a distance of 80 m from the source. As the noise level beyond he permissible limit, EMP measures will be strictly followed in piling activity. The construction phase noise plot is shown in **Figure 8.15**.

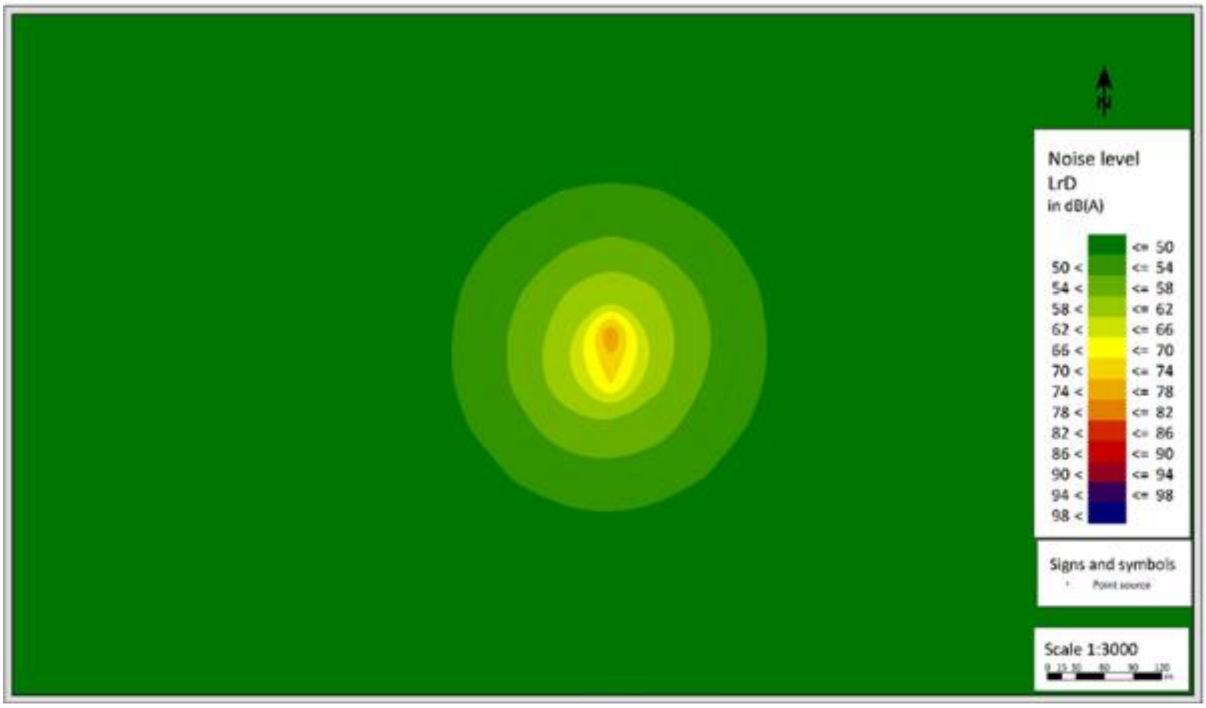


Figure 8.15. Prediction of Construction Noise

8.6.6. Risks & Impacts on Vibration

Significant impacts due to vibration are predicted during project construction and operation. Required mitigation measures will be implemented as per the requirement to control impact of vibration on structures, sensitive receptors and human beings.

8.6.6.1. Vibration Impacts and Risk to Existing Buildings

Significant impacts due to vibration are anticipated from the project construction activity. Mitigation measures will be implemented. Prior to this building condition survey will be conducted before, during and after construction. Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013, specified threshold criteria for various structures are listed in **Table 8.23**. These criteria for monuments are more stringent than those prescribed in UK, Germany, Switzerland and Japan. Vibration source levels for typical construction equipment are listed in **Table 8.24**.

Table 8.23. Guideline Vibration Damage Threshold Criteria

Structure and Condition	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent Intermittent Sources
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Note: Transient sources create a single isolated vibration event, such as blasting or drop balls. Continuous / frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

Source: Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013

Table 8.24. Vibration Source levels for Construction Equipment

Equipment		PPV at 7.6m (in/sec)	Approximate L # at 7.6m v
Pile Driver (impact)	Upper range	1.518	112
	Typical	0.644	104
Pile Driver (sonic)	Upper range	0.734	105
	Typical	0.170	93
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	85
Jackhammer		0.0345	79
Small bulldozer		0.003	58
# RMS velocity in decibels (VdB) re 1 µ inch/sec			

Source: Transit Noise and Vibration Impact Assessment, Federal Transit Administration, May 2006

Construction activities involve various sources of vibrations such as blasting, pile driving, dynamic compaction of weak soils, and operating heavy machines. Dynamic effects of these sources may create substantial vibration problems for surrounding buildings influencing structures, sensitive devices, and people. The level of structural vibrations caused by construction work depends mostly on interaction of three major factors: dynamic sources, geology, and structures. Each of them affects structural vibrations. Only dynamic sourcescan be modified in certain degree to comply with vibration limits. The rest of the two cannotbe changed. Operating frequencies are typically between 25 and 50Hz.

Based on the baseline vibration monitoring performed, except for Corridor 1 V3 location – NITTE Global Institute, Yalahanka where the Peak Particle Velocity (PPV) is 0.128 mm/s which is less the threshold trigger level (05mm/s). Rest all of the locations the PPV is higher than the threshold triggering level. The maximum was recorded at Corridor 3 V-3 location, Karnataka Welfare Association for the Blind, Sheshadripuram which showed a PPV of 8.636 mm/s. The second highest was recorded at Corridor 3 V-1 location, Suhasini Hospital Kengeri, which recorded a PPV of 6.171 mm/s. These two areas fall under the Corridor 3 and proper action has to be taken to reduce the baseline vibration levels. Corridor 1 V-1 location recorded a PPV of 1.107 mm/s and Corridor 4 V-2 location recorded a PPV of 1.313 mm/s, which is the third highest value and proper remedial action, has to be taken to bring down the vibration level below the threshold trigger level. All other locations indicated less than 1.00 mm/s but higher than 0.5mm/s threshold trigger level. Hence, the construction team must give priority and take proper corrective and preventive action to mitigate and reduce the vibration level. Threshold limit (upper Limit) of the vibration monitors were set to 0.5 mm/s limit. The construction team must give priority and take additional care with proper corrective and preventive action to mitigate and reduce the vibration level at these above mentioned 2 locations of sensitive receptors.

The factors which affect the level of vibration at in the ground, arising from any activity, are: the amount of energy transmitted into the ground by the source; the rate of attenuation of the energy as it propagates through the ground; and the distance of the observation point from the location at which the energy enters the ground. Piling methods differ from many other vibration sources in that the position of the source which transfers energy into the ground continually changes as piling progresses, since the tip gets progressively deeper and encounters different soil and the length of the pile shaft in contact with the ground increases as driving progresses. A further difference is that the actual energy source does not come into direct contact with the ground, except in the case of end-driven piles. Therefore, factors which may need to be considered are the details of the pile and piling hammer or driver, the nature of the ground into which the pile is being driven and the distance from the pile to the measurement location.

Based on the summary of the baseline vibration monitoring performed, it was observed that, the Peak Particle Velocity (PPV) is higher than the threshold trigger level except for V-3 location of Corridor 1 (NITTE Global Institute).

The maximum PPV was recorded at Corridor 3 V-3 location, Karnataka Welfare Association for the Blind School, Sheshadripuram which showed a PPV of 8.636 mm/s. The second highest was recorded at Corridor 3 V-1 location, Suhasini Hospital, Kengeri, which recorded a PPV of 6.171 mm/s. These two areas fall under the corridor 3.

Corridor 1 V-1 and Corridor 4 V-2 locations recorded a PPV of more than 1 mm/s. PPV recorded for all other location is < 1.00 mm/s, but > 0.5mm/s the threshold trigger level.

The proposed rail corridors do not pose any serious risk to existing buildings as the corridors pass almost within the existing ROW and already there are existing functional/operative railway corridors however, minor risks of vibration in association with noise have been predicted which can be resolved by adopting specified mitigation measures during construction. The ground stability and settlement analysis is a mandatory activity prior to the commencement of construction activities at designated site locations.

8.6.6.2. Risks and Impacts of Vibration on Sensitive Receptors

The major impacts to the sensitive receptors are due to vibration. Vibration levels are assessed at the sensitive receptors identified along all the corridors as given at **Table 5.48.** The analysis of the results indicates the following:

Impact piles shall be used only when any structure comes under older Residential and Historic old Buildings located at a distance of more than 50 m.

- Vibration levels generated are exceeding at 01 no. educational institute along Corridor 1.
- Vibration levels generated are exceeding at 01 no. educational and 01 no. Hospital along Corridor 3.
- Vibration levels generated are exceeding at 01 no. educational institute along Corridor 4.

As discussed in Section 5.8.2, there are 12 numbers of sensitive receptors identified within 100 m on either side of the alignment for Vibration study. The nearest receptor is 30 meters away from the centre line of suburban rail alignment. Disturbance to facilities such as Schools, Hospitals and Parks are anticipated as proposed alignments are at grade and elevated levels. None of the Station locations lies in any park area. The major construction activities causing vibration and noise pollution include excavation, loading, transportation of materials and operation of construction equipment and DG sets etc.

The potential impact of vibration due to Construction activities is mainly annoying public nearby. The typical levels of vibration for construction equipment as recommended by Federal Transit Administration (FTA) are briefed in **Table 8.25**. In the table the values at 25 feet are based on the FTA 1995. On the basis of reference values of vibration at 7.6m, an impact at 22.8m, 30m and 45m are calculated. The ground borne vibration impacts may be somewhat perceptible to people who are outdoors, it is almost never annoying and does not cause a strong adverse human reaction. According to the California Department of Transportation, (2004), the threshold of perception, or roughly 0.25 mm/s (108 VdB) may be considered annoying to people and the architectural damage criterion for continuous vibrations is 5 mm/s (134 VdB).

Table 8.25. Typical Levels of Vibration for Construction Equipment

SI. No.	Construction Equipment	VdB at 7.6m	VdB at 22.8m	VdB at 30m	VdB at 45m
1	Rock drilling (Rig Pile)	115.9	101.6	97.9	94.3
2	Dump trucks	122.7	108.3	104.6	99.3
3	Bulldozer	124.0	109.7	106.0	100.7
4	Excavator 0.089, 106	124.0	109.7	106.0	100.7
5	Hydraulic Crane 0.808, 87	143.2	128.9	125.1	119.8

Source: *Transit Noise and Vibration Impact Assessment, Federal Transit Administration (FTA).*

There are no adverse vibrations risks & impacts predicted on environment or buildings nearby from construction activities that will be carried out for at grade sections. Vibration impacts on environment are anticipated during construction of elevated sections. Pile-driving is one of the major sources of vibration during project construction. Continuous operation of Vibratory piles at a fixed frequency may be more noticeable to nearby residents, even at lower vibration levels. The steady-state excitation of the ground may induce a growth in the resonant response of building components.

Mitigation Measures : The mitigation measures to reduce the construction vibration are:

- Routing heavily-loaded trucks away from residential and sensitive areas,
- Operation of earth-moving equipment on the construction site as far away from vibration - sensitive sites as possible,

- Phase demolition, earth-moving and ground-impacting operations so as not to occur in the same time period. The total vibration level produced could be significantly less when each vibration source operates separately,
- Avoidance of night time construction activities near residential and sensitive areas,
- Avoidance of impact pile-driving where possible in vibration-sensitive areas,
- Avoidance of vibratory rollers near sensitive areas.

Preparation and implementation of a Vibration mitigation plan will be done by the contractor incorporating all required above mitigation measures and as per codes of practice during construction phase of the project. This scheme of the Vibration Mitigation Plan shall include:

- Monitoring of requirements for vibrations at regular intervals throughout the construction period.
- Pre-construction structural integrity inspections of protected monuments, heritage assets or other sensitive structures.
- Information dissemination about the construction method, probable effects, quality control measures and precautions to be used.
- Vibration monitoring plan during final design and the implementation of a compliance monitoring program during construction
- Proper scheduling of construction activities producing vibration shall be taken, such that demolition, earth moving and ground-impacting operations to not to take place at the same time. Unlike noise, the total vibration produced may be significantly less when vibration sources operate separately.
- Construction activities shall be avoided during night hours when people are more aware of vibration.
- Press piling shall be adopted by the contractor to minimise vibration levels during piling along the path in conjunction with pre-auguring and jetting dependent on ground conditions. Vibration levels at properties due to press piling including pre auguring are predicted to be less than 0.2mm/s at 23m.
- Piling programmes should be arranged to control the amount of disturbance in noise and vibration sensitive areas at times that are considered of greatest sensitivity. If piling works are in progress on a site at the same time as other works of construction or demolition that themselves may generate significant noise and vibration, the working programme should be phased so as to prevent unacceptable disturbance at any time.
- Maintain the setback distances for construction equipment.
- Site-specific mitigation will be determined prior to the start of construction based on selected means and methods.
- Develop a communications protocol for providing advanced notice of construction work and addressing public complaints in a timely manner.

The project will implement above mentioned Vibration Mitigation Measures and thus, comply with the Indian regulations and WBESF guidelines.

Residual impact: With proper execution of the proposed mitigation measures the residual impact is expected to be negligible. If any damage is caused and proven to be valid then it will be incumbent on the contractor to pay compensation.

The project will implement above mentioned Vibration Mitigation Measures and thus, comply with the Indian regulations and WBESF guidelines and EIB Standards 1 & 3.

8.6.7. Risks & Impacts on Water Resources and its Quality

8.6.7.1. Impact on Drainage and Hydrological Flow

The project road runs through plain terrain. There is no river crossing in the project stretch but the project road abut water bodies - lakes at 8 locations and natural drainage channels /nala /streams at two locations. During heavy rainfall these natural drainage channels carry swift flow. As the existing CD structures and bridges will be suitably supporting the water flow, there is no obstruction or disturbance to the water bodies. Therefore, no impact on drainage is envisaged.

During Construction there may be risks and Risks and Impacts of the following nature :

- Chances of filling of existing drainage courses during earth filling.
- There may be potential drainage Risks and Impacts relating to the establishments of construction camps and various plants such as batching etc. drainage Risks and Impacts at these locations may result in loss of top soil.

Mitigation Measures : Measures to avoid risks and impacts on Drainage and Hydrological Flow include the following :

a) Adequate side drains will be provided along the corridor to facilitate its better maintenance and to avoid soil erosion and land degradation due to water stagnation.
b) Filling of existing drainage courses will be strictly avoided
c) Construction works of cross drainage structures, if any, are taken up during the lean flow periods in summer to minimize the impacts on drainage.
d) Construction work near natural drainage channels / low lying areas shall be carried out in such a way that flow of water is not blocked and even if it has to be blocked then the contractor must ensure that the local communities are informed about the same in advance
e) Suitable drainage at construction site & camp will be provided to eliminate the chances of formation of stagnant water pools that leads to soil erosion & breeding of mosquitoes.

The proposed project activities may impact Water sources and Water bodies as mentioned below :

8.6.7.2. Impact on Water Sources

The Water sources along the proposed suburban rail corridors are listed below :

Table 8.26. Water Sources along the Suburban Rail Corridors

Corridor 1	Corridor 2	Corridor 3	Corridor 4
Streams at RHS Km 2/610 and 11/850;	No Lakes or Streams. Open Wells at 4	No Lakes or Streams. Bore well at RHS Km	Lakes along the existing corridor -

Gantigunahalli Lake at LHS Km 4/200 and Nellukunte Lake at Km 6/300 and at RHS Km 1/350 Yelahanka Lake and Open Well at Km LHS 12/000.	locations - RHS at km 216/830, Km 217/450, Km 217/600 & Km 218/100 and at LHS Km 217/550 and Bore well with Pump at RHS Km 216/625.	6/820 and Open Well at RHS Km 349/860.	Huskur Lake at LHS Km 188/600, Panathur Lake at LHS Km 185/800 and Doddanekundi Lake at LHS Km 202/050; Jakkur Lake at RHS Km 12/880 and Yelahanka Lake at RHS Km 17/600.

Mitigation Measures : Proper care and measures shall be undertaken as mentioned above and in line with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank. Measures to avoid risks and impacts on Water Sources include the following :

a) Affected hand pump, bore well and open well shall be relocated in such a manner that it should not hamper the access to drinking water.
b) Construction will not be started until all drinking water sources are replaced with new ones.
c) Supply water is the main sources of drinking water in the project area. Therefore, no major impact is envisaged on the user.

8.6.7.3. Water Usage/consumption for Construction

During construction period Water is required for compaction of embankment, dust suppression, concrete making and domestic use in construction camp. Water use balance for the project during construction is presented in below table.

Table 8.27. Water Use Balance for the Project during construction

Sl. No.	Water requiring Activities	Quantity of Water Consumption (KL)			Water for Recycling (KL)	Water usage for Project (KL)	Reuse of recycled Water
		Corridor 2	Remaining 3 Corridors	Total Project			
1	Operation of Batching Plant	44200	221000	265200	-	265200	-
2	Washing of TM	2600	13000	15600	15600	-	Used for flushing of toilets at labour camp, office and gardening
3	Curing	520000	2600000	3120000	624000	2496000	-
4	Labour/Base Camp	109350	546750	656100	557685	98415	Used for flushing of toilets at labour camp, office and gardening
Total		**6,76,150**	**33,80,750**	**40,56,900**	**11,97,285**	**28,59,615**	

Mitigation Measures: Measures to avoid risks and impacts on Water usage for Construction include the following :

- Minimum use of water from existing sources for construction purpose will be ensured to minimize likely risks and impacts on other users.
- The contractor will arrange water required for construction in such a way that the water availability and supply to nearby communities remain unaffected.
- If new tube-wells are to be bored, due to the non-availability of water required for construction, prior sanctions and approvals by the Ground Water Department has to be obtained by the Contractor.
- Wastage of water during the construction shall be minimized.

Residual Impact: After implementation of the mitigation measures described above residual impacts are expected to be minor.

8.6.7.4. Risks and Impacts on Water Quality

During construction phase, leakage of Petroleum, Oil and Lubricants (POL) could lead to an increase in water pollution level of the region. Anticipated potential Risks and Impacts are due to spillage of construction materials, such as, cement, Petroleum, Oil and Lubricants (POL), etc. discharged in to the drainage channels from workshops, construction camps, and quarry / borrow areas, etc. of the Contractor.

- Accident involving hazardous materials may cause pollution but the occurrence of large scale spillage of is extremely rare.
- Increase of sediment load in the run off from construction sites and increase in turbidity in receiving streams/water bodies
- Water pollution due to sewage from construction camps

Mitigation Measures: Control Measures to avoid risks and impacts on Water Quality (Water Pollution Control Measures) are as follows :

Waste water will be generated from construction activities and labour activities at base camp due to cleaning, washing, etc. Waste water generated from the site during the construction contains suspended materials, spillage and washings which can pollute surface and ground water. Such washings/waste water shall be led through separate drains in to precipitation chambers before their discharge into the sewage drain, in accordance to the standards prescribed for disposal and Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank & EIB's ESS 3.

Measures to avoid risks and impacts of water pollution due to project activities during construction are as given below :

Control Measures for Water Pollution from Construction Wastes :

- The Contractor shall take all precautionary measures to prevent entering of wastewater into streams, water bodies or the irrigation system during construction.
- Contractor shall avoid construction works close to the water bodies during monsoon.

- Contractor shall not wash his vehicles in water body and shall not enter the water body for any purpose.
- Measures such as sedimentation tanks on site for batching plants shall be implemented.
- Contractor shall try and reduce the water consumption through use of energy efficient water fixtures at sites and project offices.
- Leakage of water should not be allowed through pipes and valves.
- Reuse of water used for curing and for other uses shall be planned.
- Proper sanitation facilities (mobile toilets) may be provided at the construction site to prevent health related problems due water contamination
- An effective traffic management plan is to be implemented to avoid any accidental spillage of risky materials.
- All the construction and preparatory activities including construction of CD structures will be carried out during dry seasons only.
- The CD structures should not be drained to the agricultural and horticultural farms or to the immediate vicinity of houses of the locales.
- The unlined roadside drains in rural stretches carrying storm water will be connected to the nearest natural drainage channel, water bodies with silt traps.

Control Measures for Water Pollution from Fuel and Lubricants :

- The Contractor shall ensure that all construction vehicle parking locations, fuel/lubricants storage sites, vehicle, machinery and equipment maintenance and refueling sites shall be located at least 500 m away from rivers and irrigation canal/ponds.
- The Contractor shall submit all locations and layout plans of such sites prior to their establishment and shall be approved by the Environmental Specialist of GC.
- Contractor shall ensure that all vehicle/machinery and equipment operation, maintenance and refueling shall be carried out in such a manner that spillage of fuels and lubricants does not contaminate the ground.
- Provision for oil interceptors shall be made at all the construction camps / workshop areas to separate the oil and grease waste generated from servicing of equipment and vehicles used in the construction. Wastewater from vehicle parking, fuel storage areas, workshops, wash down and refueling areas shall be treated in an oil interceptor before discharging it on land or into surface water bodies or into other treatment system.
- Overall fuel storage and refueling areas, if located on agricultural land or areas supporting vegetation, the topsoil shall be stripped, stockpiled and returned after cessation of such storage.
- Contractor shall arrange for collection, storing and disposal of oily wastes to the pre-identified disposal sites (list to be submitted to GC and K RIDE) and approved by the Environmental Specialist of GC. All spills and collected petroleum wastes shall be disposed-off in accordance with Petroleum Rules and PCB guidelines.

Residual Impact: After implementation of the mitigation measures described above residual impacts are expected to be minor.

8.6.7.5. Impact from Siltation and Sedimentation

Silt Run off during earth activities due to unmanaged construction materials and excavated earth materials lead to siltation and sedimentation of water bodies and thereby reducing the water storage capacity of Water Bodies.

Mitigation Measures : The Contractor shall not excavate beds of any stream/canals/any other water body for borrowing earth for embankment construction in compliance with WB ESS 3 and EIB Standards 1 & 3..

Contractor shall construct silt fencing at the base of the embankment construction for the entire perimeter of any water body adjacent to the project corridor and around the stockpiles at the construction sites including ancillary sites close to water bodies. The fencing shall be provided prior to commencement of earthwork and continue till the stabilization of the embankment slopes, on the particular section of the project corridor.

A temporary basin at the lowest point of the site has to be constructed for collecting, trapping and storing sediment produced by the construction activities, together with a flow detention facility for reducing peak runoff rates. This would allow most of the sediments to settle before the runoff is directed towards the outfall.

Typical cross section of Silt trap is presented in **Annexure 10.31**. Contractor shall ensure that construction materials containing fine particles are stored in an enclosure such that sediment-laden water does not drain into nearby watercourse. Guidelines on sediment control measures are presented in **Annexure 10.6.**

8.6.7.6. Drain choking and Flood Control

The large-scale choking of the storm water drains due to construction waste and debris such as bricks, aggregates, cement, etc. during rainy season cause flooding in the surrounding area.

Mitigation Measures : Contractor shall ensure that no construction materials like earth, stone, or appendage disposed-off in a manner that block the flow of water of any water course and cross drainage channels in compliance with WB ESS 3 and EIB Standards 1 & 3..

Contractor shall take all necessary measures to prevent any blockage to the water flow. In addition to the design requirements, the Contractor shall take all required measures as directed by the Environmental Specialist of GC to prevent temporary or permanent flooding of the site or any adjacent area.

8.6.7.7. Risks and Impacts on Ground and Surface Water Quality

Risks and Impacts : Impact on Ground water is anticipated if sewage is not treated properly and disposed. Ground water contamination is predicted if sewage at labour camps or chemical substances from construction site or dumped muck or construction/demolition waste or used water from the RMC plant are not treated properly; they get leached by precipitation of water and percolate to the ground water table.

Mitigation Measures : The construction activities shall be planned in such a way that the water resources will not be affected in accordance with Water (Prevention and Controlof Pollution) Act, 1974 & its amendments and ESS 3 of World Bank & EIB's ESS 3.

Waste water shall be treated by appropriate sedimentation/ETP facilities to a conforming standard before its release. Part of the treated wastewater is also recycled to minimize the quantum of release of wastewater into the water body. Treated water shall be reused for construction activities.

Ground Water Pollution Control Measures:

The measures proposed to prevent ingress of toxic / heavy metals shall be implemented. By implementing the proposed measures, the project is expected to comply with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank & EIB's ESS 3.

Suitable storage area for such materials shall be prepared and equipment shall be made available for handling of these materials.

Contractor shall take all necessary precautions such that construction material, diesel, grease, waste oil, chemicals etc. does not spill on ground.

Regular monitoring of groundwater and soil leachate shall be conducted at muck disposal areas where possibility of ground water contamination is anticipated. Reporting format for pollution monitoring is presented in **Annexure 10.34.**

Water Quality Monitoring: Apart from provision of the mitigation measures, water quality shall be monitored to understand the effectiveness and further improvement in designs in reducing the concentration of pollutants. The monitoring plan shall be functional in construction as well as in operation stages. The frequency, duration and responsibility will be as per the Environmental Monitoring Plan (Section 10.10 of Chapter-10). The maximum desirable limits as per the water quality standards are given in **Annexure 8.3** and the monitored values should correspond with the table. All deviated results shall be reported to Sr. Environmental Specialist of the General Consultant for remedial measures. It should be ensured that no construction camps or stockyards are set up near rivers, irrigation canals and water bodies to prevent oil spills.

Silt Fencing: Silt fencing will be provided to prevent sediments from the construction site entering into the nearby watercourses. The silt fencing consists of geo textile with extremely small size supported by a wire mesh mounted on a panel made up of angle / wooden frame and post. The frame will be installed at the edge of the water body along which construction is in progress. It is proposed to install silt trap at the edge of all water bodies located along the project road, major and minor bridge locations. Further, silt fence will be mounted in guiding drains at a distance of 3 to 5 m in the upstream direction depending on the gradient of the guiding drains. However location of silt traps will depend on contractor's proposal for site facilities and work sites and should be provided in the contractor's proposals. This will be checked by Sr. Environmental Specialist of the General Consultant and monitored by PIA. Drawing of typical silt trap is given in **Annexure 10.31**.

Oil Interceptors: Oil and grease from road run-off is another major concern during construction as well as operation. During construction, discharge of oil and grease is most likely from workshops, oil and waste oil storage locations, and vehicle parking areas of the contractor camp. Therefore, location of Oil Interceptors has been considered such that each construction camp having refuelling stations, oil and lubricants storage places will have one oil interceptor to stop & separate the floating oils. The arrested products shall be disposed as per MoEF&CC and CPCB guidelines. However, the number of interceptors shall increase as the situation demands or during the accidental spillages. Actual number will be decided by the Contractor with the consent of Sr. Environmental Specialist of the General Consultant. Drawing of typical Oil Interceptor is given in **Annexure 10.33.**

Ground Water Recharge Pit/ Rainwater Harvesting Structures with silt fences have been proposed near water bodies and local stream crossings to improve the water table in this region and conserve water bodies. It has been observed from the past meteorological data of IMD, total number of rainy days in Bengaluru is 58.5 rainfall days and average 974.5mm (38.37") of precipitation.

The project will implement these above mentioned water pollution control measures and thus, comply with the Indian regulations and WBESF guidelines.

Residual impact: After implementation of the mitigation measures described above residual impacts are expected to be minor.

8.6.7.8. Increased Water supply and Demand

There will be increased water demand during construction phase. Total water demand is 40,56,900 KL during construction stage, out of which, 34,00,800 KL for construction activities and 6,56,100 KL for Labour camp. Sufficient water for construction will be made available by digging bore hole/bore well within the project site vicinity or by public water supply.

Therefore, proper care shall be administered while deciding the location of these activities or drawing water from public facilities.

8.6.8. Risks & Impacts on Flora & Fauna and their Protection

8.6.8.1. Risks and Impacts on Flora

Clearing and Grubbing (C & G) activities for Vegetation clearance at work sites may affect the adjacent or nearby flora by damaging and disruption to their growth. There are no threatened tree species falling within the ROW along the project corridors.

Mitigation Measures: Vegetation shall be removed from the construction zone before commencement of construction. All works shall be carried out such that the damage or disruption of flora other than those identified for cutting is minimal.

Only ground cover/shrubs that impinge directly on the permanent works or necessary temporary works shall be removed with prior approval from the Sr. Environmental Specialist of GC.

The Contractor, under any circumstances shall not cut or damage trees and forest reserves. Trees identified under the project shall be cut only after receiving clearance from the BBMP Forest Wing/Forest Dept./DoEF/MoEFCC (as applicable) and after the receipt of K RIDE’s written permission in this regard. This will be in line with ESS 1 & 6 of World Bank and EIB Standards 1 & 3.

Vegetation only with girth size of over 30 cm shall be considered as trees and shall be compensated, in the event of K RIDE’s instruction to undertake tree cutting.

Translocation of trees less than 30cm and trees as suggested by BBMP Forest Wing/Forest Dept. shall be carried out adequately.

Compensatory afforestation for the tree cut and translocated trees shall be carried out by BBMP forest Wing/ Forest Dept. in coordination with K RIDE as per the Tree Management Plan.

The tree protection/preservation, cutting and disposal shall be planned in line with The Karnataka Tree Preservation Act, 1976 & amendment Rule 2008, Tree Management Plan, Forest Conservation Act 1980 and ESS 6 of World Bank & EIB's ESS 4.

- The Contractor, under any circumstances shall not cut or damage trees and forest reserves. Trees identified under the project shall be cut only after receiving clearance from the BBMP Forest Wing/Forest Dept./DoEF/MoEFCC (as applicable) and after the receipt of K RIDE's written permission in this regard. This will be in line with ESS 1 & 6 of World Bank & EIB's ESS 1 & 4.
- Deposition of fugitive dust on pubescent leaves of nearby vegetation may lead to temporary reduction of photosynthesis. Such impacts will, however, be confined mostly to the initial periods of the construction phase and in the immediate vicinity of the construction area.
- Biomass shall not be stored at site for more than 15 days.
- The Contractor shall do turfing on embankment slopes, plantation of shrubs as specified in the Contract.

8.6.8.2. Risks and Impacts on Fauna

Except the domestic fauna such as dogs, cows, Oxen, hens, buffaloes, snakes, monkeys, donkeys, etc. and birds such as crows, parrots, pigeons, etc., there are no wild or endangered animals or birds noticed in the vicinity of all the corridors of the project. Therefore, no risks or impacts on wildlife or domestic fauna are anticipated due to the proposed BSR Project.

8.6.8.3. Protection of Chance found Wild Flora and Fauna

The Contractor shall take reasonable precaution to prevent his workmen or any other persons from removing and damaging any flora (plant/vegetation) and fauna (animal) including fishing in any water body and hunting of any animal, nearby. If any wild animal is found in the vicinity of construction sites by chance, at any point of time, the contractor shall immediately upon discovery thereof acquaint in the Environmental Specialist of GC and carry out his instructions for dealing with the same. The related procedure shall be followed and records shall be maintained.

Residual Impact: No residual impact is expected on ecologically important areas as long as resource materials are sourced from approved legitimate suppliers.

8.6.9. Risks and Impacts Due to Solid Waste

8.6.9.1. Construction /Demolition Waste Materials

Surplus or unused materials and Construction Wastes with Debris will be generated from dismantling structures and from activities at work zones along the corridors. During rainy season this may leach out along with run off in to nearby low lying areas or water bodies.

Mitigation Measures: Construction Waste and Debris shall be disposed as per Guidelines provided in EMP and complying with the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB and ESS 1 & 3 of World Bank and EIB Standards 1 & 3.

The pre-identified disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan shall be prepared by the Contractor for disposal of debris in consultation and with approval of Environmental Specialist of GC. In the case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB.

Surplus materials and other debris generated due to dismantling of the existing structures along the corridors shall be suitably reused in the proposed construction zone, subjected to the structure suitability of the materials and approval of the Resident Engineer and Sr. Environmental Specialist of GC as follows:

- For filling and levelling of School grounds and proposed parking areas.
- Earth from cutting shall be used as embankment fill material.

Existing base and sub-base material shall be recycled as sub-base of the haul road or access roads.

The existing bitumen road shall be utilized as haulage routes for transportation of materials.

The Contractor shall suitably dispose-off unutilized debris materials either through filling up of borrows areas located in wasteland or at pre-designated disposal locations, subject to the approval of the Environmental Specialist of GC.

All arrangements for transportation during construction including provision, maintenance, dismantling and clearing debris, shall be considered incidental to the work and shall be planned and implemented by the Contractor as approved and directed by the Environmental Specialist of GC.

Reuse and Recycling of materials shall be carried out as follows :

- Segregation and temporary storage of reusable and recyclable materials at identified locations. Transportation of recyclable materials to construction sites.
- Sale of metal scrap and other saleable waste.
- Identification of intended transport means and route.
- Obtaining permission wherever required, for treatment of the hazardous component and its disposal.
- Concrete material shall be broken in to coarse size and reutilized in filling.

The pre-designed disposal locations shall be a part of Waste Disposal Plan in consultation and with approval of Environmental Specialist of GC. Debris generated from pile driving or other construction activities shall be disposed such that it does not flow into the nearby surface water bodies or for mud puddles in the area.

The Contractor shall identify dumping sites as per the Debris Disposal Plan prepared using the Guidelines provided in the **Annexure 10.8**; The identified locations shall be reported to the Environmental Specialist of GC. These locations shall be checked on site and accordingly approved by Environmental Specialist of GC prior to any disposal of waste materials. Reporting format for identification and site selection and management of Debris disposal site is presented in **Annexure 10.21** and **Annexure 10.22** respectively.

8.6.9.2. Risks and Impacts due to Construction/Demolition Waste Disposal

Risks and Impacts : Improper disposal or dumping of Construction /Demolition Wastes and other debris at construction sites result in air and water pollution, noise, diversion of green parks and temporary displacement. Approximately 26135 m3 of construction/ demolition was generated from the BSRP.

Table 8.28. Quantity of Construction/Demolition Waste Generated from BSRP

BSRP Corridors	Corridor 1	Corridor 2	Corridor 3	Corridor 4	Total Quantity in m3
Quantity Construction/ Demolition waste generated in m3	8262.6424	4982.13	3679.32	9211.26	26135.35

About 10-15% of the C&D wastes are from the Contractor's Camp. Improper management of C & D waste and Quarry dust by dumping irregularly or haphazardly at construction sites or in labour camps may lead to surface and ground water pollution in nearby areas and may cause loss of natural resources.

During construction period the demolition waste materials and surplus or unwanted construction materials as wastes [Construction and Demolition (C&D) waste] are considered as the solid waste materials resulting from land clearing, excavation, construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste has the potential to save natural resources (stone, rivers and soil, etc.) and energy, reduce transportation over long distances for dumping, and reduce space occupied at landfill sites.

C&D waste generated from Suburban Railway construction has potential reuse after processing, grading solid waste and recycling. The C&D waste generated will be reused and remaining will be disposed in a manner that will not affect the human health and environment in line with C&D Waste Management Rules, 2016 & its amendments, regulation of PCB and ESS 3 of World Bank and EIB Standards 1 & 3.

Mitigation Measures : Following are the measures to be followed by the Contractor during C & D Management:

- The pre-identified disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan shall be prepared by the Contractor for disposal of debris in consultation and with approval of Environmental Specialist of GC. In the case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB.
- Surplus materials and other debris generated due to dismantling of the existing structures along the corridors shall be suitably reused in the proposed construction zone, subjected to the structure suitability of the materials and approval of the Resident Engineer and Sr. Environmental Specialist of GC as follows:
  - For filling and leveling of School grounds and proposed parking areas.
  - Earth from cutting shall be used as embankment fill material.
- Existing base and sub-base material shall be recycled as sub-base of the haul road or access roads.

- The existing bitumen road shall be utilized as haulage routes for transportation of materials.
- The Contractor shall suitably dispose-off unutilized debris materials either through filling up of borrows areas located in wasteland or at pre-designated disposal locations, subject to the approval of the Environmental Specialist of GC.
- All arrangements for transportation during construction including provision, maintenance, dismantling and clearing debris, shall be considered incidental to the work and shall be planned and implemented by the Contractor as approved and directed by the Environmental Specialist of GC.
- Reuse and Recycling of materials :
    - Segregation and temporary storage of reusable and recyclable materials at identified locations. Transportation of recyclable materials to construction sites.
    - Sale of metal scrap and other saleable waste.
    - Identification of intended transport means and route.
    - Obtaining permission wherever required, for treatment of the hazardous component and its disposal.
    - Concrete material shall be broken in to coarse size and reutilized in filling.
- The treatment and disposal sites will be identified by K RIDE in consultation with KSPCB such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. Before dumping, recyclable material will be removed. The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.
- The pre-designed disposal locations shall be a part of Waste Disposal Plan in consultation and with approval of Environmental Specialist of GC. Debris generated from pile driving or other construction activities shall be disposed such that it does not flow into the nearby surface water bodies or for mud puddles in the area.

The Contractor shall identify dumping sites as per the Debris Disposal Plan prepared using the Guidelines provided in the **Annexure 10.8**; The identified locations shall be reported to the Environmental Specialist of GC. These locations shall be checked on site and accordingly approved by Environmental Specialist of GC prior to any disposal of waste materials. Reporting format for identification and site selection and management of Debris disposal site is presented in **Annexure 10.21** and **Annexure 10.22** respectively.

By implementing these waste management measures, the project is expected to comply with the Indian Standards and WBESF guidelines.

Residual Impact: With proper implementation of the proposed mitigation measures the residual impact during construction will be minimal.

8.6.9.3. Risks and Impacts due to Muck Disposal

After the reuse of the graded excavated materials during construction, the left over materials form the muck for disposal. Prior cautions need to be taken by the Contractor by checking the quality of soil before excavation for presence of heavy metals in soil and the results will be compared with standards. If the soil is contaminated, disposal will be done with due treatment or isolation of such muck.

The muck generation is unavoidable from the proposed project activities. All the Suburban Rail Corridors are a mix of elevated and at grade right of way. The short term construction activity involves cut and cover, excavation and fills. All these activities will result in excavation of about 826688.4 m3 and fill of about 372009.8 m3 with net quantity to be disposed of about 454678.6 m3.

Corridor wise Muck generated for the BSRP corridor is presented in **Table 8.29**;

Table 8.29. Quantity of Muck Generated from BSRP

BSRP Corridors	Corridor 1	Corridor 2	Corridor 3	Corridor 4	Total Quantity in m3
Quantity Muck generated in m3	261355.98	157589.88	116380.85	291361.70	826688.4

The location shall be identified in consultation / coordination with local authorities, Pollution control Board & all the Environmental safeguards by the contractor shall be ensured.

These details will be provided in due course of time and contractor shall require to submit the details in Monthly Environmental Report.

Risks and Impacts : Muck disposal if not properly done can result in environmental pollution. The impacts predicted are as follows:

8.6.9.4. Obstruction to Natural Watercourses

If muck materials are not disposed properly, this will enter into nearby water courses along with surface run-off and cause obstruction to the natural water courses – river, streams, etc. and lead to flooding affecting people residing at low lying areas.

8.6.9.5. Siltation in Surface Water Bodies

Muck materials along with run-off if enter into Surface Water bodies downstream, then deposit heavily and lead to high siltation, thereby substantially reducing the water holding capacity of the Water body in a very short span. Since De-siltation is expensive, the clearance of silt will be delayed by the authority.

8.6.9.6. Soil Erosion

If muck disposal is not proper at Disposal site, it will directly impact soil by eroding and thus, causing enormous soil erosion. The precipitation and the consequent run off will erode the loose materials by way of suspension and solution.

The total muck generation predicted is about 826688.4 m3.

Mitigation Measures : Due to the scarcity of land/space in busy city like Bengaluru, where elaborate measures are required for collection, storage, transfer and disposal, the generated waste muck will be reused to the maximum. This avoids dust generation during transportation of muck to the disposal site. If any balance muck, then it will be disposed in a manner that will not affect the human health and environment in line with ESS 3 of World Bank & EIB's ESS 3. For safe stacking or storage of dumped material, concrete reinforced retaining wall is proposed to be built before dumping of any material on the pre-identified muck dumping sites. The details will be provided by the Contractor once the muck disposal land is identified.

Disposal sites will be identified by K RIDE in consultation with Urban Local Body and KSPCB such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved.

Location of disposal sites shall be finalized prior to initiation of the works on any particular section of the corridor. The Environmental Specialist of GC shall approve these disposal sites after conducting a joint inspection on the site with the Contractor.

The pre-identified Muck disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan including Muck disposal shall be prepared by the Contractor in consultation and with approval of Environmental Specialist of GC. Muck disposal plan contain Dumping site selection criteria, precautions to be taken and actions to be implemented during muck disposal (**Annexure 10.7**) to avoid the negative impact on human health and environment as specified in ESS 3 of World Bank and ESS 3 of EIB. In the case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB, also in line with WB ESS 3 and EIB Standards 1 & 3.

The following are the mitigation measures which shall be taken up by the Contractor for Muck Disposal Management:

- Contractor shall ensure that any spoils or material unsuitable for embankment fill shall not be disposed-off near any water course or agricultural land, orchards and Natural Habitats like Grasslands. Such spoils from excavation can be used to reclaim borrow pits and low-lying areas located in barren lands along the project corridor (if it so desired by the owner/community and approved by the Environmental Specialist, GC).
- Non-bituminous wastes shall be dumped in borrow pits covered with a layer of 30cm soil to ensure that borrow pit is restored to original use. No new disposal site shall be created as part of the project, except with prior approval of the Environmental Specialist of GC.
- All waste materials shall be completely disposed and the site shall be completely cleaned and certified by Environmental Specialist of GC before handing over.
- Contractor shall carry out the reconciliation for the disposed soil and quantities shall submit to K RIDE on quarterly basis.
- Dry wheel wash facilities shall be provided at exit gate, from where soil disposal shall be carried.
- Sufficient staff shall be made available at site to control the disposal of muck/soil from site such as a supervisor, labors for wheel cleaning; brooms for wheel cleaning and concrete pad where wheels will be cleaned.
- The dumpers carrying the muck/dry soil has to be covered while plying on the roads on the way to disposal location.
- Contractor shall take due care that muck generated during piling works does not get contaminated with any contaminant.

- The onsite muck shall be monitored quarterly at random location during piling works in progress. In case any polluted muck is produced; the muck shall be handled and disposed as per provisions of Hazardous and Other Wastes (Management and Trans boundary Movement) Rules, 2016 and its amendments and Control of Substances Hazardous to Health (COSHH)
- Construction and Demolition Waste shall be disposed in accordance with the provisions of C & D waste Handling Rules 2016 and its amendments.
- The Contractor at his own cost shall resolve any claim, arising out of waste disposal management.

The following activities are to be followed by the Contractor for Muck Disposal Site Management:

- Disposal sites shall be cleaned and then treated so that leached water does not contaminate the Ground Water.
- Material will be stock-piled with suitable slopes
- Material will be stabilised each day by watering or other accepted dust suppression techniques. The muck shall be filled in the dumping site in layers and compacted mechanically.
- Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top and covered with vegetation.

Guidelines on muck and debris disposal and site management are provided in **Annexure 10.7** and **Annexure 10.8** respectively. Reporting format on muck and debris disposal and site selection and management are provided in **Annexure 10.22** and **Annexure 10.23**. Guidelines for storage, handling, use and emergency response for Hazardous substance are provided in **Annexure 10.12**.

The project will comply with the Indian regulations and WBESF guidelines by adopting the Dumping site selection criteria and precautions with necessary actions for muck disposal.

Residual Impact: After implementation of the mitigation measures described above residual impacts are expected to be minor.

8.6.9.7. Risks and Impacts due to Hazardous Waste

Risks and Impacts : Hazardous materials required to be used in the project includes the following :

Hazardous waste will mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, bulbs, air filters, spent solvents, paints, petroleum products (vehicular & Generator fuel), etc. Approved materials in accordance with the Control of Substances Hazardous to Health Support (COSHH) and MSDS will be used for the project. The following are the anticipated risks and impacts of mismanagement of hazardous materials :

- Accident involving hazardous materials may cause water pollution but the occurrence of large scale spillage of is extremely rare.

- Dumping of hazardous materials on land without care will spoil the fertility of the soil and thereby leading to land degradation.
- Hazardous materials may lead to major accidents from injury to fatality of people during transportation
- Unsafe disposal can result in water and soil pollution, diversion of green parks and temporary displacement.

Mitigation Measures : The following measures are mandatory to be followed by the Contractor during Construction phase :

Hazardous material spill prevention and control plans shall be made,

- to clearly stating measures to stop the source of the spill,
- to contain the spill,
- to dispose the contaminated material and hazardous wastes, and
- stating designation of personnel trained to prevent and control spills.

EHS guidelines in line with Metro Rail projects is part of the EPC tender document of K Ride it is mandatory for Contractors to implement and manage accordingly. This EHS guidelines shall be formulated and redeveloped as per project activities and in accordance with all applicable legislation and Indian Statutory requirements listed as well as International Standards –IFC's EHS Guidelines for Railways.

In addition, Hazardous Substance Management Plan shall be prepared by the Contractor prior to respective Construction activities in compliance with PCB's guidelines of Hazardous and Other Wastes (Management and Trans boundary Movement) Rules, 2016 & its amendments. The storage, handling, utilization and disposal shall be carried out by the Contractor in line with PCB's Hazardous Waste Management Rules, 2000.

The Hazardous waste management shall be handled diligently by authorized / licensed agent as per guidelines of Hazardous and Other Wastes (Management and Trans boundary Movement) Rules, 2016 & its amendments, Control of Substances Hazardous to Health (COSHH) and ESS 3 of World Bank and EIB Standards 1 & 3.

Residual Impact: With proper implementation of the proposed mitigation measures the residual impact during construction will be minimal.

8.6.9.8. Municipal Solid Waste Management

The pre-identified disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan to be prepared by the Contractor in consultation and with approval of Environmental Specialist of GC. In case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB; and in line with WB ESS 3.

The Contractor shall provide with colour coded garbage bins for wet and dry wastes 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 Specialist of GC.

Solid waste generated from labour camps shall be segregated and collected in separate Garbage bins for non-biodegradable and biodegradable waste and regularly emptied and the garbage shall be disposed-off in a hygienic manner. Biodegradable Municipal solid waste shall be collected by local BBMP and transported to local municipal bins for onward disposal to disposal site. Non-biodegradable waste shall be disposed by selling to scrap dealers (recyclable) and to existing authorized agency (inert and non-recyclables).

About 4,000 persons are likely to work during construction activity including skilled and unskilled workers. One fourth of persons involved in construction works are assumed as skilled workers. The skilled workers associated with fabrication and structure works are supposed to stay at labour camp while the local workers will be employed for other associated works like earthwork and concreting. About 400 skilled workers may stay at labour camps. Four labour camps may be proposed for 4 Corridors at appropriate and suitable locations. Considering that 80% of labourers are married, in 80% of married families both husband and wife will be working and taking average family size as 4, total workforce in the labour camps will be about 700 in numbers. It is estimated that about 300 Kg per day municipal solid waste may be generated from the 4 labour camps during construction. The collection, conveyance and disposal facilities shall be made available by providing 20 litres capacity bin with handle and cover for 8 workers. In addition, one community colour coded garbage bins for wet and dry wastes would be provided for effective collection of the waste. The disposal of the waste will be at municipal corporation landfill site.

Guidelines for preparation of Comprehensive Waste Management Plan are provided presented in **Annexure 10.9.** This Comprehensive Waste Disposal or Management Plan includes Solid Waste Management Plan for Management of Surplus materials which can be reusable or recyclable.

8.6.9.9. Risks & Impacts of Plastics

Plastic contributes to global warming. Almost all plastics are made from chemicals that come from the production of planet-warming fuels (gas, oil and even coal). Plastic pollution can alter habitats and natural processes, reducing ecosystems' ability to adapt to climate change, directly affecting millions of people's livelihoods, food production capabilities and social well-being.

There shall be total ban on usage of plastics and one time use plastic in accordance with the Plastic Waste Management Amendment Rules, 2021.

The usage of Paper or cotton bags shall be encouraged and shall be in practice, complying with WB ESS 1, 2, 3 & 4 and EIB Standards 1 & 3.

8.6.10. Risks & Impacts on Traffic

During construction period, complete/partial traffic diversions on road will be carried out based on the activity with strategic procedures. Proper entry and exits will be made along with required cautionary and information signage. Wherever the project alignment pass nearby roads it is advisable to allow for single lane traffic operation, during construction. Advance traffic updates/information on communication systems will be an advantage to affected road users.

The rail project will not pose any serious risks to existing buildings, as major parts of the project alignment lie at grade and elevated within the vicinity of existing rail corridors. However, works at corridors may get affected due to traffic issues and improper management. Also subsequently, it delays work completion.

Mitigation Measures : To avoid work interruption and delay in work completion due to traffic and safety issues at construction sites, satisfactory traffic management shall be undertaken by the Contractor. This will help in easing out traffic flow during construction. The Contractor shall prepare Traffic Management Plan in accordance with codes of practice in advance and obtain approval from the Consultant or the project Authority prior to construction activities. Accordingly, the Traffic Management Plan should include provisions for provide the maximum safety to the population and project personnel and alternative access roads in coordination with local (transport) authorities. Following are the minimal measures:

- 20Km/h speed limit should be maintained for all the vehicles entering project site, construction camp and labour camps.
- The road users and residents should be very well notified and informed in advance to avoid problems and possible complaints.
- The prime measures include road widening, traffic segregation, one-way movements, traffic diversions, acquisition of service lanes, etc.
- All construction workers shall be provided with high visibility jackets
- All road users shall be warned in advance.
- All safe and clearly marked lanes, buffer and work zones shall be provided guiding road users.
- Various construction technologies like cut and cover can be employed to ensure that traffic impedance is minimized.

Residual Impacts: No impact on the ecosystem.

The project will implement these above mentioned Traffic Management measures and thus, comply with the Indian regulations and WB ESF guidelines and EIB Standards 1 & 9.

8.6.11. Energy Management

Energy is crucial to socio-economic and sustainable environmental development, as well as for improvement in the quality of life. Indirect methods may be adopted to achieve energy efficiency. Substandard and improper maintenance of construction vehicles, equipment and machinery lead to energy destruction or loss during construction period of the proposed project.

All necessary measures shall be taken by the contractor to use and maintain lighting, tools and equipment of appropriate specifications so as to conserve energy. Energy efficient construction vehicles should be used for construction activities. Fuel efficiency should be undertaken by the Contractor. An energy audit needs to be conducted to know the energy management during construction. Proper maintenance of Construction vehicles aid energy saving. More than technical measures organizational measures play vital role in the management of energy efficiency.

The project will implement these above mentioned Energy Efficiency measures and thus, comply with the Indian regulations and WB ESF guidelines ESS 1 & 3 and EIB Standards 1 & 3.

8.6.12. Risks & Impacts due to Labour Camps

Improper disposal of municipal solid waste generated by labour camps can pollute surface water bodies and groundwater. Burning of waste can cause air pollution. Construction workers are more prone to infectious diseases like HIV/AIDS due to unsafe sexual activity and lack of sanitation facilities (water supply and human waste disposal) and insect vectors. Problems could arise due to cultural differences between workers from outside and local residents. Approximately 1,000 persons are likely to work during peak construction activity in all the corridors. 04 numbers of labour camps will be proposed at appropriate locations.

The water requirement at all labour camps (for 4000 workers for all corridors) will be 6,56,100 KL, waste water generation 4,92,075 KL & Municipal solid waste generation 1600 Kg per day (400gm/capita waste generation). Waste water will be treated in accordance with CPHEEO, PCB Standards. And the recycled waste water will be used for toilet flushing, cleaning and washing. Septic tanks and soak pits will be provided at certain sites, if required and sewage will be connected to sewer line after septic tank. Municipal Solid Waste will be segregated and handed over to local body. Training and awareness programme will be conducted during construction to avoid the spread of infected diseases and maintain good sanitation in labour camp.

Selection of Location for Construction/Labour Camp

- Construction camps shall not be proposed at a distance of 500m from the nearest settlements to avoid conflicts and stress over the infrastructure facilities with the local community.
- Contractor's camps shall be identified at least 2km away from the Forest Reserves.
- Location for stockyards for construction materials shall be identified at least 300m away from watercourses.
- The Sewage Treatment Plant and solid waste treatment for the camp shall be designed, built and operated.
- Guidelines and layout for setting-up of Construction Camp is presented as **Annexure 10.2.** And Reporting format for identification and establishment of Construction camp is presented in **Annexure 10.16** and **Annexure 10.17** respectively.

During Construction Stage the Contractor will provide, erect and maintain necessary (temporary) living accommodation for construction workers at locations away from construction sites in line with National regulations, as per IFC's Workers accommodation procedures (**as given Annexure 10. 20.)** and World Bank ESS 2 guidelines and EIB Standard 8.

Welfare of Labour on Construction Sites

Labour camps will be setup by the contractor at suitable locations, in accordance with the stipulated guidelines. Siting of the construction camps shall be as per the guidelines and details of layout to be approved by GC Resident Engineer and Environment Specialist; complying with Occupational Safety and Health Standards, Part 1910.142 and in line with ESS 1, 2, 3 & 6 of World Bank and EIB Standards 1, 2, 3, 4, 5, 8 & 9.

Contractor shall follow all relevant provisions of the Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act, 1996 (including Section 32) and Factories Act, 1948 and amended in 1987 and WB ESS 2 for construction and maintenance of labour camp. The location, layout and basic facility provision of each labour camp shall be submitted to GC and K RIDE prior to their construction. The Construction shall commence only upon the written approval of the

Environmental Specialist of GC. The following welfare facilities should be provided by the Contractor for labourers/ Workers at Base Camp:

- **Shelter at Workplace**: At every workplace, shelter shall be provided free of cost, separately for use of men and women labourers. The height of shelter shall not be less than 3m from floor level to lowest part of the roof. Shelters shall be with adequate illumination and ventilation and the space provided shall be on the basis of at least 0.5m^2 per head. Sufficient number of mosquito nets shall be provided. Housekeeping and hygiene are monitored by the Contractor. The Contractor shall maintain necessary living accommodation and ancillary facilities in functional and hygienic manner and as approved by the Sr. Environmental Specialist, GC.
- **Canteen Facilities :** A cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered necessary. Usage of Fire Wood for cooking or any other purpose shall be totally avoided to prevent CO_2 emission.
- **Conveyance :** Free and adequate transport facilities shall be provided for all workers employed by the Contractor and residing at base camp to construction sites and Back.
- **Water supply (Provision of drinking Water) :** The Contractor shall construct and maintain all labour accommodation in such a fashion that potable water is available for drinking, cooking, floor cleaning and washing. The Contractor shall also provide potable water facilities within the premises of every camp at an accessible place, as per standards set by the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 & as per IFC's Workers accommodation procedures (**as given Annexure 10.20.)**. The Contractor shall also guarantee the following:
    - Supply of sufficient quantity of Potable Water (as per IS) in every workplace/labour camp Site at suitable and easily accessible places and regular maintenance of such facilities.
    - If any water storage tank is provided that shall be kept such that the bottom of the tank at least 1 m above the surrounding ground level.
    - If water is drawn from any existing well, which is within 30 m proximity of any toilet, drain or other source of pollution, the well shall be disinfected before water is used for drinking.
    - All such wells shall be entirely covered and provided with a trap door, which shall be dust proof and water proof.
    - A reliable pump shall be fitted to each covered well. The trap door shall be kept locked and opened only for cleaning or inspection, which shall be done at least once in a month.
    - Analysis of water shall be done every month as per parameters prescribed in IS 10500-1991. Water quality testing shall be carried out as per the guidelines provided in Environmental Monitoring plan is presented in Chapter 10 and reporting format for recording results is given in **Annexure 10.40**.

Sanitation Facilities and Waste Water treatment : The Contractor shall implement proper sanitation and sewage system in accordance with the Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act, 1996 and Factories Act, 1948 and amended in 1987.

- The Sewage system for the camp are designed, built and operated in such a manner that no health hazards occurs and no pollution to the air, ground water or adjacent water courses take place.
- Separate and adequate toilets/urinals and wash room Facilities shall be provided at Base Camp for Workers, separate for men and women (marked in vernacular). Cleaning/washing and bathing places shall be provided. Separate and adequate toilets and bathrooms, wherever required, shall be provided for men and women.
- Adequate water supply shall be provided in all toilets and urinals; and wash rooms/bath rooms.
- Drains for waste water shall be provided for the flow of used water outside the camp. Drains and ditches shall be treated on a regular basis.
- Wastewater shall be discharged to the existing sewage network or will be disposed-off in septic tank and soak pit.
- Night soil can be disposed of with the help of local municipal extractor or disposed of by putting layer of it at the bottom of a permanent tank prepared for the purpose and covered with 15 cm layer of waste or refuse and then covered with a layer of earth for fortnight.
- Hygienic condition shall be maintained till the closure of labour camp. All septic tank/soak pits shall be regularly serviced and emptied to reduce the risk of surface or groundwater pollution.
- The contractor shall conform generally to sanitary requirements of local medical, health and municipal authorities and at all times adopt such precautions as may be necessary to prevent soil pollution of the site.

8.6.13. Occupational Health Risks

8.6.13.1. Occupational Health Risks of Workers

Health risks include accidents due to improper construction practice and hazard diseases due to lack of drinking water and sanitation facilities (i.e., water supply and human waste disposal). Implementation of good construction practice may reduce the chance of accident at work place.

8.6.13.2. Occupational Health Risks due to improper Construction Practices

Occupational Health risks for workers include accidents due to improper construction practice and hazard diseases due to lack of drinking water and sanitation facilities (i.e., water supply and human waste disposal). Occupational Health and Safety hazards that may result in a wide range of injuries from minor to fatal, including train/worker accidents, rotating and moving equipment, electrical hazards, fire and explosions, eye hazards, noise and vibration, and fatigue including struck by moving objects; and air or water borne diseases. Implementation of good construction practice may reduce the chance of accident at work place.

8.6.13.3. Risks and Impacts of Air Pollution on Human Health

Air pollution is one of the major present day concerns of new civilized world, because it has a serious toxicological impact on human health and the environment. The proposed project contributes to air pollution.

According to the World Health Organization and CPCB regulations, major air pollutants include particulates, ground-level ozone, carbon monoxide, carbon dioxide, sulfur oxides, nitrogen oxides, Hydrocarbon, and lead. Long and short term exposure to air suspended toxicants has a different toxicological impact on human including respiratory and cardiovascular diseases, neuropsychiatric complications, the eyes irritation, skin diseases, and long-term chronic diseases such as cancer. Several reports have revealed the direct association between exposure to the poor air quality and increasing rate of morbidity and mortality mostly due to cardiovascular and respiratory diseases. By adopting proper mitigation measures health risk due to air pollution can be reduced during construction phase of the project.

8.6.13.4. Impacts of Water Pollution and Poor Sanitation on Human Health

Health risks include accidents due to improper construction practice and hazard diseases due to lack of drinking water and sanitation facilities (i.e., water supply and human waste disposal). Implementation of good construction practice may reduce the chance of accident at work place.

Mitigation measures should include proper water supply, sanitation, drainage, health care and human waste disposal facilities at construction site. In addition to these, efforts need to be made to avoid water spills, adopting disease control measures, awareness programmes etc.

8.6.13.5. Impacts of Noise and Vibration on Human Health

Impacts of noise and vibration on human health have been predicted, analysed and assessed. The modern development of technology, equipping enterprises with powerful and fast-moving machines and mechanisms leads to the fact that people are constantly exposed to noise of increasing intensity. Increasing noise and vibration in the workplace has a harmful effect on the human body. Long-term exposure to transport noise and vibration can have significant impacts on human health, primarily related to sleep disruption and stress, and the resulting health impacts. Other impacts may include speech interference, cognitive impacts, and psychological and behavioural impacts. As a result of prolonged exposure to noise, the normal activity of the cardiovascular and nervous systems, digestive and hematopoietic organs is disturbed, and professional hearing loss develops, the progression of which can lead to complete hearing loss. Elevated workplace or environmental noise can cause hearing impairment, tinnitus, hypertension, ischemic heart disease, annoyance, and sleep disturbance.

8.6.13.6. Occupational Health Risks due to communicable diseases

Occupational health Risks/hazards also include communicable diseases such as HIV/AIDS/COVID due to close interaction and working atmosphere among workers and accidents during working or operation of Plants & equipment. Construction workers are more prone to Infectious diseases such as HIV/AIDS/COVID.

Mitigation measures : Measures include proper water supply, sanitation, drainage, health care and human waste disposal facilities at construction site. In addition to these, efforts need to be made to avoid water spills, adopting disease control measures, awareness programmes etc. It should be prevented by following Counselling, community events, clinic and coordination with local health authority.

Health care facilities : The following health care facilities shall be provided by the Contractor for labourers/Workers at Base Camp :

- Medical Facilities on site: Occupational Health Centre, Ambulance van and clinical room to test HIV/ AIDS/COVID prevention and control with all requirements.
- First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances will be provided. Suitable transport will be provided to facilitate taking injured and ill persons to the nearest hospital.
- A readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone and Labour Camp.
- Availability of suitable transport at all times to take injured or sick person(s) to the nearest hospital.
- Equipment and trained nursing staff at construction camp.
- Periodical health check-up for construction workers and their family and for the sick persons.
- Control of Occupational Health Hazards : Housekeeping and hygienic (cleanliness) conditions shall be well maintained at labour camps and construction sites to avoid any epidemics such as COVID, etc. among workers. Mosquito breeding shall be prevented by avoiding any stagnant water at base camps or at work sites. Mosquito control fogging shall be carried out in all sites as well as in labor camps for Malaria and Dengue control. Rest sheds shall be provided to workers working on sites to avoid humidity effects and rest during lunch hours. Provision of conditions in contract and good construction practices will take care of any occupational health hazard issues and provide environmentally safe work areas.
- Prevention of Infectious Diseases: Construction workers are more prone to Infectious diseases such as HIV/AIDS/COVID. It should be prevented by following actions as depicted below:
- One-one interactions – helps to build confidence,
- Counselling- addressing the myths and misconceptions,
- Community events-street theatre, puppetry, cultural programs are proven communication tools to the illiterate community to message dissemination,
- STD clinic - early identification through testing,
- Condom promotion- encouraging condom usage, an accessible place, made available at all times and free distribution.
- Advertisement board at appropriate location will be put to make aware about the infectious diseases.
- Co-ordination with State Aids Control Society and Health Department

Residual Impacts: No impact on the ecosystem.

The project will comply with the Indian regulations and WBESF guidelines (WB ESS 2)and EIB Standards 1 & 9 by implementing these labour welfare/health care facilities as proposed in the EHS guidelines (**Annexure 10.11**).

8.6.14. Occupational Safety Risks

Safety Management is a major and significant part during construction and operation stages of the proposed project. It is the prime responsibility of Contractor to take safety measures during Construction and Project authority during project operation.

Safety of primary supply chain workers: Workers' Safety during construction on elevated and at grade sections is a statutory requirement and also has impact on progress of work.

The Contractor shall make reasonable efforts to assess if there are significant health and safety risks associated with the workers of the primary supplier of the goods and materials central to the core functions of the project. Where there are significant health and safety risks related to supply chain workers, the Contractor shall resort to a primary supplier that can prove is compliant with this standard.

The Contractor shall require the relevant primary supplier to introduce procedures and mitigation measures to address such risks. The promoter shall periodically monitor and review the effectiveness of such procedures and mitigation measures.

If the health and safety risks are identified in relation to an existing primary supplier, the Contractor shall engage with the relevant primary supplier in order to take the appropriate steps to remediate and eliminate such practices in a satisfactory manner and within a reasonable time frame. In this process, the ability of the Contractor to get the primary supplier to address these risks depends on the level of influence and control of the Contractor over its primary suppliers. When remedy proves to be impossible, the K RIDE shall resort, within a reasonable timeframe agreed with the EIB in consideration of the existing contractual relations, to different primary suppliers that can prove to be compliant with the requirements set out in this Standard.

Mitigation Measures: The Contractors shall ensure system safety and integrity; safety and health management for workers, Technical Staff and public in the vicinity of the project construction sites, plant & Equipment sites and at labour camps.

A Safety Management shall be carried out during execution of construction activities as per Environment, Health and Safety (EHS) manual (**Annexure 10.11**) prepared in line with World Bank ESS guidelines and National regulations and guidelines-OHSAS 18001-2007: Occupational Health and Safety Management System and ISO 14001-2015: Environmental Management Systems. Prior approval of Safety Management shall be obtained from the Supervision Consultant/Project Authority for implementation. The Safety Management Plan includes identified safety haza Emergency Response Planrd, control measures, schedule and responsible personnel for safety management to prevent/control any untoward events/accidents during construction. Approved Safety Management Plan shall be executed at Construction sites/ work places for traffic diversion, personal safety, fire safety, electrical safety and chemical safety in accordance with safety rules, regulations and guidelines.

Work place safety : Work place safety shall be ensured with special focus on following key areas:

- Housekeeping
- Working at Height and Falling objects and Danger areas
- Lifting Appliances
- Launching Operations
- Construction machinery, tools equipment – Safe worthiness
- Electrical Points, machinery/Equipment
- Lighting
- Exposure of worker to use of exhaust or harmful gases in confined locations
- Fire prevention, protection and fighting system
- Corrosive substances
- Demolition
- Excavation
- Traffic Management
- Personal Protective Equipment(PPE)

Following are the Safety Management Activities which will be carried out during construction at work sites:

- Safety Management at work sites :
- Traffic management with proper plan and prior approval from the Engineer –in- Charge.
- Personnel/Workers' Safety at work places –
- The construction personnel will wear protective headgear, mask, gloves, safety jacket, safety shoes/footwear, safety belt and other special garments designed for safety with applicable code practices.
- The specific high rise working areas during construction can have their own unique hazards that personnel requires to be made aware of by providing training and displaying the instruction wherever it requires.
- The weather proofed 'First aid boxes' will be made available at appropriate locations. Detailed instructions will be followed for handling and storage of explosives to be used in controlled blasting if any.

The Contractor shall comply with all the precautions as required for ensuring the safety of the workmen as per the International Labour Organization (ILO) Convention No. 62 as far as those are applicable to this contract. The Contractor shall make sure that during the construction work all relevant provisions of Building and other Construction Workers (regulation of Employment and Conditions of Services) Act, 1996 are adhered to. Contractor shall provide safety to working personnel complying with WB ESS 1 & 4 and EIB ESS 1 & 9.

The Contractor shall not employ any person below the age of 18 Years (18 years as per ILO stipulations for hazardous work) for any work and no woman shall be employed on the work of painting with products containing lead in any form. The Contractor shall also ensure that paint containing lead or lead products is used in the form of paste or readymade paint.

The Contractor shall confirm the following personnel safety during construction:

- Protective footwear, protective goggles and nose masks to the workers employed in asphalt works, concrete works, crusher etc.
- Welder's protective eye-shields to workers who are engaged in welding works
- Earplugs to workers exposed to loud noise, and workers working in crushing or compaction
- The Contractor shall comply with all regulations regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress.
- Contractor shall provide the adequate personal protection equipment such as belts, protective hats/helmets, jackets, shoes, gloves, welding shields, etc. for the workers working with height and heavy electric equipment.

The Contractor shall follow the Guidelines to ensure worker safety during construction as presented in **Annexure 10.11**. Periodically contractor should report the workers safety to GC Environmental Specialist using Reporting format for Safety checklist and project safety measure are presented in **Annexure 10.26** and **Annexure 10.27**.

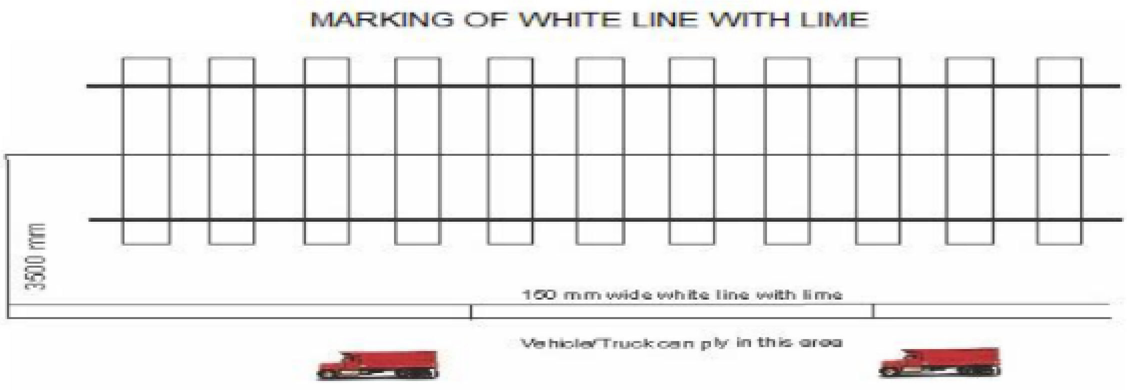
Safety Precautions at Worksites Adjacent to Existing Railway Track :

All works planned for execution close to the running lines and fixed structures, on bridges, inside cutting, constricted area etc. should be carried out only after preparation of detailed plans for the same and getting clearance from Engineering Department of open line and approval of competent authority to ensure that the execution of the work will not in any way infringe the prescribed schedule of dimension or aggravate existing permissible infringement.

Safety measures shall be carried out in accordance with Safety Precautions at Worksites Adjacent To existing Railway Track, Ministry of Railways, GOI, 2015. Before starting any track work the engineering in-charge of the section and Representative Engineers from Contractor shall ensure that he has complete knowledge of the following aspects;

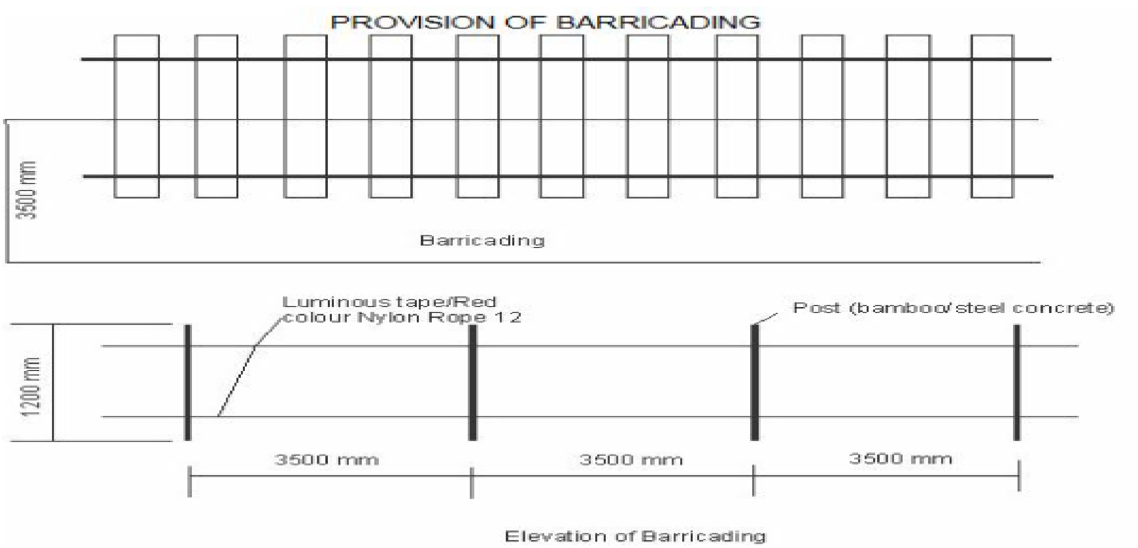
1) Detailed planning of the work including protection of track and safety measures proposed to be adopted and precautions to be taken at site for working of trains including materials required for protection after joint survey of site by the supervisors of the contractor and Railway.
2) Railway supervisor at site will ensure safety precautions against any danger to safety of track and will accordingly educate the contractor's staff and take their acknowledgement before starting the work.
3) Before permitting the execution of certain works close vicinity of existing running line like earthwork, supply of ballast for new or existing rail line, gauge conversion or laying of concrete sleepers and rails etc. where it is necessary to use road vehicle/ machinery, Open lines Engineer-in-charge and K RIDE Engineers/Officials of the section shall ensure that he receives the prior intimation of the following aspects from Assistant Engineer/ Assistant Officer in charge of the work of the executing agency i.e. construction, electrification, S& T, etc.
4) Name and address of the contractor assigned to execute the work.
5) List of individual vehicle with numbers, name and licence particulars of the drivers, those are proposed to be used by contractor at work site.

6) Information regarding location, where the vehicles are planned to be plied.
7) The supervisor/workmen should be counselled about safety measures. The staff of the contractor should be fully trained for the work. List of contractor's supervisors who have been issued competency certificate with location and the nature of works they will supervise, shall be submitted to Engineer In-Charge.
8) The other organisations working in the section should submit to K RIDE the names of supervisors of construction organisations/other organisations who are going to be site in-charge / in-charge of work site.
9) Before the start of work, the land strip adjacent to running track where road vehicle machinery is to ply for the work shall be demarcated with lime in advance at the appropriate distance from the centre of existing track and acknowledged by contractor. Sketches showing the location of marking are as under;



Source: Safety Precautions at Worksites Adjacent To existing Railway Track, Ministry of Railways, GOI, 2015

10) Barricading as design given below shall be provided in full length of work area along the track at the specified distance;



Source: Safety Precautions at Worksites Adjacent To existing Railway Track, Ministry of Railways, GOI, 2015

11) the worksite shall be suitably demarcated to keep public and passengers away from work area. Necessary signage boards such as 'Work in progress' etc. shall be provided at appropriate locations to warn the public/passengers.

Safety Measures to be ensured during the Execution of the Work by Executing Agency and Engineer In-charge

The Engineer in-charge shall approve the methodology proposed to be adopted by the contractor, with a view to ensure safety of trains, passengers and workers and he shall also ensure that the methods and arrangements are actually available at site before start of the work and the contractor's supervisors and the workers have clearly understood the safety aspects and requirements to be adopted/followed while executing the work.

i) There shall be an assurance register kept at each site, which will have to be signed by both, i.e. Railway Supervisor or his representative as well as the contractor's supervisor as a token of their having understood the safety precautions to be observed at site.

ii) The contractor shall not start any work without the presence of railway supervisor or his representative and contractors supervisor at site.

iii) Only trained supervisors have been deputed at work sites duly certified by K RIDE/in charge of the work.

iv) Drivers of road vehicles / machinery have been briefed about the safety and precautions to be taken while moving / working close to traffic / track.

v) The contractor shall not allow any road vehicle belonging to him or his suppliers etc. to ply within 6meters from centre of running line without presence of railway trained supervisor.

vi) Contractor shall ply road vehicles only between sunrise and sunset. When vehicle is plied to work during night hours, sufficient lighting shall be ensured in the complete work area for the safety of public and passengers. Engineering indicator will be of luminous material. Also the luminous tapes should be used for demarcation of prohibited area. Additional staff shall be posted as necessary for night working.

vii) The area of work should be demarcated by providing barricades and Sign Boards, which will enable the work-men posted at site and also the lorry drives to have clear guide lines of the movement on vehicles.

viii) Contractor shall ensure that road vehicle / machinery ply in a way so that these do not infringe the line of demarcation.

ix) The look out and whistle caution orders shall be issued to the trains and speed restrictions imposed where considered necessary. Suitable flagmen/detonators shall be provided where necessary for protection of trains.

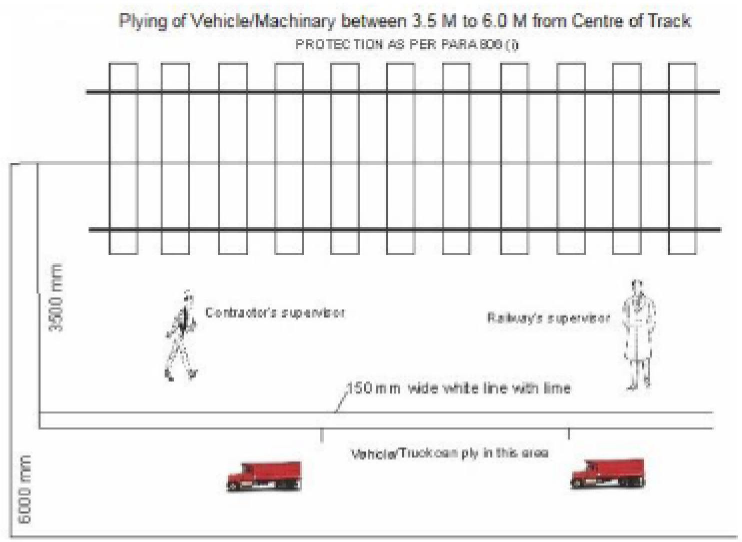
x) In unusual circumstances, where operator apprehends infringement to track while working truck/machinery near running track, following action shall be taken;

a) The track should be protected as per the provision of IRPWM laid in para 806(i) by the Railway staff.

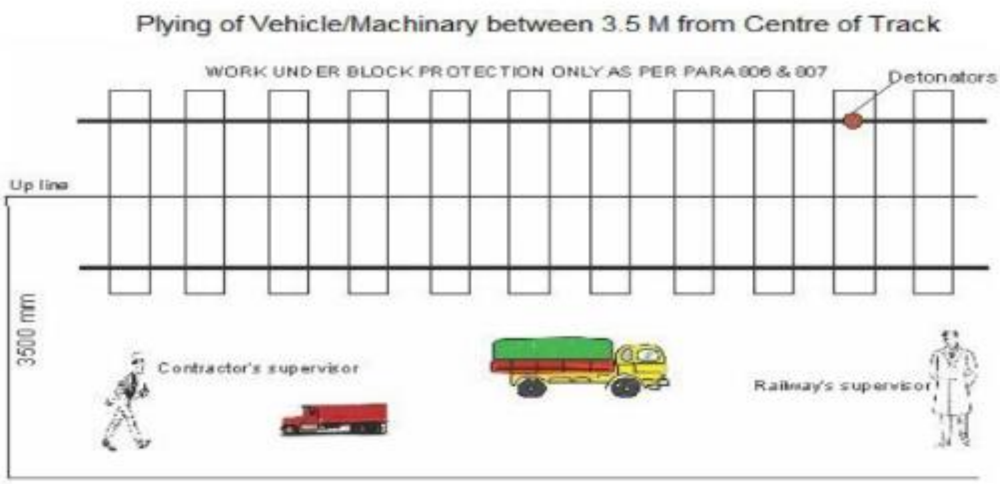
b) Any emergency, if occurs, will be protected and attended by the Railway staff, contractor's staff may assist the Railway staff.

xi) All temporary arrangements required to be made during execution of work shall be made in such a manner that moving dimensions are not infringe. Necessary checks shall be exercised by site in-charge from time to time.

xii) In case, work has been planned to be done within 6m but beyond 3.5 m of centre of track, it shall be ensured that, necessary precautions for protection of track have been taken as per para 806(i) of IRPWM and look out man has been posted where necessary.



xiii) In case work is planned within 3.5 m of centre line of adjacent track, it shall be ensured that the work is done under block protection only and necessary safety precautions for protection to track as per para no. 806 and 807 of IRPWM are taken.



xiv) Proper communication system shall be available in form of Mobile phones or Walkie-Talkie sets, where necessary at works sites.

xv) In one block section, Lorries should be permitted to work at not more than two locations at a time.

xvi) Where turnings of Lorries are found necessary in course of work, locations for reversing for the purpose of turning should be nominated and should be selected in such a way that there is no danger to the running train. At such locations, a Railway official not below the rank of Works / P-Way supervisor should be available with Hand Signal Flag to ensure that the Lorries do not infringe the Standard Dimension for the running lines. Sufficiently strong stoppers or rail barricades should be installed at such locations wherever required to ensure that even by carelessness or oversight the Lorries do not infringe the fixed dimensions. Wherever Lorries have to take turn, the reversing should be done in such a way the driver invariably faces the running lines at all time.
xvii) The new embankment for doubling should be made extra wide at every 500m or so interval for permitting turning/crossing of vehicles/construction machinery. The extra earthwork involved in such widening of embankment, may be included in the schedule of quantities as a paid item.

xvii) Engineering Supervisors and Contractor's representative should ensure the clearance of total infringements before they leave the work site.

xviii) Supplementary site specific instructions, wherever considered necessary, shall be issued by the Engineer in Charge.

xix) While inspecting the worksite check list given in Annexure -II shall be used to ensure that all the Requisites measures have been taken during the execution of the work.

Safety Measures While Undertaking Excavation & Trenching adjacent to Track

i) Before taking up any digging activity on a particular work by any agency Sr. DSTE/DSTE or Sr. DEE/DEE of the section shall be approached in writing by the concerned Eng. or S&T or Electrical officer for permitting to undertake the work.

ii) After getting the permission from S&T or Electrical Dept. as case may be the, relevant portion of the cable route plan shall be attached to the letter through which permission is issued to the contractor by concerned Eng. official for commencement of work and ensuring that the contractors has fully understood the cable rout plan and precautions to be taken to prevent damage to the underground cables. The contractor shall be asked to study the cable plan and follow it meticulously to ensure that the safety the cable is not endangered. Such a provision including any penalty for default should form part of agreement also. However, basic responsibility will be of the Department executing the work and the Contractor.

iii) While digging in station area, if any cable is found, digging should be stopped and concerned signalling /electrical staff should be informed immediately.

iv) No new OFC or Quad cable shall be laid close to the existing track. It shall be laid close to the Railway boundary to the extent possible to avoid any interference with the future work (doubling etc.). It shall be ensured in the new work of the cable laying that the cable route is properly identified with electronic or concrete markers.

v) Trenches and foundation pits should be adequately and securely fenced, provided with proper caution signs and marked with red lights at suitable intervals during night to avoid accidents. Adequate protective measures should be taken to see that the excavation operations do not affect or damage adjoining existing buildings.

vi) Position of all underground installations such as sewer, gas pipes, water pipes, electrical cables and other civic facilities that may cause danger during the work should be checked and proper precautions should be taken not to damage them.

vii) Land should be cleared of trees, loose boulders and other obstructions before excavation commences so as to avoid accidents.

viii) Where hard rock is found with and blasting operations are considered necessary, the contractor should obtain the permission of the Engineer-in-Charge in writing for resorting to blasting operation.

ix) Proper precautions should be taken for safety of persons and adjacent track before undertaking any blasting operation. Red flags should be prominently displayed around the area to be blasted. All the people on the work except those who actually light the fuses should be withdrawn to a safe distance of not less than 300 metres from the blasting site.

Unloading and Stacking of Materials along the Railway Track

i) The sites for material stacking shall be selected in advance ensuring that no part of the stacked material would infringe the standard moving dimensions or inconvenience to any worker or the public. Necessary fencing and lights are to be provided. Later on the material may be stacked to a place from where it may be conveniently disposed-off. A plan of proposed stacking locations be made and signed jointly by a competent Railway representative and authorized Contractor's representative, if stacking is done within 6 meters of track centre.

ii) The selected locations within 6 meters shall be marked by lime in advance.

iii) All unloading operations near the track should be undertaken under the supervision of a competent P.Way Supervisor.

iv) The unloaded ballast/rails/sleepers/other P.Way materials after unloading along track should be kept clear off moving dimensions and stacked as per the specified heights and distance from the running track, which will not cause infringement to SOD in case of accidental roll off.

v) After completion of work, the released sleepers and fittings shall be properly stacked away from the track clear of moving dimensions.

vi) While inspecting the worksite, check list given In Annexure-II shall be used to ensure that all the requisite measures have been taken during the execution of work.

Precaution required to be taken during Execution of Work demanding Traffic Block

i) Any work, which infringes moving dimension, shall be started only after the traffic blocks have been imposed and track protected.

ii) At location where night working is unavoidable, proper lighting arrangement should be made.

iii) Before closing the work, the track shall be left with the proper track geometry so that the trains run safely. After completion of work, the released sleepers and fittings should properly stacked away from the track to be kept clear of moving dimensions.

iv) Block shall be removed only when all the temporary arrangements, machineries, tools, plants, etc. have been kept clear of moving dimensions.

Safety aspects to be observed while working in OHE area

i) The risk of direct contact with live OHE is ever present while working in electrified sections such as for painting of steel work of through spans of bridges and platform cover.

ii) The return current in the rails may cause dangerous voltages. During maintenance or renewal of track, continuity of the rails serving electrified tracks shall invariably be maintained. For bridging gaps which may be caused during removal of fish-plates or rails, temporary metallic jumpers of approved design shall be provided.

iii) No electrical work close to running track shall be carried out without permission of Railway's representative.

iv) No work shall be done within a distance of two meters from the live parts of the OHE without a 'permit-to-work'.

v) While unloading rails from BFRs in an electrified section, it should be ensured that no metallic rod/ stick held by the workmen come in touch with the OHE. A minimum distance of 2 m has to be maintained between live OHE wire and body part of worker or tools or metallic supports, etc.

vi) It is important to note that dangerous voltages may be induced in metallic masses such as fencing posts, continuous metallic mass (unloaded rails) of length greater than 300 metres in the vicinity of traction conductors. To avoid possibility of shock due to such voltages, the metallic structures are bonded together and earthed.

vii) No electric connection etc. can be tapped from OHE.

viii) Authorized OHE staff should invariably be present when the relaying work or any major work is carried out.

ix) In the electrified territories, the cutting and day to day trimming of the trees, wherever required shall be done in the presence of authorized engineering and TRD staff to ensure safety and to maintain the 4 m safety clearances from OHE.

x) Power block is correctly taken and 'Permit to work' is issued.

xi) The structure bonds, track bonds, cross bonds, longitudinal rail bonds are not disturbed and if disconnected for the work, they are reconnected properly when the track work is completed.

xii) The track level is not raised beyond the permissible limit during the work.

xiii) The relative alignment of the centre line of the track with respect to the alignment of the contact wire must be maintained within the specified tolerances.

xiv) No fallen wire or wires shall be touched unless the power has been switched off and the wire or wires have been suitably earthed.

xv) In the electrified section, for carrying out repairs/ painting works etc. to bottom of elevated sections, top chords and bracing of trough type / semi through type girder bridges and other overhead structures over track, power block should be taken before commencing the work in consultation with SSE (Electrical). Staff working on station roofs and signal gantries and similar structures adjacent to Live Overhead

Equipment shall not use any measuring tapes, tools and materials when there is a possibility of their being dropped or carried by wind on to the live overhead equipment.

xvi) In AC traction areas, intimation should be given to the concerned officers of the Electrical General services and also S&T Department, since all the S&T and Electrical lines are cabled on account of Electrical Induction.

xvii) During excavation, if workmen come across tiles or bricks in an arranged manner, they should at once report the matter to the higher officials. Any further excavation should be carried out only in the presence of the authorized staff of Electrical and or S&T department as the case may be.

xviii) No crane shall be worked except on the authorised 'permit-to-work'.

xix) For inspection of roofs and sides of a tunnel, the overhead equipment shall be rendered 'dead'.

Safety during working of Track Machines

Track machine working is likely to produce a dusty atmosphere and/or heavy noise pollution. Hence extra care is necessary at site to ensure safety of workers. For this, the following steps should be taken.

i) Hooters should be provided on the track machines. These hooters should preferably have remove control operation so that the Lookout man standing around 150 m away from the track machine can operate the hooter to warn the staff working on/around the track machine about approaching train on adjoining track.

ii) Temporary `Whistle Board` should be fixed on the adjoining track, which can be moved along with track machine worksite.

iii) It is necessary that all trains passing on the adjoining track should be issued a caution order "OBSERVE HAND SIGNAL, WHISTLE FREELY AND STOP, IF REQUIRED". Such caution order on the adjoining track is necessary due to high noise level caused by track machine and large concentration of staff working around it.

Precautions prior to Demolition of Structure near Running Track

i) If the structure to be demolished is one which may have got hidden damages, caused by fire, flood or earthquake, measures necessary to prevent accidental collapse by way of bracing, shoring, etc., should be provided.

ii) When demolition by explosives has to be resorted to, this should be done only after the approval of the Authority and after taking necessary precautions.

iii) Prominent danger signs should be posted all around the property and all openings giving access to the structures should be kept barricaded or manned except during the actual passage of workmen or equipment. However, provision should be made for at least two independent exits for escape of workmen during any emergency. During night, warning lights should be placed on or above all barricades.

iv) All gas, water, electricity, steam and other service lines should be shut off outside the property line after notifying the service companies and concerned authorities and obtaining their approval. Any temporary service connections required for the demolition work should be separately taken and arranged in such a manner as to afford safety to the workmen.

v) When work is not in progress, watchmen should be provided to prevent unauthorised entry of the public in the danger zone.

vi) All necessary safety appliances should be issued to the workers prior to starting of work.

vii) Safety distances to ensure safety of the public should be clearly marked and prominent sign boards posted. Every sidewalk or road adjacent to the work should be closed or protected.

Dos and Don'ts during Construction for Safety

a. Boulders including CST-9 plate, rail pieces etc., should not be left unguarded in the mid-section to facilitate miscreants for their unauthorized placing on the track particularly in areas prone for such miscreant activities.
b. Whenever construction is undertaken alongside the Railway line, based on the severity of risks and danger, fencing should be erected for complete length of the work section where to prevent any infringements to the moving dimensions likely to be caused by moving or stationary vehicles used for execution of the works. The fencing should conform to the design approved by CE/Construction.
c. Suitable gates/barriers should be installed across the new embankment, preferably adjoining the manned/unmanned level crossings. The entry for the vehicles should be regulated by an authorized representative of the Engineer-in-charge during the working hours.
d. The design & drawings of elevated corridor stretches other than standard designs/drawings, if adopted, should be adopted "in Toto" without any alterations. If any alternation, modification required fresh design should be done.
e. Any unusual noticed at site during fabrication & erection shall be viewed seriously and shall not be neglected. The design section should be consulted immediately. In case it is not possible to attend the same well in time do not keep it in a state affecting the running line till it is attended.
f. Open line Supervisors & Officers should be vigilant about the work being carried out by Construction Organization on & near running lines and promptly bring into the notice of any deficiencies/defects/unusual noticed and prompt remedial action should be taken.
g. During construction it should be ensured that any structure or part of the structure should not be subjected to loads for which it is not designed, especially at elevated sections. Precast slabs to be placed should not be stacked at one place.

- **Safety Audit:** Conducting Periodical Safety Audit, Electrical Safety Audit and External EHS Audit to assess potential risks, liabilities and the degree of compliance of construction Safety as per Safety legislation regulations and requirements of the employer;
- **Safety Training:** Awareness/Orientation Training on Construction Safety and Workers'/Personnel Safety through Workshops, Tool Kit training, Mock Drills, etc.
- **Safety Management** through campaigns and display of safety banners, posters, billboards, glow sign boards, etc. at and near work places;

- **Accident reporting** and investigation as per Employer's requirements and Govt. Regulations
- Periodical Reporting of all accidents(fatal, injury, Near misses and minor accidents) and dangerous occurrences to the Employer and
- Periodical Reporting of Investigations conducted for Accidents and dangerous occurrences to Govt. organisations, as per requirement.
- Preparation of an Emergency Response Plan for all work sites including injury, sickness, evacuation, fire, chemical spillage, severe weather and rescue.
- All preventive measures shall be taken for Fire Safety. Adequate Fire extinguishers shall be provided at Plant site and Base Camp locations.
- The Contractor shall employ qualified personnel on site and for requirements of operation of electrical machinery/equipment, distribution, etc. and for handling of chemicals and other materials.
- Safety Reporting – reports, minutes, inspection reports, and Training & audit reports

Residual Impact: No impact on the ecosystem.

With proper implementation of the proposed mitigation measures the likelihood of any residual impact on occupational health and safety will be reduced as much as practically possible but are still considered as minor during construction.

8.6.15. Community Health and Safety Risks

Risks and Impacts : The risks and impacts of the project on the health and safety of the affected communities during the project are assessed as part of the Environmental Impact Assessment. Project-related activities may directly, indirectly or cumulatively change community exposure to hazards.

The preventive measures and plans to address Community Health and Safety will favour the prevention or avoidance of risks and impacts over their minimization and reduction. Appropriate ad project specific health and safety assessments are undertaken with good international practice, tailored to the project specific activities.

Health and Safety risks in the project are known to be associated with (a) nearby Water bodies with risks of drowning, flooding, or water-related diseases; (b) Waste disposal activities with risks of toxicity, waste dump collapse, or air pollution; (c) failure in the operation of equipment; (d) Water and sanitation services involving risks of contaminated water or spread of disease; (e) Electricity supply at work sites which may result in electric shock from electrical cabinets or cables; (f) Service providers, who may use their service for the purpose of financial, sexual, or other exploitation, particularly of vulnerable groups such as women, children, and the elderly people. The project shall be managed during construction by implementing all required health and safety protocols.

The assessment and adopted management measures take into account differences in risk exposure and sensitivity of women and men, as well as marginalized and disadvantaged groups, including children, older persons; persons with disabilities, minorities and local people.

8.6.15.1. Infrastructure and equipment design and safety

The Structural Design of Structural elements of the project is carried out by the competent professional considering the climate change also and will be in accordance with the Indian Railway Standards, EHS guidelines and other applicable guidelines/Manual. The project location is not at high risk situations. However, the potential exposure of community to operational accidents or natural hazards including extreme weather conditions is considered.

- The construction or installation/commission of plants, equipment, machinery and structures shall be carried out by the Contractor with due care and concern to communities.
- Standard and approved plant, equipment and machinery shall be used in the project by the Contractor.
- Necessary caution/warning signage, safety barricades, shall be applied during work execution.
- Other than the workers no one shall be allowed to enter the work sites.
- Also the construction of the same will be carried out by competent contractors in accordance with the applicable standards.
- International EHS guidelines shall be followed by the Contractor to ensure community safety.

In addition, Contractors working for project-related construction activities, ensure appropriate control of site access (e.g. fencing, security), use of appropriate personal protective equipment, safely designed work platforms, appropriate engineering and administrative controls (e.g. detours, traffic calming, signs), and safety barriers. Construction personnel will have appropriate qualifications and training. Where public access is intended, incremental risks of public's potential exposure to operational accidents or natural hazards are considered. Additionally, during construction potential traffic and road safety risks associated with project activities will be identified, evaluated and monitored by the Contractor and the Supervision authorities. Contractors working on project sites will ensure that appropriately manage health and safety risks and address the requirements.

8.6.15.2. Traffic and Road safety

Traffic and Road Safety risks shall be assessed during every phase of construction by the Contractor in consultation with local traffic officials and the Environmental and Safety personnel of GC and K Ride Officials.

- Impacts associated with the increased movement of people will be mitigated by the traffic and safety management by the Contractor.
- Traffic measures shall be taken up as mentioned in the Section Traffic Management in this Chapter.
- Proper Training shall be provided for Drivers, as required.
- Safety records shall be maintained by the Contractor.
- Construction Vehicular maintenance shall be ensured by the Contractor.
- Haulage vehicles shall be covered with tarpaulins to avoid any spillage of materials on the public road to avoid any nuisance or accidents to community people and public properties.
- Necessary barricading and signage shall be adopted when equipment is operated at work sites near settlements or public movements.

- Guiding and Safety person/security persons shall be employed to avoid any risks and impacts of hazards.
- Public/Community opinion shall be considered in case of needy situations.

Residual Impacts: No impact on the ecosystem.

8.6.15.3. Ecosystem Protection

Measures shall be taken to ensure that local ecosystem such as Water bodies along corridors 1 and 4 will not get disturbed and affect the community. Also it is noticed that nowhere community is dependent on the nearby water bodies and terrestrial ecosystem (particularly flora –plants for cattle) for their daily chores. The mitigation measures shall be undertaken as given under Environmental aspects such as climate change, Air Quality, Water Quality, Soil erosion, Protection of Flora, etc.

Residual Impacts: No negative impact on the ecosystem.

8.6.15.4. Hazardous materials and Safety

There are no hazardous materials or its handling /operation proposed in the project. There will be no carriage of hazardous goods or any materials. Hence, there is no risk of hazards due to hazardous materials. General measures are provided in EMAP – Table 10.2.

8.6.15.5. Universal access

Wherever feasible, it is ensured by the project authority that the concept of universal access is applied in the design and construction of facilities and services open to or provided to the public on an equal basis with others.

8.6.15.6. Emergency Preparedness and Response

Emergency events include unanticipated incidents arising from both natural and human-made hazards, typically in the form of fire, explosions, leaks or spills due to failure during operation of plants, equipment and machinery or during transportation of construction materials; or caused by failure to implement operating procedures, extreme weather or lack of early warning. An Emergency Response Plan (ERP) provided under the Chapter 10 – Environmental Management Plan (EMP) shall be referred and followed by the Contractor during construction. This ERP will be modified by the Contractor with respect to Workers safety and Community Safety, in co-ordination with local people, traffic Department and other concerned authorities. There is a requirement for personnel involved in the Emergency Response Plan to be familiar with and trained in terms of its requirements. Mock drill and training will be included in the same and local community will be invited for the same. Emergency Response Plan will be disclosed to public with proper notification. Records shall be maintained by the Contractor and submitted to K RIDE. The same will be implemented after the approval from the GC and K RIDE.

ERP is prepared by the Contractor to respond to accidental and emergency situations in a manner appropriate to prevent and mitigate any harm to people and/or the environment. Emergency preparedness, reflected in planning documents, includes the identification of areas where accidents and emergency situations may occur, communities and individuals that may be impacted, response procedures, provision of equipment and resources, designation of responsibilities, communication and notification channels, and periodic training to ensure effective response. The emergency preparedness and response activities is periodically reviewed and revised, as necessary to reflect changing conditions. Moreover, it is also ensured to consider the differential impacts of emergency situations on women and men, the elderly, children, persons with disabilities, and potentially marginalized groups, and strengthen the participation of women in decision-making processes on emergency preparedness and response strategies. Appropriate information about emergency preparedness and response activities, resources, and responsibilities with remedies will be disclosed to affected communities.

Residual Impacts: No negative impact on the ecosystem.

8.6.15.7. Security-related Safety

Security personnel shall be employed directly or through contracted agencies by the Contractor (during Construction) or by K Ride (during operation) to safeguard project facilities, personnel and properties or to otherwise engage in project activities. Human rights of security guards shall be protected in line with The National Security Guard Act, 1986. The risks and impacts of Security personnel anticipated include abuses and all allegations of unlawful or abusive acts to the community people inside or outside the project.

Mitigation Measures : The following mitigation measures shall be undertaken :

- Security arrangements shall be provided in a manner that does not violate international human rights standards or principles, or jeopardize the community's safety and security.
- Reasonable inquiries shall be made by the Contractor (during Construction) or by K RIDE (during operation) to verify that potential security personnel have not been implicated in past abuses and all allegations of unlawful or abusive acts; same will be reviewed and actions taken to prevent recurrence and reprisals against individuals and communities.
- Trained security personnel with good and proper back ground shall be assessed before deployment.
- Regular training shall be provided to the security personnel in the use of force and appropriate conduct towards workers and communities in the vicinity.
- Potential risks posed by security arrangements to those within and outside the project area shall be assessed, that those providing security are appropriately vetted, trained and supervised, and that security arrangements are appropriately monitored and reported by the Contractor during Construction Stage and K RIDE during operation stage. Wherever necessary, unlawful and abusive acts if noticed, will be reported to K Ride.
- K RIDE will review abuses and all allegations of unlawful or abusive acts of the security personnel and actions will be taken in line with the applicable law and regulations by reporting to the relevant authorities.

8.6.15.8. Health and Safety of Community Members Living and Working near Existing Railway Lines

Potential safety risks : The main risks to community near existing railway lines are:

- Being hit by a train, on-track plant, or a road-cum-rail vehicle while carelessly crossing railway lines
- Electrocution from an overhead live power line (or a conductor rail) or from the strung conductor due to induction
- Falls with fatal or non-fatal accidents at construction sites

Mitigation Measures : Measures to avoid accidents include the following :

- Restricting access to the sites through a combination of institutional and administrative controls, with a focus on risk structures or areas depending on site specific situations including fencing, signage and communication of risks to the local community.
- Removing hazardous conditions on construction sites that cannot be controlled effectively with site access restrictions, such as covering any openings or pits left to small confined areas, ensuring means of escape to larger openings such as trenches or excavations, or locked storage of hazardous materials

Residual Impacts: No adverse impact on the ecosystem.

8.6.15.9. Health and Safety Risks due to Noise & Vibrations

Noise-induced hearing loss remains highly prevalent in occupational settings of workers working and local community living near existing railway lines. Impacts may be auditory or non-auditory impairments. Non-auditory effects of noise can cause tinnitus, headache, auricular plenitude, dizziness, and gastric, endocrine imbalance, cardiovascular disorders, loss of sleep/insomnia (6% population approximately) and mood disorders. Health effects of environmental noise are manifold, serious and, because of the widespread exposure, very prevalent.

Mitigation Measures : Measures to reduce the risk of health impacts include the following :

- Selecting equipment with lower sound power levels
- Installing silencers for fans, if applicable
- Installing suitable mufflers on engine exhausts and compressor components
- Installing acoustic enclosures for equipment radiating noise
- Installing temporary solid noise barriers or sound insulators near sensitive receptors and nearby community buildings
- Installing acoustic barriers without gaps and with s continuous minimum surface density of 10 Kg/m2 in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the receptor locations to be effective
- Installing vibration isolation for mechanical equipment
- Limiting the hours of operation for specific equipment, especially mobile sources operating through community areas
- Re-locating noise sources to less sensitive areas to take advantage of distance and shielding
- Siting permanent facilities away from community areas, as far as possible
- Taking advantage of the natural topography as a source buffer during facility design
- Reducing project traffic through community areas wherever possible
- Developing a mechanism to record and respond to communities and to take remedial actions

Residual Impacts: No adverse impact on the ecosystem.

8.6.15.10. Health and Safety Risks due to influx of Labour or Work Force

There may be chances of risks such as Gender-Based Violence (GBV) or Sexual Exploitation and Abuse (SEA) of children, or spread of communicable diseases, which may arise from the interaction of project workers with local communities. A significant concern is the spread of communicable diseases from the workforce to the surrounding communities. These risks are potentially high due to labour influx in the project, BSRP.

Mitigation Measures : General Health and Safety of the Public /local community shall be addressed with the following measures:

- Establishing workers camps separated from local communities (500ms away from the settlements) with strict protocols for interaction with local communities in order to avoid project impacts from labour influx;
- Implementing sensitization and specific mitigation measures for social impacts from labour influx during construction or service provision of the project;
- Adopting all required mitigation measures to avoid air, water, soil and noise pollution & vibration as mentioned under Mitigation Measures for air, water, soil and noise pollution & vibration Sections in this Chapter;
- Providing first aid facilities and establishing health clinics;
- Incorporating safe road crossings into project design;
- Implementing safety signage and traffic management during construction at work sites;
- Adopting all required safety protocols at work sites
- Strict following of protocols for temporary blasting during demolition at the reinstatement or restoration phase;
- Establishing emergency-response planning and monitoring for pollution or other incidents during operation.
- Attention shall be given to the health and safety risks posed by the influx of workers or people providing support services into an area as a result of the project. Risks such as Gender-Based Violence (GBV) or Sexual Exploitation and Abuse (SEA) of children, or communicable diseases, which may arise from the interaction of project workers with local communities, shall be totally avoided by taking diligent care and concerns.
- Measures also include the employing of skilled trainers to raise awareness among project workers of the risks, expected behaviours, and consequences of violations, communicated through training, and publicized codes of conduct. The environmental and social documents shall be maintained for the project to describe such community health and safety risks and measures to address them.
- Periodical Health and Safety Awareness programs shall be conducted among local community members and health authorities regarding the risks and measures among community members and inform them about available grievance mechanisms.
- The risks and mitigation measures relating to project workers shall be reflected in the labour management procedures for the project.

- Local health authorities are advised and requested by the project authority K RIDE to ensure appropriate processes are in place for community feedback and taking any necessary action.

Residual Impacts: No adverse impact on the ecosystem.

8.6.15.11. Community Exposure to Health Risks

Air, Water and Vector-borne Diseases:

An airborne disease is any disease that is caused by pathogens and transmitted through the air. Airborne diseases such as common cold, pneumonia, tuberculosis, etc. are spread when droplets of pathogens are expelled into the air due to coughing, sneezing or talking. Water-borne disease is any disease that is caused by pathogenic microorganisms. Water-borne diseases such as Cholera, jaundice, dysentery, dengue, typhoid, etc. most commonly transmitted through contact or consumption of infected water.

Mitigation measures to prevent air borne diseases include the following :

- Stay away from the diseased person.
- Wear a mask when you need to contact a diseased person.
- Cover your mouth and nose while coughing or sneezing to prevent the spread of the disease.

Mitigation measures to prevent water borne diseases

- Ensure proper disposal of sewage.
- Ensure safe drinking water supply.

Mitigation measures to prevent vector borne diseases arising from wastes are as mentioned below :

- Provide a clean environment, which helps in preventing vectors like mosquitoes from breeding.
- Availability of proper nutrition - If proper and sufficient nutrition is not available, the immune system of the body will not function properly.

Communicable diseases

Sensitive people in the community are vulnerable to the communicable diseases such as HIV-AIDs, Influenza, COVID, etc. which are transmitted through contact with blood and bodily fluids; breathing in an airborne virus; or by being bitten by an insect. Following measures shall be followed and advised to adopt by the community and workers whoever affected :

- washing hands thoroughly and regularly after using toilet and before taking any food
- disinfecting commonly used surfaces at home and outside, especially doorknobs and food areas
- disinfecting personal items such as phones
- avoiding sharing Personal Items
- cooking foods thoroughly
- practicing good hygiene when preparing and handling food

- using face masks
- coughing and sneezing into a Tissue or to Sleeve
- avoiding eating spoiled food
- avoiding touching wild animals
- receiving available vaccinations
- taking antimalarial medications when traveling where there is a malaria risk
- checking for ticks and other parasites
- resting when sick

Non-communicable diseases

Non-communicable diseases (NCDs) include hypertension, heart disease, stroke, cancer, diabetes, chronic lung disease, etc. which may arise due to night time works, air and noise pollution due to project activities such as earth works and plant, equipment or machinery operation, works at height, etc. without any proper care and safety and traffic management. Measures are as follows :

- following air and noise pollution mitigation measures as stated under Environmental aspects of this Chapter.
- Following traffic management during project activities and at work sites
- Avoiding night time works near habitats
- Alerting community people before commencing works
- Consulting local community regularly/periodically before commencing any works at site

Residual impact: With proper implementation of the proposed mitigation measures the likelihood of any residual impact on public health and safety will be reduced as much as possible.

8.6.16. Risks and Impacts on Cultural Heritage and Archaeological and Historical/Cultural Properties

8.6.16.1. Archaeological and Historical/Cultural Properties

The risks and impacts on legally protected Archaeological Monuments are anticipated only at Corridor 1 which has protected archaeological monuments such as Devanahalli Fort and Tippu Sultan's Birth Place at Devanahalli, as per The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010. There are no Archaeological monuments or Heritages noticed along other 3 corridors of the project.

As per the base line study and impact analysis, no damage to Archeological Monuments is predicted. However, during construction, archaeological or historical structures may get affected by direct or indirect construction activities. There are about 106 cultural/religious structures present along the project corridors.

Mitigation Measures : A prior survey shall also be conducted before construction to identify if there is any historical structure nearby construction sites, which may get impacted. Necessary measures shall be undertaken accordingly, if any. Devanahalli Fort and Tippu Sultan birth Place at Devanahalli are the Archaeological Survey of India Protected monuments located at 228m and 271m respectively to the alignment – Corridor 1, for which necessary procedure will be followed to obtain the necessary construction permit from ASI. Prior to the initiation of construction, K RIDE will inform the ASI authority.

Stipulated measures shall be implemented as per the stipulated conditions of ASI and in line WB ESS 8 & EIB's ESS 10. ASI Stipulations to be followed are as follows -

1) Interpretation panels/signage must be provided for the monument.
2) Drainage system should be checked so that the corridor level should not be higher than the monument and water should not enter inside the monument complex.
3) Prior intimation should be given to ASI authority to monitor the site and also to check the impact on monument during /post digging (excavation) process.
4) Prior permission must be obtained from the Competent Authority for any construction or increase in height.
5) A certificate should be furnished to the Competent Authority on completion of proposed construction to effect that it has complied with all conditions of the permission.
6) The compliance must be with the heritage bye-laws of the protected monument concerned as and when the bye-laws are approved.
7) In case of cultural/religious structures, water sprinkling, barricading, flagman and signboard should be provided.

Residual Impacts: With proper implementation of prevention measures no impact on physical and cultural resources or environment is expected.

8.6.16.2. Chance find procedures

All fossils, coins, articles of value of antiquity, structures and other remains of archaeological interest discovered on the sites shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation - The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI) and in line WB ESS 8 and EIB Standard 10.

The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He shall, immediately upon discovery thereof and before removal acquaint the Environmental Specialist of GC of such discovery and carry out the GC's instructions for dealing with the same. Works shall be resumed once approval is obtained from the GC and K RIDE. The GC shall seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work in the site. The Archaeological structures/ materials identified along the project corrid ors, if any, shall be protected/ preserved or enhanced and handed over to ASI as per the law. The details regarding Chance Find procedure is given in **Annexure 10.5.**

Residual Impacts: With proper implementation of chance find procedures no impact on physical and cultural resources is expected.

8.7. Impacts Due to Project Operation and its Mitigation Measures

Along with many positive impacts the project may cause the following negative impacts during operation of the project:

- Risks & Impacts on Noise Level
- Risks & Impacts on Vibration
- Risks & Impacts on Track Side Vegetation
- Energy Consumption at stations and Efficiency
- Electro-magnetic Compatibility
- Risks & Impacts on Ground water
- Risks & Impacts due to Depots and Stations
- Risks & Impacts on Air Quality due to Inter model operational vehicles
- Water supply, Waste water and Municipal solid waste disposal at Stations
- Risks & Impacts on Topography and Natural Drainage
- Soil Erosion at Closed Borrow areas and Embankments
- Pedestrian and Road Traffic Congestion around Stations
- Risks & Impacts on Operational and Community Safety
- Risks & Impacts on Community Health

8.7.1. Risks & Impacts on Noise Level

Impact of noise pollution caused due to the project activities during operation phase has been predicted as briefly discussed in sections below.

8.7.1.1. Noise Modelling

Noise Modelling is a powerful tool to assess noise from industrial facilities with many noise sources. The SoundPLAN 8.2 software was used to predict noise levels from the proposed rail traffic. Soundplan is used in

- Calculation of sound propagation from the noise source to the relevant receiver.
- Prognosis, documentation and noise reduction measures for a present or future noise situation

SoundPLAN 8.2 is integrated with a GIS tool which provides storing and retrieving, transforming and displaying spatial data. SoundPLAN 8.2 facilitates the visual representation of the noise effects and an additional tool for analysing the results. The model provides fast and accurate assessment of the anticipated sound pressure levels. Noise contours can be generated in the software based on the noise propagation calculation. It is possible to generate a continuous spatial model of noise levels using SoundPLAN 8.2. The maps are a graphical representation of the calculated sound pressure levels, considering the possible reflections and diffractions of sound, and the geometry of buildings at the site and topography. SoundPLAN 8.2 generates industrial noise maps using the calculation methods given by standards ISO 9613:1996 for noise propagation.

The detailed methodology used for the present study is given in **Figure 8.16**.

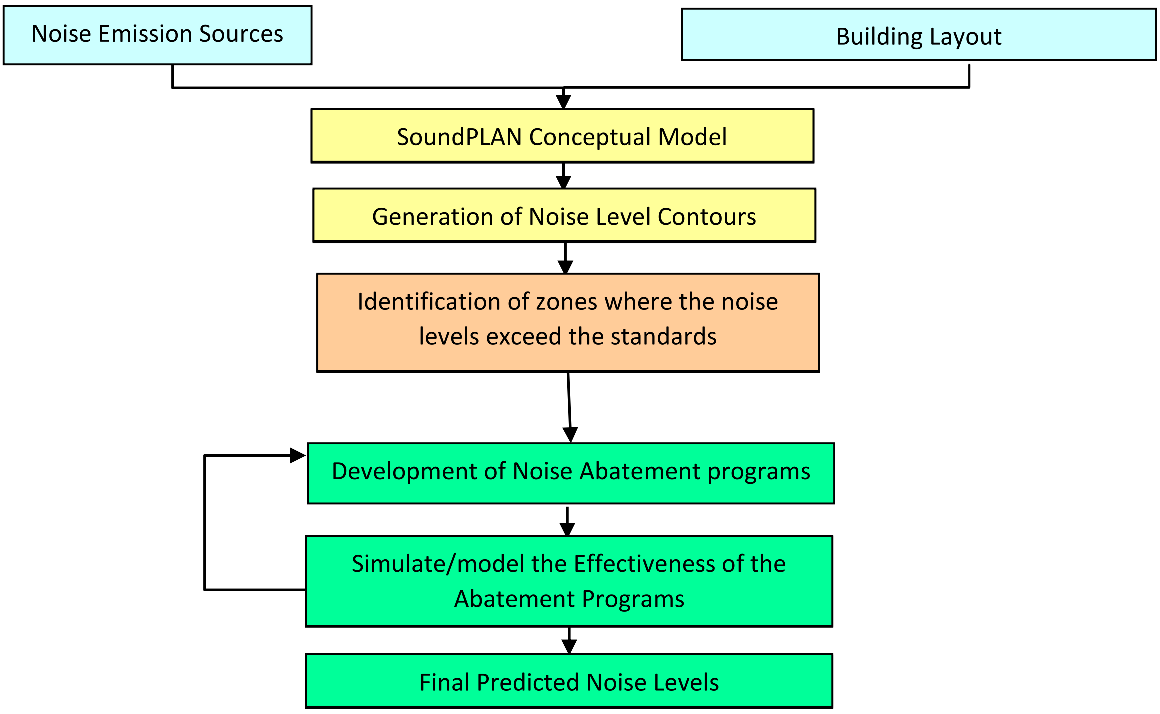


Figure 8.16. Modelling Methodology

Model Inputs and Assumptions

Standards Used

Railway Noise Calculation Standards – FTA/FRA-HGST (2005) Standards were used to compute the rail noise with the help of SoundPLAN 8.2.

Model Parameters Considered

- Assessment Period: Day Average (LrD), Night Average (LrN), Day-Night Average (LrDN
- Emission Time Slices : 6-22, 22-6, 0-24
- Reflection Order : 2
- Maximum Search Radius: 1500 m
- Maximum Reflection Distance : 200 m
- Grid Map Spacing : 10 m

Study Area

A 50 m buffer on either side of all proposed railway line is generated using GIS software and the same was utilized as study area to assess the impacts of noise. Buildings falling within this 50 m buffer area was mapped and incorporated into the noise model.

Topography and Terrain

ASTER Digital Elevation Model (DEM) procured from Unites States Geological Survey (USGS) with a spatial resolution of 15 m was used to generate the Digital Ground Model.

Building Attributes

Building footprint data was obtained from the open street map in the form of polygon shapefiles and imported into the SoundPLAN 8.2 software.

Rail Noise Inputs

Train Speed

The present study has been done considering the train design speed of 90 KMPH.

Proposed Railway Line, Bengaluru City – Devanahalli (Corridor 1)

The total length of the corridor is 41.40 Km out of which 18.98 Km is elevated and 'At Grade' is 22.42 Km. It has a total of 15 Nos. of stations out of which 8 Nos. of stations are elevated and 7 Nos. of stations are 'At Grade'.

Rail Traffic

The hourly train operation plan for the sub urban rail corridors for the year 2025, 2031 and 2041 were adopted from the detailed project report and presented in **Table 8.30**.

Table 8.30. Hourly Train Operation Plan for Bengaluru City – Devanahalli (Corridor 1)

From	To	Cars/Train	Trains/Hour		
			2025	2031	2041
12:00 AM	1:00 AM	6	0	0	0
1:00 AM	2:00 AM	6	0	0	0
2:00 AM	3:00 AM	6	0	0	0
3:00 AM	4:00 AM	6	0	0	0
4:00 AM	5:00 AM	6	0	0	0
5:00 AM	6:00 AM	6	2	2	3
6:00 AM	7:00 AM	6	3	4	5
7:00 AM	8:00 AM	6	4	5	6
8:00 AM	9:00 AM	6	6	7	9
9:00 AM	10:00 AM	6	6	7	9
10:00 AM	11:00 AM	6	5	6	7
11:00 AM	12:00 PM	6	4	4	5
12:00 PM	1:00 PM	6	3	4	5
1:00 PM	2:00 PM	6	2	2	3
2:00 PM	3:00 PM	6	3	4	5
3:00 PM	4:00 PM	6	4	4	5
4:00 PM	5:00 PM	6	5	6	7
5:00 PM	6:00 PM	6	6	7	9
6:00 PM	7:00 PM	6	6	7	9
7:00 PM	8:00 PM	6	5	6	7
8:00 PM	9:00 PM	6	4	4	5
9:00 PM	10:00 PM	6	3	4	5
10:00 PM	11:00 PM	6	2	3	4

From	To	Cars/Train	Trains/Hour		
			2025	2031	2041
11:00 PM	12:00 AM	6	2	2	3
Total			**75**	**88**	**111**

Source: BSRP Feasibility Report

Post Project (Cumulative) Noise Estimation

The baseline noise readings and model predicted noise pressure values are added logarithmically to estimate the cumulative noise values. The estimated noise values of the different scenarios (horizon year) are given in the following tables.

Table 8.31. Corridor 1 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (without barrier)

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ1	57.1	45.3	60.5	51	62.1	52.0	57.1	45.3	61.2	51	62.6	52.0	57.1	45.3	62.2	52.8	63.4	53.5
NQ2	56.1	43.9	64.3	54.8	64.9	55.1	56.1	43.9	65	54.8	65.5	55.1	56.1	43.9	66	56.6	66.4	56.8
NQ3	54.8	41.3	73.6	64.1	73.7	64.1	54.8	41.3	74.3	64.1	74.3	64.1	54.8	41.3	75.3	65.9	75.3	65.9
NQ4	53.5	43.8	74.5	65	74.5	65.0	53.5	43.8	75.2	65	75.2	65.0	53.5	43.8	76.2	66.8	76.2	66.8
NQ5	52.8	41.6	78	68.5	78.0	68.5	52.8	41.6	78.7	68.5	78.7	68.5	52.8	41.6	79.7	70.3	79.7	70.3
NQ6	55.7	42.8	63	53.5	63.7	53.9	55.7	42.8	63.7	53.5	64.3	53.9	55.7	42.8	64.7	55.3	65.2	55.5
NQ7	51.6	38.5	66.7	57.2	66.8	57.3	51.6	38.5	67.4	57.2	67.5	57.3	51.6	38.5	68.4	59	68.5	59.0
NQ8	52.1	40.6	63.7	54.2	64.0	54.4	52.1	40.6	64.4	54.2	64.6	54.4	52.1	40.6	65.4	56	65.6	56.1
NQ9	60.8	48.2	64.2	54.7	65.8	55.6	60.8	48.2	64.9	54.7	66.3	55.6	60.8	48.2	65.9	56.5	67.1	57.1
NQ10	53.5	41.8	64.2	54.7	64.6	54.9	53.5	41.8	64.9	54.7	65.2	54.9	53.5	41.8	65.9	56.5	66.1	56.6
NQ11	53.2	42.9	73.6	64.2	73.6	64.2	53.2	42.9	74.3	64.1	74.3	64.1	53.2	42.9	75.3	65.9	75.3	65.9
NQ12	52.8	41.7	60.9	51.4	61.5	51.8	52.8	41.7	61.6	51.4	62.1	51.8	52.8	41.7	62.6	53.2	63.0	53.5
NQ13	53.9	40.8	62.9	53.5	63.4	53.7	53.9	40.8	63.6	53.4	64.0	53.6	53.9	40.8	64.6	55.2	65.0	55.4
NQ14	52.5	41.1	72.3	62.8	72.3	62.8	52.5	41.1	73	62.8	73.0	62.8	52.5	41.1	74	64.6	74.0	64.6
NQ15	53.1	41.9	64	54.5	64.3	54.7	53.1	41.9	64.7	54.5	65.0	54.7	53.1	41.9	65.7	56.3	65.9	56.5
NQ16	54.6	42.8	61.4	51.9	62.2	52.4	54.6	42.8	62.1	51.9	62.8	52.4	54.6	42.8	63.1	53.7	63.7	54.0
NQ17	51.9	39.2	56.9	47.4	58.1	48.0	51.9	39.2	57.6	47.4	58.6	48.0	51.9	39.2	58.6	49.2	59.4	49.6
NQ18	53.6	42.7	68.4	58.9	68.5	59.0	53.6	42.7	69.1	58.9	69.2	59.0	53.6	42.7	70.1	60.7	70.2	60.8
NQ19	52.4	41.1	70.4	60.9	70.5	60.9	52.4	41.1	71.1	60.9	71.2	60.9	52.4	41.1	72.1	62.7	72.1	62.7

Table 8.32. Corridor 1 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (With Barrier)

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ1	57.1	45.3	45.3	35.8	57.4	45.8	57.1	45.3	46.3	36.1	57.4	45.8	57.1	45.3	47	37.6	57.5	46.0
NQ2	56.1	43.9	66.3	56.8	66.7	57.0	56.1	43.9	68.1	57.9	68.4	58.1	56.1	43.9	68	58.6	68.3	58.7
NQ3	54.8	41.3	75.7	66.3	75.7	66.3	54.8	41.3	77.7	67.5	77.7	67.5	54.8	41.3	77.4	68	77.4	68.0
NQ4	53.5	43.8	43.7	34.2	53.9	44.3	53.5	43.8	44.5	34.3	54.0	44.3	53.5	43.8	45.4	36	54.1	44.5
NQ5	52.8	41.6	78.1	68.6	78.1	68.6	52.8	41.6	79	68.8	79.0	68.8	52.8	41.6	79.8	70.4	79.8	70.4
NQ6	55.7	42.8	65.5	56	65.9	56.2	55.7	42.8	67.6	57.4	67.9	57.5	55.7	42.8	67.2	57.8	67.5	57.9
NQ7	51.6	38.5	66.7	57.2	66.8	57.3	51.6	38.5	67.4	57.2	67.5	57.3	51.6	38.5	68.4	59	68.5	59.0
NQ8	52.1	40.6	46.3	36.9	53.1	42.1	52.1	40.6	47.4	37.2	53.4	42.2	52.1	40.6	48	38.6	53.5	42.7
NQ9	60.8	48.2	64.2	54.7	65.8	55.6	60.8	48.2	64.9	54.7	66.3	55.6	60.8	48.2	65.9	56.5	67.1	57.1
NQ10	53.5	41.8	64.3	54.8	64.6	55.0	53.5	41.8	65.1	54.9	65.4	55.1	53.5	41.8	66	56.6	66.2	56.7
NQ11	53.2	42.9	73.6	64.2	73.6	64.2	53.2	42.9	74.3	64.1	74.3	64.1	53.2	42.9	75.3	65.9	75.3	65.9
NQ12	52.8	41.7	60.9	51.4	61.5	51.8	52.8	41.7	61.6	51.4	62.1	51.8	52.8	41.7	62.6	53.2	63.0	53.5
NQ13	53.9	40.8	62.9	53.4	63.4	53.6	53.9	40.8	63.6	53.4	64.0	53.6	53.9	40.8	64.6	55.2	65.0	55.4
NQ14	52.5	41.1	50.3	40.9	54.5	44.0	52.5	41.1	51	40.8	54.8	44.0	52.5	41.1	52	42.6	55.3	44.9
NQ15	53.1	41.9	63.4	54	63.8	54.3	53.1	41.9	64.1	53.9	64.4	54.2	53.1	41.9	65.1	55.7	65.4	55.9
NQ16	54.6	42.8	61.3	51.8	62.1	52.3	54.6	42.8	62	51.8	62.7	52.3	54.6	42.8	63	53.6	63.6	53.9
NQ17	51.9	39.2	56.9	47.4	58.1	48.0	51.9	39.2	57.6	47.4	58.6	48.0	51.9	39.2	58.6	49.2	59.4	49.6
NQ18	53.6	42.7	68.4	58.9	68.5	59.0	53.6	42.7	69.1	58.9	69.2	59.0	53.6	42.7	70.1	60.7	70.2	60.8
NQ19	52.4	41.1	72.6	63.1	72.6	63.1	52.4	41.1	74.6	64.4	74.6	64.4	52.4	41.1	74.3	64.9	74.3	64.9

The Noise modelling results for Corridor 1 for baseline environmental monitoring locations for the projected horizon period shows that, there is a considerable reduction in cumulative noise level ie., 8 to 10 db(A) for day time and night time for with barrier and without barrier scenario.

Impact on Sensitive Areas

Predicted Noise on the Building Façade

The impact on sensitive receptors for Corridor 1 for various years 2025, 2031 and 2041 are presented in table below. This has been done with proven statistical methods (by adopting Sound Attenuation - Inverse Square Law).

The inverse square law formula is as follows,

$$Lp(R2)=Lp(R1)-20\cdot Log10(R2/R1)$$

Where:

Lp(R1) = Known sound pressure level at the first location (typically measured data or equipment vendor data)

Lp(R2) = Unknown sound pressure level at the second location Location

R1 = Distance from the noise source to location of known sound pressure level

R2 = Distance from noise source to the second location

Note: Lp(R1) is taken from the model calculated value of SoundPLAN Rail Noise.

Impact on Sensitive Areas

Predicted Noise on the Building Façade

The impact on sensitive receptors for various years 2025, 2031 and 2041 are presented in **Table 8.33** and **Table 8.34**. Noise contour maps showing with barrier and without barrier for environmental features including receptors are presented in **Annexure 8.6.**

Table 8.33. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 1 Right Hand Side

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Barrier-2041		
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)		Lr D	Lr N	LrD N	Lr D	Lr N	LrD N	Lr D	Lr N	LrD N	Lr D	Lr N	LrD N	Lr D	Lr N	LrD N	Lr D	Lr N	LrD N	Lr D	Lr N	LrD N	Lr D	Lr N	LrD N	Lr D	Lr N	LrD N
1	2+100	New Clinton Public High School, Srirampura.	35	38	18	40x1.2x0.2	86	78	82	87	79	83	88.3	80.3	84.3	43.2	37	40.0	60.4	52	56.4	44.0	38	40.8	61.4	53	57.4	45.1	39	41.9	62.7	55	58.7
2	2+770	Manipal Hospital, Malleshwaram.	45	47	18	50x1.2x0.2	86	78	82	87	79	83	88.3	80.3	84.3	41.4	35	38.2	58.6	51	54.6	42.2	36	39.0	59.6	52	55.6	43.2	37	40.0	60.9	53	56.9
3	3+200	Cluny Convent High School Malleshwaram	10	30	18	70x1.3x0.3	86	78	82	87	79	83	88.3	80.3	84.3	45.3	39	42.1	62.5	54	58.5	46.1	40	42.9	63.5	55	59.5	47.1	41	43.9	64.8	57	60.8
4	10+900	Bishop Sergeant Central School, Lottegollahalli.	10	10	12	-	86	78	82	87	79	83	88.3	80.3	84.3	54.8	48	51.6	72.0	64	68.0	55.6	49	52.4	73.0	65	69.0	56.7	50	53.5	74.3	66	70.3
5	13+500	Dental Clinic, Kodigehalli.	25	25	18	15x1.2x0.2	86	78	82	87	79	83	88.3	80.3	84.3	46.9	40	43.7	64.1	56	60.1	47.7	41	44.5	65.1	57	61.1	48.7	42	45.5	66.4	58	62.4
6	3+100	Nitte Global Institute, Yelahanka.	25	50	25	100x1.2x0.2	86	78	82	87	79	83	88.3	80.3	84.3	40.8	34	37.6	58.0	50	54.0	41.6	35	38.4	59.0	51	55.0	42.7	36	39.5	60.3	52	56.3
7	3+150	Hostel, Nitte Global Institute, Yelahanka.	30	50	20	70x1.2x0.2	86	78	82	87	79	83	88.3	80.3	84.3	40.8	34	37.6	58.0	50	54.0	41.6	35	38.4	59.0	51	55.0	42.7	36	39.5	60.3	52	56.3
8	12+580	Clinic, Doddajala.	-	15	14	-	86	78	82	87	79	83	88.3	80.3	84.3	51.3	45	48.1	68.5	60	64.5	52.1	46	48.9	69.5	61	65.5	53.1	47	49.9	70.8	63	66.8

Table 8.34. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 1 Left Hand Side

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Barrier-2041		
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)		LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN
Nil																																	

Proposed Railway Line, Baiyyappanahalli Terminal to Chikkabanavara (Corridor 2)

The hourly train operation plan for the sub urban rail corridors for the year 2025, 2031 and 2041 were adopted from the detailed project report and presented in **Table 8.35**.

Table 8.35. Hourly Train Operation Plan Baiyyappanahalli Terminal to Chikkabanavara (Corridor 2)

From	To	Cars/Train	Trains/Hour		
			2025	2031	2041
12:00 AM	1:00 AM	6	0	0	0
1:00 AM	2:00 AM	6	0	0	0
2:00 AM	3:00 AM	6	0	0	0
3:00 AM	4:00 AM	6	0	0	0
4:00 AM	5:00 AM	6	0	0	0
5:00 AM	6:00 AM	6	1	2	2
6:00 AM	7:00 AM	6	2	3	4
7:00 AM	8:00 AM	6	3	4	5
8:00 AM	9:00 AM	6	4	5	7
9:00 AM	10:00 AM	6	4	5	7
10:00 AM	11:00 AM	6	3	4	6
11:00 AM	12:00 PM	6	2	3	4
12:00 PM	1:00 PM	6	2	3	4
1:00 PM	2:00 PM	6	1	2	2
2:00 PM	3:00 PM	6	2	3	4
3:00 PM	4:00 PM	6	2	3	4
4:00 PM	5:00 PM	6	3	4	6
5:00 PM	6:00 PM	6	4	5	7
6:00 PM	7:00 PM	6	4	5	7
7:00 PM	8:00 PM	6	3	4	6
8:00 PM	9:00 PM	6	2	3	4
9:00 PM	10:00 PM	6	2	3	4
10:00 PM	11:00 PM	6	2	2	3
11:00 PM	12:00 AM	6	1	2	2
Total			**47**	**65**	**88**

Source: BSRP Feasibility Report

Post Project (Cumulative) Noise Estimation

The baseline noise readings and model predicted noise pressure values are added logarithmically to estimate the cumulative noise values. The estimated noise values of the different scenarios (horizon year) are given in the following **Table 8.36** & **Table 8.37.**

Impact on Sensitive Areas

Predicted Noise on the Building Façade

The impact on sensitive receptors for various years 2025, 2031 and 2041 are presented in **Table 8.38** & **Table 8.39**. Noise contour maps showing with barrier and without barrier for environmental features including receptors are presented in **Annexure 8.6.**

Table 8.36. Corridor 2 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (without barrier)

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ1	54.3	43.6	1	11	54.3	43.6	54.3	43.6	0.3	8.5	54.3	43.6	54.3	43.6	1.7	8.5	54.3	43.6
NQ2	52.1	41.4	21.2	10.7	52.1	41.4	52.1	41.4	22.5	13.7	52.1	41.4	52.1	41.4	23.9	13.7	52.1	41.4
NQ3	52.7	41.9	34.2	23.7	52.8	42.0	52.7	41.9	35.5	26.7	52.8	42.0	52.7	41.9	36.9	26.7	52.8	42.0
NQ4	56.7	44.6	63.6	53.1	64.4	53.7	56.7	44.6	65	56.2	65.6	56.5	56.7	44.6	66.4	56.2	66.8	56.5
NQ5	54.2	43.5	65	54.4	65.3	54.7	54.2	43.5	66.3	57.5	66.6	57.7	54.2	43.5	67.7	57.5	67.9	57.7
NQ6	56.1	45.8	62.6	52.1	63.5	53.0	56.1	45.8	63.9	55.1	64.6	55.6	56.1	45.8	65.3	55.1	65.8	55.6
NQ7	53.2	42.9	70.8	60.2	70.9	60.3	53.2	42.9	72.1	63.3	72.2	63.3	53.2	42.9	73.5	63.3	73.5	63.3
NQ8	55.8	43.6	69.3	58.8	69.5	58.9	55.8	43.6	70.6	61.8	70.7	61.9	55.8	43.6	72	61.8	72.1	61.9
NQ9	53.6	44.1	57.2	46.7	58.8	48.6	53.6	44.1	58.6	49.8	59.8	50.8	53.6	44.1	60	49.8	60.9	50.8
NQ10	52.8	43.7	56.4	45.9	58.0	47.9	52.8	43.7	57.7	48.9	58.9	50.0	52.8	43.7	59.1	48.9	60.0	50.0
NQ11	51.4	40.8	52.3	41.8	54.9	44.3	51.4	40.8	53.6	44.8	55.6	46.3	51.4	40.8	55	44.8	56.6	46.3

Table 8.37. Corridor 2 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (with barrier)

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ1	54.3	43.6	0.7	6	54.3	43.6	54.3	43.6	0.6	6	54.3	43.6	54.3	43.6	2	5	54.3	43.6
NQ2	52.1	41.4	21.4	10.9	52.1	41.4	52.1	41.4	22.7	13.9	52.1	41.4	52.1	41.4	24.1	13.9	52.1	41.4
NQ3	52.7	41.9	33.8	23.3	52.8	42.0	52.7	41.9	35.1	26.3	52.8	42.0	52.7	41.9	36.5	26.3	52.8	42.0
NQ4	56.7	44.6	63.6	53.1	64.4	53.7	56.7	44.6	64.9	56.1	65.5	56.4	56.7	44.6	66.3	56.1	66.8	56.4
NQ5	54.2	43.5	65	54.4	65.3	54.7	54.2	43.5	66.3	57.5	66.6	57.7	54.2	43.5	67.7	57.5	67.9	57.7

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ6	56.1	45.8	62.6	52.1	63.5	53.0	56.1	45.8	63.9	55.1	64.6	55.6	56.1	45.8	65.3	55.1	65.8	55.6
NQ7	53.2	42.9	70.8	60.2	70.9	60.3	53.2	42.9	72.1	63.3	72.2	63.3	53.2	42.9	73.5	63.3	73.5	63.3
NQ8	55.8	43.6	69.3	58.8	69.5	58.9	55.8	43.6	70.6	61.8	70.7	61.9	55.8	43.6	72	61.8	72.1	61.9
NQ9	53.6	44.1	40.4	29.9	53.8	44.3	53.6	44.1	41.7	32.9	53.9	44.4	53.6	44.1	43.1	32.9	54.0	44.4
NQ10	52.8	43.7	56.4	45.9	58.0	47.9	52.8	43.7	57.7	48.9	58.9	50.0	52.8	43.7	59.1	48.9	60.0	50.0
NQ11	51.4	40.8	52.3	41.8	54.9	44.3	51.4	40.8	53.7	44.9	55.7	46.3	51.4	40.8	55.1	44.9	56.6	46.3

Table 8.38. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 2 Right Hand Side

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Barrier-2041	
			To Compound Wall (m)	To the first Building (m)	Height of the Building (m)		LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN
1	204+890	New Pratham Public School, Mahadevapura.	34	35	15	70x2x0.2	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45
2	206+400	NMT Elder Care J P Nagar.	40	43	5	25x2x0.2	72	68	70	73	69	71	74.3	70.3	72.3	31.0	28	29.4	45.4	41	43.4	31.8	29	30.2	46.4	42	44.4	32.8	30	31.2	47.7	44
3	207+440	Mother Mary English School, Chikkabanasawadi.	-	30	14	-	72	68	70	73	69	71	74.3	70.3	72.3	34.1	31	32.5	48.5	44	46.5	34.9	32	33.3	49.5	45	47.5	35.9	33	34.3	50.8	47
4	210+710	Siddhartha PU College, 7th Cross Lingarajapura Hennur Main Road.	60	70	6	100x2x0.2	72	68	70	73	69	71	74.3	70.3	72.3	26.7	24	25.1	41.1	37	39.1	27.5	24	25.9	42.1	38	40.1	28.6	25	27.0	43.4	39
5	213+750	Jauhar Shifa Khana, Clinic in Byrappa Layout, R M V 2nd Stage.	-	35	8	-	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45
6	214+680	St Pauls Public School and Apartment, Arabic college Road, Jogappa Layout Nagavara.	30	45	130	200x2x0.3	72	68	70	73	69	71	74.3	70.3	72.3	30.6	27	29.0	45.0	41	43.0	31.4	28	29.8	46.0	42	44.0	32.4	29	30.8	47.3	43
7	15+550	Clinic	-	-	15	-	72	68	70	73	69	71	74.3	70.3	72.3	30.6	27	29.0	45.0	41	43.0	31.4	28	29.8	46.0	42	44.0	32.4	29	30.8	47.3	43
8	15+800	Hospital	-	-	20	-	72	68	70	73	69	71	74.3	70.3	72.3	30.6	27	29.0	45.0	41	43.0	31.4	28	29.8	46.0	42	44.0	32.4	29	30.8	47.3	43
9	16+500	Clinic	-	-	14	-	72	68	70	73	69	71	74.3	70.3	72.3	30.6	27	29.0	45.0	41	43.0	31.4	28	29.8	46.0	42	44.0	32.4	29	30.8	47.3	43
10	18+740	Other govt hospital	30	36	5	300x2x0.5	72	68	70	73	69	71	74.3	70.3	72.3	32.5	29	30.9	46.9	43	44.9	33.3	30	31.7	47.9	44	45.9	34.3	31	32.7	49.2	45
11	23+700	R.R Institute college	5	35	24	20x2.5x0.5	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45
12	23+900	National Public School, Chikkabanavara.	10	15	27	30x2.5x0.2	72	68	70	73	69	71	74.3	70.3	72.3	40.1	37	38.5	54.5	50	52.5	40.9	38	39.3	55.5	51	53.5	41.9	39	40.3	56.8	53

Table 8.39. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 2 Left Hand Side

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Ba 2041	
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)		LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN
1	205+360	Government Higher Primary School, Benniganahalli.	30	32	14	36x1.5x0.2	72	68	70	73	69	71	74.3	70.3	72.3	33.5	30	31.9	47.9	44	45.9	34.3	31	32.7	48.9	45	46.9	35.4	32	33.8	50.2	46
2	205+780	Little Angels Modern High School, NGEF Layout,	32	34	14	30x1.5x0.2	72	68	70	73	69	71	74.3	70.3	72.3	33.0	30	31.4	47.4	43	45.4	33.8	31	32.2	48.4	44	46.4	34.8	32	33.2	49.7	46

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Ba 2041	
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)		LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN
		Sadananda Nagar, Benniganahalli.																														
3	208+400	Cecilia English Nursery & High School, Maruthi Seva Nagar.	7	10	18	15x1.5x0.3	72	68	70	73	69	71	74.3	70.3	72.3	43.6	40	42.0	58.0	54	56.0	44.4	41	42.8	59.0	55	57.0	45.5	42	43.9	60.3	56
4	210+600	Eunice English Medium High School, Thomas Town, Lingarajapuram, Bengaluru.	15	20	20	60x1.5x0.3	72	68	70	73	69	71	74.3	70.3	72.3	37.6	34	36.0	52.0	48	50.0	38.4	35	36.8	53.0	49	51.0	39.4	36	37.8	54.3	50
5	210+650	Manahil English High School, Kadugondanahalli.	5	8	18	30x2x0.3	72	68	70	73	69	71	74.3	70.3	72.3	45.6	42	44.0	60.0	56	58.0	46.4	43	44.8	61.0	57	59.0	47.4	44	45.8	62.3	58
6	213+250	Beacon English High School, 1st main Road, Shampura, Kaval Bairasandra.	15	18	18	30x2x0.2	72	68	70	73	69	71	74.3	70.3	72.3	38.5	35	36.9	52.9	49	50.9	39.3	36	37.7	53.9	50	51.9	40.4	37	38.8	55.2	51
7	213+640	School, Kaval Bairasandra.	30	34	23	30x1.5x0.2	72	68	70	73	69	71	74.3	70.3	72.3	33.0	30	31.4	47.4	43	45.4	33.8	31	32.2	48.4	44	46.4	34.8	32	33.2	49.7	46
8	214+380	BIG Institute of Managerial	15	20	22	30x1.5x0.3	72	68	70	73	69	71	74.3	70.3	72.3	37.6	34	36.0	52.0	48	50.0	38.4	35	36.8	53.0	49	51.0	39.4	36	37.8	54.3	50
9	215+50	Government School	20	22	9	20x1.5x0.2	72	68	70	73	69	71	74.3	70.3	72.3	36.8	34	35.2	51.2	47	49.2	37.6	34	36.0	52.2	48	50.2	38.6	35	37.0	53.5	49
10	216+900	Hebbal Agriculture School	15	18	12	100x2x0.2	72	68	70	73	69	71	74.3	70.3	72.3	38.5	35	36.9	52.9	49	50.9	39.3	36	37.7	53.9	50	51.9	40.4	37	38.8	55.2	51
11	218+440	New Florence Public School, KSFC Layout, Lingarajapuram.	-	20	18	-	72	68	70	73	69	71	74.3	70.3	72.3	37.6	34	36.0	52.0	48	50.0	38.4	35	36.8	53.0	49	51.0	39.4	36	37.8	54.3	50
12	218+830	BBMP, Public Library	-	15	4	-	72	68	70	73	69	71	74.3	70.3	72.3	40.1	37	38.5	54.5	50	52.5	40.9	38	39.3	55.5	51	53.5	41.9	39	40.3	56.8	53
13	14+900	Ashwin Vidyalaya, 4th cross Road, Ramakrishna Gardens, Sundar Nagar, Gokula Extension, Mathikere.	-	-	30	20x2.5x0.10	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45
14	15+550	St. Antony primary School, Mathikere.	-	-	18	-	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45
15	16+50	Monisha Clinic, Mohankumar Nagar, Yeshwanthpur.	-	-	9	-	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45
16	16+030	S.L.V Clinical Laboratary, Mohankumar Nagar, Yeshwanthpur.	-	-	10	-	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45
17	16+150	P.R Public School, Mohankumar Nagar, Yeshwanthpur.	-	-	16	70x1.5x0.3	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Ba 2041	
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)		LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN
18	16+270	Sir Hanuman Vidhyalaya, Mohankumar Nagar, Yeshwanthpur.	-	-	14	-	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45
19	16+270	Venkateswara clinic, Yeshwanthpur.	-	-	12	-	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45
20	23+460	Cecilia English Nursery & High School, Maruthi Seva Nagar.	25	35	30	50x2x0.2	72	68	70	73	69	71	74.3	70.3	72.3	32.7	30	31.1	47.1	43	45.1	33.5	30	31.9	48.1	44	46.1	34.6	31	33.0	49.4	45

Proposed Railway Line, Kengeri to Bengaluru Cantonment (Corridor 3)

The hourly train operation plan for the sub urban rail corridors for the year 2025, 2031 and 2041 were adopted from the detailed project report and presented in table below,

Table 8.40. Hourly Train Operation Plan Kengeri to Bengaluru Cantonment (Corridor 3)

From	To	Cars/Train	Trains/Hour		
			2025	2031	2041
12:00 AM	1:00 AM	6.00	0	0	0
1:00 AM	2:00 AM	6.00	0	0	0
2:00 AM	3:00 AM	6.00	0	0	0
3:00 AM	4:00 AM	6.00	0	0	0
4:00 AM	5:00 AM	6.00	0	0	0
5:00 AM	6:00 AM	6.00	1	1	2
6:00 AM	7:00 AM	6.00	2	2	3
7:00 AM	8:00 AM	6.00	2	3	4
8:00 AM	9:00 AM	6.00	3	4	5
9:00 AM	10:00 AM	6.00	3	4	5
10:00 AM	11:00 AM	6.00	2	3	4
11:00 AM	12:00 PM	6.00	2	2	3
12:00 PM	1:00 PM	6.00	2	2	3
1:00 PM	2:00 PM	6.00	1	1	2
2:00 PM	3:00 PM	6.00	2	2	3
3:00 PM	4:00 PM	6.00	2	2	3
4:00 PM	5:00 PM	6.00	2	3	4
5:00 PM	6:00 PM	6.00	3	4	5
6:00 PM	7:00 PM	6.00	3	4	5
7:00 PM	8:00 PM	6.00	2	3	4
8:00 PM	9:00 PM	6.00	2	2	3
9:00 PM	10:00 PM	6.00	2	2	3
10:00 PM	11:00 PM	6.00	1	2	2
11:00 PM	12:00 AM	6.00	1	1	2
Total			**38**	**47**	**65**

Post Project (Cumulative) Noise Estimation

The baseline noise readings and model predicted noise pressure values are added logarithmically to estimate the cumulative noise values. The estimated noise values of the different scenarios (horizon year) are given in **Table 8.41** & **Table 8.42**.

Impact on Sensitive Areas

Predicted Noise on the Building Façade

The impact on sensitive receptors for various years 2025, 2031 and 2041 are presented in **Table 8.43** & **Table 8.44**.Noise contour maps showing with barrier and without barrier for environmental features including receptors are presented in **Annexure 8.6.**

Table 8.41. Corridor 3 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (without barrier)

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ1	53.8	42.9	65.5	55.9	65.8	56.1	53.8	42.9	66.4	55.9	66.6	56.1	53.8	42.9	67.7	58.9	67.9	59.0
NQ2	52.6	39.1	66.1	56.5	66.3	56.6	52.6	39.1	67.1	56.6	67.3	56.7	52.6	39.1	68.4	59.6	68.5	59.6
NQ3	53.5	40.8	78.3	68.8	78.3	68.8	53.5	40.8	79.3	68.8	79.3	68.8	53.5	40.8	80.6	71.8	80.6	71.8
NQ4	52.8	41.4	69	59.4	69.1	59.5	52.8	41.4	70	59.5	70.1	59.6	52.8	41.4	71.3	62.5	71.4	62.5
NQ5	57.1	43.9	77.1	67.6	77.1	67.6	57.1	43.9	78.1	67.6	78.1	67.6	57.1	43.9	79.4	70.6	79.4	70.6
NQ6	56.2	42.7	65.5	56	66.0	56.2	56.2	42.7	66.5	56	66.9	56.2	56.2	42.7	67.8	59	68.1	59.1
NQ7	52.2	41.9	66.5	57	66.7	57.1	52.2	41.9	67.5	57	67.6	57.1	52.2	41.9	68.8	60	68.9	60.1
NQ8	54.1	42.6	65.5	55.9	65.8	56.1	54.1	42.6	66.5	56	66.7	56.2	54.1	42.6	67.8	59	68.0	59.1
NQ9	54.3	44	60	50.5	61.0	51.4	54.3	44	61	50.5	61.8	51.4	54.3	44	62.3	53.5	62.9	54.0
NQ10	52.2	40.4	58.8	49.2	59.7	49.7	52.2	40.4	59.8	49.3	60.5	49.8	52.2	40.4	61.1	52.3	61.6	52.6

Table 8.42. Corridor 3 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (with barrier)

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ1	53.8	42.9	66	56.4	66.3	56.6	53.8	42.9	67	56.5	67.2	56.7	53.8	42.9	68.3	59.5	68.5	59.6
NQ2	52.6	39.1	66.2	56.6	66.4	56.7	52.6	39.1	67.2	56.7	67.3	56.8	52.6	39.1	68.5	59.7	68.6	59.7
NQ3	53.5	40.8	78.3	68.8	78.3	68.8	53.5	40.8	79.3	68.8	79.3	68.8	53.5	40.8	80.6	71.8	80.6	71.8
NQ4	52.8	41.4	69	59.4	69.1	59.5	52.8	41.4	70	59.5	70.1	59.6	52.8	41.4	71.3	62.5	71.4	62.5
NQ5	57.1	43.9	77.1	67.6	77.1	67.6	57.1	43.9	78.1	67.6	78.1	67.6	57.1	43.9	79.4	70.6	79.4	70.6
NQ6	56.2	42.7	65.5	56	66.0	56.2	56.2	42.7	66.5	56	66.9	56.2	56.2	42.7	67.8	59	68.1	59.1
NQ7	52.2	41.9	66.5	57	66.7	57.1	52.2	41.9	67.5	57	67.6	57.1	52.2	41.9	68.8	60	68.9	60.1

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ8	54.1	42.6	65.5	55.9	65.8	56.1	54.1	42.6	66.5	56	66.7	56.2	54.1	42.6	67.8	59	68.0	59.1
NQ9	54.3	44	60	50.5	61.0	51.4	54.3	44	61	50.5	61.8	51.4	54.3	44	62.3	53.5	62.9	54.0
NQ10	52.2	40.4	58.8	49.2	59.7	49.7	52.2	40.4	59.8	49.3	60.5	49.8	52.2	40.4	61.1	52.3	61.6	52.6

Table 8.43. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 3 Right Hand Side

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Barrier-2041		
			To Compound Wall (m)	To the first Building (m)	Height of the Building (m)		LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN
1	10+500	BIMS, Boys Hostel, Kengeri Satellite Town.	15	17	40	80x1.2x0.3	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	38.4	34	36.3	52.6	47	50.0	39.2	35	37.1	53.6	48	51.0	40.2	36	38.1	54.9	50	52.3
2	10+400	Orchids School, Mysore Road, Kengeri satellite Town.	10	15	30	30x1.2x0.2	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	39.5	35	37.4	53.7	48	51.1	40.3	36	38.2	54.7	49	52.1	41.3	37	39.2	56.0	51	53.4
3	10+300	Benguluru Institute of Management, Mysore Road, Kengeri Satellite Town.	10	15	10	50x1.2x0.2	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	39.5	35	37.4	53.7	48	51.1	40.3	36	38.2	54.7	49	52.1	41.3	37	39.2	56.0	51	53.4
4	8+150	College	12	15	15	20x1.2x0.3	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	39.5	35	37.4	53.7	48	51.1	40.3	36	38.2	54.7	49	52.1	41.3	37	39.2	56.0	51	53.4
5	6+830	Piles and Fistula Clinic	-	15	9	-	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	39.5	35	37.4	53.7	48	51.1	40.3	36	38.2	54.7	49	52.1	41.3	37	39.2	56.0	51	53.4
6	5+900	Madarasa Women's Arabic School, Roshan Nagar.	-	10	-	-	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	43.0	39	40.9	57.2	52	54.6	43.8	40	41.7	58.2	53	55.6	44.8	41	42.7	59.5	54	56.9
7	5+860	Government Urdu Primary School, Roshan Nagar.	10	11	10	12x1.2x0.2	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	42.2	38	40.1	56.4	51	53.8	43.0	39	40.9	57.4	52	54.8	44.0	40	41.9	58.7	53	56.1
8	349+570	City Multi Speciality and Trauma Centre, Hospital, Pulikeshi Nagar.	15	16	20	20x1.2x0.3	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	38.9	35	36.8	53.1	48	50.5	39.7	36	37.6	54.1	49	51.5	40.7	37	38.7	55.4	50	52.8

Table 8.44. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 3 Left Hand Side

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Barrier-2041		
			To Compound Wall (m)	To the first Building (m)	Height of the Building (m)		LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN
1	12+700	Government, High School and First Grade College, Kengeri.	13	35	20	30x1.5x0.3	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	32.1	28	30.0	46.3	41	43.7	32.9	29	30.8	47.3	42	44.7	33.9	30	31.9	48.6	43	46.0
2	11+950	Dr.Suhasini Hospital, Kengeri Satellite Town.	-	18	30	-	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	37.9	34	35.8	52.1	47	49.5	38.7	35	36.6	53.1	48	50.5	39.7	36	37.6	54.4	49	51.8
3	11+470	National Public School, Kengeri Satellite Town.	20	24	35	30x1.5x0.3	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	35.4	31	33.3	49.6	44	47.0	36.2	32	34.1	50.6	45	48.0	37.2	33	35.1	51.9	47	49.3
4	9+320	Indian Statistical Institute, Mysore Road.	10	20	-	100x2.5x0.3	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	37.0	33	34.9	51.2	46	48.6	37.8	34	35.7	52.2	47	49.6	38.8	35	36.7	53.5	48	50.9
5	5+150	Ananya Hospital	15	16	25	75x1x0.2	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	38.9	35	36.8	53.1	48	50.5	39.7	36	37.6	54.1	49	51.5	40.7	37	38.7	55.4	50	52.8
6	4+950	Dhanvantari Clinic, Railway Parallel Road, Vijayanagar.	-	15	20	-	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	39.5	35	37.4	53.7	48	51.1	40.3	36	38.2	54.7	49	52.1	41.3	37	39.2	56.0	51	53.4
7	4+925	St. Michaels, High School, Hampinagar.	-	15	22	-	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	39.5	35	37.4	53.7	48	51.1	40.3	36	38.2	54.7	49	52.1	41.3	37	39.2	56.0	51	53.4
8	2+130	Roses Convent School, Binnipete, Kempapura.	10	14	20	350x7x0.5	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	40.1	36	38.0	54.3	49	51.7	40.9	37	38.8	55.3	50	52.7	41.9	38	39.8	56.6	51	54.0
9	353+890	Star Health Allied	10	13	30	100x1.2x0.2	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	40.7	37	38.6	54.9	50	52.3	41.5	37	39.4	55.9	51	53.3	42.5	38	40.5	57.2	52	54.6
10	353+680	Eye Hospital and Squite Centre.	14	15	12	40x1x0.2	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	39.5	35	37.4	53.7	48	51.1	40.3	36	38.2	54.7	49	52.1	41.3	37	39.2	56.0	51	53.4
11	350+390	MQI Degree College, Benson Town.	20	22	30	30x1.2x0.5	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	36.1	32	34.1	50.4	45	47.8	36.9	33	34.9	51.4	46	48.8	38.0	34	35.9	52.7	47	50.1
12	349+220	Clerence High School, Rechards Town.	10	20	20	70x1.5x0.35	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	37.0	33	34.9	51.2	46	48.6	37.8	34	35.7	52.2	47	49.6	38.8	35	36.7	53.5	48	50.9
13	348+770	Medico Pertrol Association Center for Mental Health	15	18	15	45x1.5x0.35	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	37.9	34	35.8	52.1	47	49.5	38.7	35	36.6	53.1	48	50.5	39.7	36	37.6	54.4	49	51.8
14	347+600	Jeevan Clinic	10	10	15	10x1x0.10	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	43.0	39	40.9	57.2	52	54.6	43.8	40	41.7	58.2	53	55.6	44.8	41	42.7	59.5	54	56.9
15	377+340	Chaithanya Clinic, Saketha Nagar, Hoodi.	10	10	8	-	71.2	66	68.6	72.2	67	69.6	73.5	68.3	70.9	43.0	39	40.9	57.2	52	54.6	43.8	40	41.7	58.2	53	55.6	44.8	41	42.7	59.5	54	56.9

Proposed Railway Line, Heelalige to Rajanakunte (Corridor 4)

Rail Traffic

The hourly train operation plan for the sub urban rail corridors for the year 2025, 2031 and 2041 were adopted from the detailed project report and presented in **Table 8.45**.

Table 8.45. Hourly Train Operation Plan Heelalige to Rajanakunte (Corridor 4)

From	To	Cars/Train	Trains/Hour		
			2025	2031	2041
12:00 AM	1:00 AM	6	0	0	0
1:00 AM	2:00 AM	6	0	0	0
2:00 AM	3:00 AM	6	0	0	0
3:00 AM	4:00 AM	6	0	0	0
4:00 AM	5:00 AM	6	0	0	0
5:00 AM	6:00 AM	6	1	2	2
6:00 AM	7:00 AM	6	2	3	3
7:00 AM	8:00 AM	6	3	4	4
8:00 AM	9:00 AM	6	4	6	6
9:00 AM	10:00 AM	6	4	6	6
10:00 AM	11:00 AM	6	3	5	5
11:00 AM	12:00 PM	6	2	4	4
12:00 PM	1:00 PM	6	2	3	3
1:00 PM	2:00 PM	6	1	2	2
2:00 PM	3:00 PM	6	2	3	3
3:00 PM	4:00 PM	6	2	4	4
4:00 PM	5:00 PM	6	3	5	5
5:00 PM	6:00 PM	6	4	6	6
6:00 PM	7:00 PM	6	4	6	6
7:00 PM	8:00 PM	6	3	5	5
8:00 PM	9:00 PM	6	2	4	4
9:00 PM	10:00 PM	6	2	3	3
10:00 PM	11:00 PM	6	2	2	2
11:00 PM	12:00 AM	6	1	2	2
Total			**47**	**75**	**75**

Post Project (Cumulative) Noise Estimation

The baseline noise readings and model predicted noise pressure values are added logarithmically to estimate the cumulative noise values. The estimated noise values of the different scenarios (horizon year) are given in **Table 8.46** and **Table 8.47**.

Impact on Sensitive Areas

Predicted Noise on the Building Façade

The impact on sensitive receptors for various years 2025, 2031 and 2041 are presented in **Table 8.48** and **Table 8.49**. Noise contour maps showing with barrier and without barrier for environmental features including receptors are presented in **Annexure 8.6.**

Table 8.46. Corridor 4 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (without barrier)

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ1	51.2	39.6	64.9	54.4	65.1	54.5	51.2	39.6	66.9	57.4	67.0	57.5	51.2	39.6	66.9	57.4	67.0	57.5
NQ2	52.8	42.7	67.5	57	67.6	57.2	52.8	42.7	69.5	60	69.6	60.1	52.8	42.7	69.5	60	69.6	60.1
NQ3	51.6	43.9	62.7	52.2	63.0	52.8	51.6	43.9	64.7	55.2	64.9	55.5	51.6	43.9	64.7	55.2	64.9	55.5
NQ4	53.1	42.8	63.6	53	64.0	53.4	53.1	42.8	65.6	56.1	65.8	56.3	53.1	42.8	65.6	56.1	65.8	56.3
NQ5	52.4	41.6	62.6	52.1	63.0	52.5	52.4	41.6	64.6	55.1	64.9	55.3	52.4	41.6	64.6	55.1	64.9	55.3
NQ6	51.7	41.2	65.2	54.6	65.4	54.8	51.7	41.2	67.2	57.7	67.3	57.8	51.7	41.2	67.2	57.7	67.3	57.8
NQ7	50.6	43.5	57.2	46.7	58.1	48.4	50.6	43.5	59.3	49.8	59.8	50.7	50.6	43.5	59.3	49.8	59.8	50.7
NQ8	52.2	42.6	69.5	59	69.6	59.1	52.2	42.6	71.6	62.1	71.6	62.1	52.2	42.6	71.6	62.1	71.6	62.1
NQ9	53.7	41.9	64.6	54.1	64.9	54.4	53.7	41.9	66.6	57.1	66.8	57.2	53.7	41.9	66.6	57.1	66.8	57.2
NQ10	54.8	40.9	66.4	55.9	66.7	56.0	54.8	40.9	68.4	58.9	68.6	59.0	54.8	40.9	68.4	58.9	68.6	59.0
NQ11	52.5	41.2	61.7	51.2	62.2	51.6	52.5	41.2	63.7	54.2	64.0	54.4	52.5	41.2	63.7	54.2	64.0	54.4
NQ12	53.4	40.6	67.6	57	67.8	57.1	53.4	40.6	69.6	60.1	69.7	60.1	53.4	40.6	69.6	60.1	69.7	60.1
NQ13	53.8	39.2	62.5	52	63.0	52.2	53.8	39.2	64.5	55	64.9	55.1	53.8	39.2	64.5	55	64.9	55.1
NQ14	54.8	42.8	62.5	52	63.2	52.5	54.8	42.8	64.6	55.1	65.0	55.3	54.8	42.8	64.6	55.1	65.0	55.3
NQ15	50.3	41.4	61.9	51.4	62.2	51.8	50.3	41.4	63.9	54.4	64.1	54.6	50.3	41.4	63.9	54.4	64.1	54.6
NQ16	52.1	40.8	67.6	57.1	67.7	57.2	52.1	40.8	69.6	60.1	69.7	60.2	52.1	40.8	69.6	60.1	69.7	60.2
NQ17	53.3	43.5	65.7	55.2	65.9	55.5	53.3	43.5	67.7	58.2	67.9	58.3	53.3	43.5	67.7	58.2	67.9	58.3
NQ18	52.9	39.7	65.6	55.1	65.8	55.2	52.9	39.7	67.6	58.1	67.7	58.2	52.9	39.7	67.6	58.1	67.7	58.2
NQ19	51.8	42.9	66.3	55.8	66.5	56.0	51.8	42.9	68.3	58.8	68.4	58.9	51.8	42.9	68.3	58.8	68.4	58.9
NQ20	52.5	41.6	68.7	58.2	68.8	58.3	52.5	41.6	70.7	61.2	70.8	61.2	52.5	41.6	70.7	61.2	70.8	61.2
NQ21	53.5	43.9	61.6	51.1	62.2	51.9	53.5	43.9	63.6	54.1	64.0	54.5	53.5	43.9	63.6	54.1	64.0	54.5
NQ22	51.9	41.8	68	57.5	68.1	57.6	51.9	41.8	70	60.5	70.1	60.6	51.9	41.8	70	60.5	70.1	60.6

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ23	53.8	43.6	70	59.5	70.1	59.6	53.8	43.6	72	62.5	72.1	62.6	53.8	43.6	72	62.5	72.1	62.6
NQ24	52.9	40.5	71.8	61.2	71.9	61.2	52.9	40.5	73.8	64.3	73.8	64.3	52.9	40.5	73.8	64.3	73.8	64.3

Table 8.47. Corridor 4 - Cumulative Noise Estimation for Baseline Noise Monitoring locations (with barrier)

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ1	51.2	39.6	64.9	54.4	65.1	54.5	51.2	39.6	66.9	57.4	67.0	57.5	51.2	39.6	66.9	57.4	67.0	57.5
NQ2	52.8	42.7	67.5	57	67.6	57.2	52.8	42.7	69.6	60.1	69.7	60.2	52.8	42.7	69.6	60.1	69.7	60.2
NQ3	51.6	43.9	62.7	52.2	63.0	52.8	51.6	43.9	64.7	55.2	64.9	55.5	51.6	43.9	64.7	55.2	64.9	55.5
NQ4	53.1	42.8	63.6	53	64.0	53.4	53.1	42.8	65.6	56.1	65.8	56.3	53.1	42.8	65.6	56.1	65.8	56.3
NQ5	52.4	41.6	62.6	52.1	63.0	52.5	52.4	41.6	64.6	55.1	64.9	55.3	52.4	41.6	64.6	55.1	64.9	55.3
NQ6	51.7	41.2	65.2	54.6	65.4	54.8	51.7	41.2	67.2	57.7	67.3	57.8	51.7	41.2	67.2	57.7	67.3	57.8
NQ7	50.6	43.5	57.2	46.7	58.1	48.4	50.6	43.5	59.3	49.8	59.8	50.7	50.6	43.5	59.3	49.8	59.8	50.7
NQ8	52.2	42.6	69.5	59	69.6	59.1	52.2	42.6	71.6	62.1	71.6	62.1	52.2	42.6	71.6	62.1	71.6	62.1
NQ9	53.7	41.9	64.6	54.1	64.9	54.4	53.7	41.9	66.6	57.1	66.8	57.2	53.7	41.9	66.6	57.1	66.8	57.2
NQ10	54.8	40.9	66.4	55.9	66.7	56.0	54.8	40.9	68.4	58.9	68.6	59.0	54.8	40.9	68.4	58.9	68.6	59.0
NQ11	52.5	41.2	61.7	51.2	62.2	51.6	52.5	41.2	63.8	54.3	64.1	54.5	52.5	41.2	63.8	54.3	64.1	54.5
NQ12	53.4	40.6	67.6	57	67.8	57.1	53.4	40.6	69.6	60.1	69.7	60.1	53.4	40.6	69.6	60.1	69.7	60.1
NQ13	53.8	39.2	62.5	51.9	63.0	52.1	53.8	39.2	64.5	55	64.9	55.1	53.8	39.2	64.5	55	64.9	55.1
NQ14	54.8	42.8	62.5	52	63.2	52.5	54.8	42.8	64.5	55	64.9	55.3	54.8	42.8	64.5	55	64.9	55.3
NQ15	50.3	41.4	61.9	51.4	62.2	51.8	50.3	41.4	63.9	54.4	64.1	54.6	50.3	41.4	63.9	54.4	64.1	54.6
NQ16	52.1	40.8	67.6	57.1	67.7	57.2	52.1	40.8	69.6	60.1	69.7	60.2	52.1	40.8	69.6	60.1	69.7	60.2

Noise Location	2025 in dB(A)						2031 in dB(A)						2041 in dB(A)					
	Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative		Baseline		Predicted		Cumulative	
	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN	LrD	LrN
NQ17	53.3	43.5	65.7	55.2	65.9	55.5	53.3	43.5	67.7	58.2	67.9	58.3	53.3	43.5	67.7	58.2	67.9	58.3
NQ18	52.9	39.7	65.6	55.1	65.8	55.2	52.9	39.7	67.6	58.1	67.7	58.2	52.9	39.7	67.6	58.1	67.7	58.2
NQ19	51.8	42.9	66.3	55.8	66.5	56.0	51.8	42.9	68.3	58.8	68.4	58.9	51.8	42.9	68.3	58.8	68.4	58.9
NQ20	52.5	41.6	68.7	58.2	68.8	58.3	52.5	41.6	70.8	61.3	70.9	61.3	52.5	41.6	70.8	61.3	70.9	61.3
NQ21	53.5	43.9	61.6	51.1	62.2	51.9	53.5	43.9	63.6	54.1	64.0	54.5	53.5	43.9	63.6	54.1	64.0	54.5
NQ22	51.9	41.8	68	57.5	68.1	57.6	51.9	41.8	70	60.5	70.1	60.6	51.9	41.8	70	60.5	70.1	60.6
NQ23	53.8	43.6	70	59.5	70.1	59.6	53.8	43.6	72	62.5	72.1	62.6	53.8	43.6	72	62.5	72.1	62.6
NQ24	52.9	40.5	71.8	61.2	71.9	61.2	52.9	40.5	73.8	64.3	73.8	64.3	52.9	40.5	73.8	64.3	73.8	64.3

Table 8.48. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 4 Right Hand Side

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Ba[rrier]-2041	
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)		LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN
1	190+400	Silkworm Seed Technology Laboratory, Kodathi.	20	45	9	100x2.5x0.2	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	31.0	26	28.6	45.6	39	42.5	31.8	27	29.4	46.6	40	43.5	32.9	28	30.4	47.9	42
2	191+050	College	25	30	4	70x2x0.5	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	34.6	30	32.1	49.1	43	46.0	35.4	30	32.9	50.1	44	47.0	36.4	31	33.9	51.4	45
3	197/790	Smile Dental Care, Munnekollal, Marathahalli.		20	14	-	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	38.1	33	35.6	52.6	46	49.5	38.9	34	36.4	53.6	47	50.5	39.9	35	37.4	54.9	49
4	198/580	Lions Airport city Hospital, Munnekollal, Marathahalli.	22	30	10	20x1.5x0.4	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	34.6	30	32.1	49.1	43	46.0	35.4	30	32.9	50.1	44	47.0	36.4	31	33.9	51.4	45
5	199/290	Kids Mansion School, Chinnappanahalli.	15	18	9	25x2.5x0.3	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	39.0	34	36.5	53.5	47	50.4	39.8	35	37.3	54.5	48	51.4	40.8	36	38.4	55.8	50

Table 8.49. Predicted Noise on Environmental Sensitive Receptor Building Façade for Corridor 4 Left Hand Side

Sl. No.	Indian Railway Chainage in (km)	Name of Envi. Feature	Distance from the Ex. Railway Track			Length and Height of CW Parallel to the Railway (m) if any	2025			2031			2041			With Barrier-2025			Without Barrier-2025			With Barrier-2031			Without Barrier-2031			With Barrier-2041			Without Barri[er]-2041		
			To Compound Wall (m)	To the first Building (m)	Height of the building (m)		LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	LrDN	LrD	LrN	Lr[DN]
1	182+800	Bangalore college of Engineering, Heelalige, Bommasandra.	40	50	15	160x3x0.1	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	30.1	25	27.6	44.6	38	41.5	30.9	26	28.4	45.6	39	42.5	32.0	27	29.5	46.9	41	4
2	184+100	School	20	25	10	50x2x0.2	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	36.1	31	33.7	50.7	44	47.6	36.9	32	34.5	51.7	45	48.6	38.0	33	35.5	53.0	47	4
3	203+050	Dental Hospital	20	22	15	20x1.5x0.2	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	37.3	32	34.8	51.8	46	48.7	38.1	33	35.6	52.8	47	49.7	39.1	34	36.6	54.1	48	5
4	23+100	Sai Speciality Center, Hospital East of NGEF Layout, Kasturi Nagar.	-	10	15	-	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	44.1	39	41.6	58.6	52	55.5	44.9	40	42.4	59.6	53	56.5	45.9	41	43.5	60.9	55	5
5	15+650	Dental Health Center	-	10	5	-	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	44.1	39	41.6	58.6	52	55.5	44.9	40	42.4	59.6	53	56.5	45.9	41	43.5	60.9	55	5
6	18+100	Masjid	10	11	10	10x2.5x0.2	72.6	66.4	69.5	73.6	67.4	70.5	74.9	68.7	71.8	43.3	38	40.8	57.8	52	54.7	44.1	39	41.6	58.8	53	55.7	45.1	40	42.6	60.1	54	5

Since, noise level is beyond the permissible limits of Noise standards for sensitive receptor for day and night time, solid concrete noise barriers are provided wherever existing compound wall are there and at places where sufficient land available to erect new concrete walls. Chainage wise details of solid concrete noise barriers proposed for each corridor is given in **Table 8.51.** At receptors where there is no existing compound walls such as clinics in a shop facing roads, backside of the few educational institutes/health center on railway land, etc., noise measures shall be undertaken in due consultation with Indian railway officials and land owners during pre-construction stage. Project proponent need to monitor the noise environment at these locations before erecting the solid noise barriers during operation.

Mitigation Measures: The impact of project on noise level during the construction period will be mainly due to operation of machinery/equipment at plant sites and construction sites; and transportation of vehicles. Noise control measures during construction will be required to minimize noise levels on existing noise-sensitive land uses. All construction activities will have to comply with Noise Pollution (Regulation and Control) Rules, 2000 & amendments and ESS 3 of World Bank and EIB Standards 1 & 3. Night time work could require a variance for local noise regulations.

The increase in noise levels varies from marginal to moderate impact; hence local population will not be adversely affected. Noise level mitigation will be achieved by following control measures:

- Source Control : Each internal combustion engine used for any purpose on the project or related to the project will be equipped with a muffler of a type recommended by the manufacturer. No internal combustion engine will be operated without a muffler.
- All Construction plants and equipment used in construction shall strictly conform to the MoEF&CC/CPCB noise standards.
- All Vehicles and equipment used in construction shall be fitted with exhaust silencers.
- Construction of permanent and temporary noise barriers; and natural and artificial barriers could be considered for use as shielding against construction noise. Strategic placement of stationary equipment, such as compressors and generators, could reduce effects at sensitive receivers.
- A main source of noise shall be controlled by Re-routing and regulating the traffic,
- Electric equipment shall be used instead of diesel powered equipment,
- Hydraulic tools shall be used instead of pneumatic tools,
- Provision of acoustic enclosures : Acoustic enclosures shall be provided for individual noise generating construction equipment. Special acoustic enclosures should be provided for individual noise generating equipment, wherever possible. Workers in those sections where periodic adjustment of equipment/machinery is necessary, shall be provided with sound proof control rooms so that exposure to higher noise level is reduced.
- Scheduling of truck loading, unloading and hauling operation,
- In Loading and un-loading areas with machinery noise muffles, etc. and personal protective gear shall be provided to workers.
- Maintenance of vehicles, equipment and machinery shall be regular and up to the satisfaction of the Environmental Specialist of GC to keep noise levels at the minimum. Proper operation and maintenance of the construction vehicles and equipment would keep them within noise limit,
- Servicing of all construction vehicles and machinery shall be done regularly and during routine servicing operations, the effectiveness of exhaust silencers shall be checked and if found defective shall be replaced,
- Job rotation - Shifting of workers to the extent possible from high noise level area to low noise level areas and vice-versa from time to time avoid the workers to get impacted due to continuous exposure to high level noise,
- Scheduling work to avoid simultaneous activities,

- Automation of equipment and machineries - Wherever possible the Automation of equipment and machineries shall be applied to avoid continuous exposure of workers to noise. If automation of machineries is not possible or feasible, then the workers exposed to noise shall be provided with protective devices.
- Related Noise Control Measures – The following noise control measures shall be undertaken:
    - Use of Anti-drumming floor and noise absorption material,
    - Use of Low speed compressor, blower and air conditioner,
    - Mounting of under frame equipment on anti-vibration pad,
    - Provision of Smooth and gradual control of door,
    - Provision of GRP baffle on the via-duct for elimination of noise transmission,
    - Provision of sound absorbing material in the supply duct and return grill of air conditioner,
    - Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes,
- Noise reduction from various sources - The noise reduction from various sources is possible with the following effective measures during the construction period:
    - The noise from air compressor can be reduced by fitting exhaust and intake mufflers.
    - Noise proof barriers will be provided on the construction boundary near the residential area.
    - Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds.
- Alternate Construction Methods – During pile driving activity increase in noise levels is anticipated even when noise mitigation measures are implemented, however, noise levels will be within acceptable limits. During these activities, alternate methods of construction may be applied to reduce noise Risks and Impacts. Vibratory or hydraulic insertion may be used for pile driving, depending on a variety of factors. Drilling holes for cast-in-place piles is an alternative construction method that may produce significantly lower level noise.
- Management of Time Schedule and Activity Constraints - Noisier activities involving large machinery will be limited to daytime hours as practical, when most people normally get affected are either not present or engaged in less noise-sensitive activities. Night time construction will require a variance. Compliance with local noise ordinances would mitigate effects associated with construction noise. To comply with these ordinances, all construction activities adjacent to residential uses will be limited to day time hours (7:00 A.M. to 6:00 P.M.) from Monday to Saturday.
- The contractor shall comply with standard specifications and all local sound control and noise level rules, regulations, and ordinances that apply to any work performed pursuant to the contract.

- At the construction sites within 150 m of the nearest habitation, noisy construction work such as crushing, operation of DG sets, use of high noise generation equipment shall be stopped during the night time between 10.00 pm to 6.00 am. Working hours of the construction activities shall be restricted around educational institutions/Health Centers (silent zones) up to a distance of 100 m from the sensitive receptors i.e., School, Health Centers and Hospitals etc.
- Environmental Sensitive Receptors - At sensitive receptors where there is no existing compound walls such as health centres/clinics and educational institutions facing roads, backside of the few educational institutes/health center on railway land, etc., noise measures shall be undertaken in due consultation with Indian railway officials and land owners prior to the commencement of construction activities and the commencement of activities will be informed to the public in advance by erecting precautionary direction and safety boards.
- With respect to occupational exposure, noise generating construction activities shall be restricted to a distance of 125 m away from all the sensitive receptors such as educational institutions and Health Centers (silent zones); also including labour camps.
- At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00.
- Noise barriers (Stone walls and plantation) for silence zones including schools and hospitals, noise barriers at sharp curves.
- Noise monitoring shall be carried out at the locations specified in monitoring plan by the K RIDE and the Engineer through the approved monitoring agency.
- Contractor shall provide noise barriers to the suggested locations of educational Institutions & health centers. List of locations for noise barriers is given in **Table 8.43** of Section 8.6.1.2. Guidelines for provision of Noise Barrier are provided as **Annexure 10. 14.**

The project will implement above mentioned Noise Mitigation Measures and thus, comply with the Indian regulations and WBESF guidelines.

Residual impact: With proper implementation of the proposed mitigation measures the residual impact will be minor to moderate, some level of noise due to construction activities will likely be unavoidable. Impacts will be local and temporary and are therefore considered to be acceptable as long as every effort has been taken to prevent these impacts.

8.7.1.2. Airborne noise impact and prediction

Airborne noise is radiated from at-grade and elevated structures. During the operation phase, the main source of noise will be from running of Suburban trains. Basic sources of wayside airborne noise are:

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

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

8.7.1.3. Noise Impact on Sensitive Receptors

Noise impact on sensitive receptors along the project corridors are modelled and given at Section 8.7.1.2. Background noise levels at the receptor are considered as noise levels of the nearest baseline noise monitoring location. The analysis of the results indicates the following:

- The cumulative noise levels at all these receptors are exceeding the permissiblelimits issued by CPCB and IFC.
- Noise impact criteria on these receptors is categorised as follows.
- No Impact - difference between baseline noise levels and cumulative noise levelsare less than 3 dB (A)
- Severe Impact - difference between baseline noise levels and cumulative noiselevels are less than 3 dB (A)

Mitigation Measures : Following noise mitigation measures need to be provided wherever noise impact criteria aresevere at the receptors.

- During operation of Suburban rails at elevated stretches the use of ballast-less track with elastic and absorbent fittings is a standard provision for noise control.
- The use of green belt with vegetation of thick foliage at Depots and stations act as noise screeners and helps to reduce noise;
- Wherever site layout permits, barrier blocks of less-vulnerable buildings may be used.
- Alternatively solid noise barrier walls may also be built (Manual on norms and standards for environment clearance of large construction projects, MoEFCC, 2007).
- Screening of noise shall be ensured by providing parabolic noise barriers on each side of the track along the curved portion of the viaduct and at sensitive receptors during operation. Polycarbonate noise barriers 15mm to 25 mm thick are known to reduce noise level by 30dB.
- Required solid Noise barriers as given below shall be erected and shall be maintained.
- Corridor 1 : Noise Barrier proposed for a length of 545 m
- Corridor 2 : Noise Barrier proposed for a length of 1161 m
- Corridor 3 : Noise Barrier proposed for a length of 937 m
- Corridor 4 : Noise Barrier proposed for a length of 415 m
- During operation of suburban rails, solid noise barriers are proposed at sharp curved portions, structures falling within 20m distance from the alignment and at sensitive receptors like educational institutions and hospitals where noise impact criteria is severe. The noise barriers are provided wherever existing compound wall are there and at places where sufficient land

available to erect new concrete walls. At receptors where there is no existing compound walls such as clinics in a shop facing roads, backside of the few educational institutes/health center on railway land, etc., noise measures shall be undertaken in due consultation with Indian railway officials and land owners during pre-construction stage. Details of solid concrete noise barriers proposed for each corridor is given in **Table 8.50.** Project proponent need to monitor the noise environment at these locations before erecting the solid noise barriers during operation.

Residual Impacts: Minor impacts predicted, however, no adverse impacts on ecosystem is anticipated.

Table 8.50. Details of Noise Barriers at Environmental Sensitive Receptor Locations

Ex. Chainage in m		Total Length of Barrier in m	Side	Remarks
From	To			
Corridor I: KSR Bengaluru City to Devanahalli				
2/100	2/140	40	RHS	New Clinton Public High School, Srirampura.
3/200	3/270	70	RHS	Cluny Convent High School Malleshwaram
3/100	3/200	200	RHS	Nitte Global Institute, Yelahanka.
3/150	3/220	70	RHS	Hostel, Nitte Global Institute, Yelahanka.
10/000	10/100	100	RHS	Sri Revana Siddeswara Institute of Technology, Chokkanahalli, Chikkajala.
2/770	2/820	50	RHS	Manipal Hospital, Malleshwaram.
13/500	13/515	15	RHS	Dental Clinic, Kodigehalli.
Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara				
205/360	205/396	36	LHS	Government Higher Primary School, Benniganahalli.
205/780	205/810	30	LHS	Little Angels Modern High School, NGEF Layout, Sadananda Nagar, Benniganahalli.
210/600	210/660	60	LHS	Eunice English Medium High School, Thomas Town, Lingarajapuram, Bengaluru.
210/650	210/680	30	LHS	Manahil English High School, Kadugondanahalli.
213/250	213/280	30	LHS	Beacon English High School, 1st main Road, Shampura, Kaval Bairasandra.
213/640	213/670	30	LHS	School, Kaval Bairasandra.
214/380	214/410	30	LHS	BIG Institute of Managerial
215/500	215/520	20	LHS	Government School
216/900	217/000	10	LHS	Hebbal Agriculture School
14/900	14/920	20	LHS	Ashwin Vidyalaya, 4th cross Road, Ramakrishna Gardens, Sundar Nagar, Gokula Extension, Mathikere.
16/150	16/220	70	LHS	P.R Public School, Mohankumar Nagar, Yeshwanthpur.
23/460	23/510	50	LHS	Cecilia English Nursery & High School, Maruthi Seva Nagar.
204/890	204/960	70	RHS	New Pratham Public School, Mahadevapura.

Ex. Chainage in m		Total Length of Barrier in m	Side	Remarks
From	To			
210/710	210/810	100	RHS	Siddhartha PU College, 7th Cross Lingarajapura Hennur Main Road.
214/680	214/880	200	RHS	St Pauls Public School and Apartment, Arabic college Road, Jogappa Layout Nagavara.
23/700	23/730	20	RHS	R.R Institute college
23/900	23/930	30	RHS	National Public School, Chikkabanavara.
206/400	206/425	25	RHS	NMT Elder Care J P Nagar.
18/740	19/040	300	RHS	Government hospital
Corridor 3: Kengeri to Whitefield (via KSR and Cantonment)				
12/700	12/730	30	LHS	Government, High School and First Grade College, Kengeri.
11/470	11/500	30	LHS	National Public School, Kengeri Satellite Town.
2/130	2/480	350	LHS	Roses Convent School, Binnipete, Kempapura.
350/390	350/420	30	LHS	MQI Degree College, Benson Town.
349/220	349/290	70	LHS	Clerence High School, Rechards Town.
5/150	5/225	75	LHS	Ananya Hospital
353/890	353/990	100	LHS	Star Health Allied
353/680	353/720	40	LHS	Eye Hospital and Squite Centre.
348/770	348/815	45	LHS	Medico Pertrol Association Center for Mental Health
347/600	347/610	10	LHS	Jeevan Clinic jeevanahalli
10/400	10/430	30	RHS	Orchids School, Mysore Road, Kengeri satellite Town.
10/300	10/350	50	RHS	Benguluru Institute of Management, Mysore Road, Kengeri Satellite Town.
8/150	8/170	20	RHS	College
5/860	5/872	12	RHS	Government Urdu Primary School, Roshan Nagar.
348/540	348/545	5	RHS	Government Primary School, Pulikeshi Nagar
339/250	339/270	20	RHS	The Brigade School, Mahadevapura.
349/570	349/590	20	RHS	City Multi Speciality and Trauma Centre, Hospital, Pulikeshi Nagar.
Corridor 4: Heelalige to Rajanukunte				
182/800	182/960	160	LHS	Bangalore college of Engineering, Heelalige, Bommasandra.
184/100	184/150	50	LHS	Norwich High School sampigenagara to Ramanagar mainroad Ramasagara,Electronics city Bengaluru.
180/600	180/645	45	LHS	Athreya Hospital Anekal Main Road, Suryanagar phase 1.
203/050	203/070	20	LHS	Smiles Dental Care, C V Raman Nagar,Kaggadasapur
191/050	191/120	70	RHS	College Chikkakanneli

Ex. Chainage in m		Total Length of Barrier in m	Side	Remarks
From	To			
199/290	191/315	25	RHS	Kids Mansion School, Chinnappanahalli.
202/400	202/425	25	RHS	Geethanjali Vidyalaya & Montress, Kaggadaspura.
198/580	198/600	20	RHS	Lions Airportcity Hospital, Munnekollal, Marathahalli.

8.7.2. Risks & Impacts on Vibration

Ground vibrations by railway traffic are generated by two prime excitation mechanisms (i) the quasi-static displacement caused by the axle load as the wheel moves along the track, and (ii) the inertia forces due to the acceleration of the unsprung mass of the train as it rolls over the irregular profile of the railhead. Rail irregularity profiles, have generally an erratic nature. Therefore, the associated ground vibrations tend to display a stochastic character.

Vibration levels reveal that most of the receptor locations fall within vibration damage threshold criteria.

Mitigation Measures : Vibration monitoring and building condition surveys at sensitive structures shall be implemented, as per requirement in line with WB's ESS 3 and EIB ESS 3. The proper maintenance of track and rolling stock during operation helps in controlling vibration. The vibration level can be significantly reduced by incorporating the following standard measures/factors:

- Vehicles with No stiff primary suspension
- No Worn or Wheel with flats
- No Worn/Corrugated Track
- With Floor-to-Floor Attenuation in receptor buildings

In case of ballast less track, the following are some measures for vibration damping:

- Use of Resilient soft base plates between rail and track slab;
- Use of Resilient rubber between the base plate and track slab;
- Application of Soft elastic fastening system and
- Deep and narrow trenches in the ground shall be tested at vibration-sensitive structures.

The project will implement the above mentioned Noise and Vibration mitigation measures and thus, comply with the Indian regulations and WBESF guidelines.

8.7.3. Risks & Impacts on Track Side Vegetation

Vegetation (shrubs, climbers and small trees) may be developed and spread along the proposed BSRP tracks. Vegetation including trees and bushes will become a danger to passing trains. The leaves they drop are also the cause of low rail adhesion.

Mitigation Measures: At present, manual clearing of vegetation along the railway tracks is practiced by Indian Railway. It is proposed to adopt same method to clear the vegetation for BSRP. Vegetation (shrubs, climbers and small trees) along the proposed BSRP tracks will be cleared manually without using any weedicide and herbicides.

Residual Impacts: No negative impact on ecosystem is anticipated.

8.7.4. Energy Consumption at Stations and Efficiency

Electricity is required at stations for facilities like lighting, passenger information, access, security, climate control, escalators/elevators etc. Proper utilization of electricity shall be made at stations in need.

8.7.5. Electro-Magnetic Compatibility

The railway project and its operating systems have been so designed to address concerns on Electro Magnetic Compatibility (EMC) and Electro Magnetic Interference (EMI). EMC is an issue that is mitigated through the application of EMC industry accepted practice during design and installation of the system, and these conform to the limits provided by the International Commission on Non-Ionizing Radiation Protection (ICNIRP 1998 guidelines). This limits the minimal effects of EMI to the environment.

8.7.6. Risks & Impacts on Ground Water

No impact on ground water is predicted. However, K RIDE shall implement Rain Water Harvesting Methods in line with WB ESS 1, 3 and 6, to augment storage of ground water. It is proposed to construct rainwater harvesting unit/structure of suitable capacity at the elevated stations and at the elevated alignment. Each pillar can have inbuilt downpipes to collect the rainwater from the viaduct and lead in to underground tanks; water collected will percolate down to the subsoil through layers of sand and gravel.

Average annual rainfall of Bengaluru is 1200 mm. Rainwater harvesting shall be carried out for Ground water recharge at each stations – at grade and elevated stations at each corridor. Total 100 numbers of Recharge Units for Corridor 1, 65 units for Corridor 2, 51 units for Corridor 3; and 114 units for Corridor 4 are proposed. The cost estimated is ₹ 94.7 Lakhs for Corridor 1, ₹ 61.56 Lakhs for Corridor 2 and ₹ 48.30 Lakhs for Corridor 3; and ₹ 108.4 Lakhs for Corridor 4.

Residual Impacts: No negative impacts are predicted on ecosystem.

8.7.7. Risks & Impacts due to Depots and Stations

The land for establishing the depots is at Akkupete (13°14'50.40"N & 77°41'26.37"E) and Soledevanahalli (13° 5'15.65"N & 77°29'34.64"E). It is proposed to mobilize the Akkupete land of about 18.6 Ha and 9.3 Ha for Soledevanahalli depot. The cost of the land is not considered as it is owned by the government depts.

Akkupete depot in the Suburban Rail Corridor 1 will be of about 18.6 Ha Acres /186000 Sqm, which needs to be diverted from Forest Department. Process obtaining depot lands from the respective department is in progress. The Depot lands are with local vegetation but without any habitat or human settlement. There will not be any major impacts on valued environmental component except tree felling due to construction of depots at these locations.

Further, two micro depots are also proposed along with Stations at Heelalige and Kengeri. Every train which ply through Corridor 3 and Corridor 4 are planned to undergo maintenance in a period of 3 days, 15 days and 45 days' time. The total cost of dry run of all the trains to perform the above scheduled maintenance is works out to Rs 75 crore/year which is 25% of the yearly maintenance cost.

The station area will be leveled through cut and fill method, as per requirement. There will be totally 58 (5 stations between Bengaluru Cant. and Whitefield) Stations along the 4 Corridors of the Suburban railway network. Each Station will be with standard size of 205m in length and 26 m in width (5330 Sqm).

General Provisions accommodated in the proposed Micro Depots are;

- Air brake checking equipment,
- Pit Bay,
- Cat walk and
- Automatic Wash plan.

Following are the main facilities of project which will be provided at these Major Depots:

- Washing Lines,
- Operation and Maintenance Lines,
- Workshop,
- Offices and
- The depot area will be levelled through cut and fill method within the depot.

Following are the main facilities of Project which will be provided at each Station :

- Offices (Station Control Room, Station Master's Office, Information & Enquiries, Ticket Office, Passenger Office, etc.)
- Cleaner's Room
- Security Room
- First Aid Room
- Miscellaneous Operations Room
- Platform Supervisor's Booth
- Traction Substation
- Staff Area
- Fire Tank and Pump Room
- Staff Toilets
- Commercial Outlets and Kiosks
- Station Store Room
- UPS and Battery Room
- Refuse Store
- Signaling/Communication Room

Issues of Impacts at Depot and Stations

- Water supply

- Effluent generation
- Solid Waste generation
- Oil Pollution
- Noise Pollution
- Surface drainage
- Loss of trees

Issues of impacts foreseen at stations are same except oil pollution and effluent treatment.

8.7.7.1. Risks & Impacts on Water Supply, Waste Water and Municipal Solid Waste (MSW) Disposal at Stations

The daily Ridership of Suburban Railways as predicted is given in Coloumn no 3 for horizon years in **Table 8.51** to **Table 8.54**. The Corridor wise water demand at stations for drinking and toilet demands; and solid waste generation for passengers and staff will be of the order of magnitude as indicated in the following Tables (**Table 8.51** to **Table 8.54**) individually for all the 4 corridors - Corridor 1, Corridor 2, Corridor 3, Corridor 4, respectively and followed by summary in **Table 8.55**. The demand is estimated onthe following assumptions:

- Alighting passenger for Year 2025, 2031 & 2041 as given in Feasibility Report are considered for the calculations.
- 15% of Alighting passengers at each station will use the toilets
- Water requirement for each user will be 5 lit/passenger/day
- 10% of Alighting passenger at each station will generate Solid Waste
- Solid Waste generation will be 100gm/passenger/day

The water demand during operation phase will be supplied by Bruhat Bengaluru Mahanagara Palike (BBMP). Daily sewage flow is considered as 90% of the water requirement at each station as given in the Table, which will be treated through Bio Digesters.

According to the CPCB regulations, railway stations generating waste water equal to or more than 100 KLD would be categorised as red, those greater than 10 KLD but less than 100 KLD would come under the orange category. Railway stations with less than 10 KLD waste water generation would be branded green category. As per estimation, the waste water generation per station is >10 KLD but < 100 KLD, as per CPCB regulations. Therefore, the project comes under Orange Category. The estimated details of Water Demand, Waste Water Generation and Solid Waste Generation are presented in the Tables (**Table 8.51** to **Table 8.54**) and summarized in **Table 8.55**. Graphical representation of Total Water Demand (KLD), Waste Water Generation (KLD), Solid Waste Generation (Kg) and consolidated for 4 Corridors are presented in **Figure 8.17** to **Figure 8.20**.

Table 8.51. Water Demand, Waste Water and Municipal Solid Waste (MSW) for Corridor 1 (KSR Bengaluru City - Devanahalli)

Sl. No.	Station Name	Water Demand (KLD)			Waste Water Generation (KLD)			Solid Waste Generation (Kg)		
		2025	2031	2041	2025	2031	2041	2025	2031	2041
1	KSR Bengaluru city	203.975	258.870	336.065	27.537	34.947	45.369	407.950	517.740	672.130
2	Srirampura	79.050	96.125	115.800	10.672	12.977	15.633	158.100	192.250	231.600
3	Malleswaram	162.140	195.325	225.900	21.889	26.369	30.497	324.280	390.650	451.800
4	Yeshwantpur	167.810	193.140	243.500	22.654	26.074	32.873	335.620	386.280	487.000
5	Muthyalanagar	138.140	165.145	192.450	18.649	22.295	25.981	276.280	330.290	384.900
6	Lottegolahalli	259.315	319.735	415.510	35.008	43.164	56.094	518.630	639.470	831.020
7	Kodigehalli	171.025	239.205	300.280	23.088	32.293	40.538	342.050	478.410	600.560
8	Judicial layout	241.330	305.125	410.510	32.580	41.192	55.419	482.660	610.250	821.020
9	Yelahanka	215.545	292.990	439.510	29.099	39.554	59.334	431.090	585.980	879.020
10	Nitte Meenakshi	68.140	87.035	148.655	9.199	11.750	20.068	136.280	174.070	297.310
11	Betahalasuru	11.640	18.385	36.195	1.571	2.482	4.886	23.280	36.770	72.390
12	Doddajala	102.885	173.845	305.320	13.889	23.469	41.218	205.770	347.690	610.640
13	Airport Trumpet	35.465	48.195	68.560	4.788	6.506	9.256	70.930	96.390	137.120
14	Future Station @ Km 38/800	90	123.51	211.89	12.18	16.67	28.61	180.46	247.02	423.78
15	Airport KIADB	96.175	145.545	274.760	12.984	19.649	37.093	192.350	291.090	549.520
16	Devanahalli	84.280	101.470	149.020	11.378	13.698	20.118	168.560	202.940	298.040
Total		**2127.143**	**2763.643**	**3873.925**	**287.166**	**373.093**	**522.983**	**4254.285**	**5527.285**	**7747.850**

Table 8.52. Water Demand, Waste Water and Municipal Solid Waste (MSW) for Corridor 2 (Baiyappanahalli - Chikkabanawar)

Sl. No.	Station Name	Alighting Passengers			Water Demand (KLD)			Waste Water Generation (KLD)			Solid Waste Generation (Kg)		
		2025	2031	2041	2025	2031	2041	2025	2031	2041	2025	2031	2041
1	Baiyyappanahalli Terminal	12779	17714	23102	63.895	88.570	115.510	8.626	11.957	15.594	127.790	177.140	231.020
2	Kasturi Nagar	13657	15930	18016	68.285	79.650	90.080	9.218	10.753	12.161	136.570	159.300	180.160
3	Sevanagar	16282	21052	22740	81.410	105.260	113.700	10.990	14.210	15.350	162.820	210.520	227.400
4	Banaswadi	11486	12985	15483	57.430	64.925	77.415	7.753	8.765	10.451	114.860	129.850	154.830

Sl. No.	Station Name	Alighting Passengers			Water Demand (KLD)			Waste Water Generation (KLD)			Solid Waste Generation (Kg)		
		2025	2031	2041	2025	2031	2041	2025	2031	2041	2025	2031	2041
5	Kaveri Nagar	22517	27966	33067	112.585	139.830	165.335	15.199	18.877	22.320	225.170	279.660	330.670
6	Nagawara	32987	41833	52015	164.935	209.165	260.075	22.266	28.237	35.110	329.870	418.330	520.150
7	Kanakanagara	14926	18229	23318	74.630	91.145	116.590	10.075	12.305	15.740	149.260	182.290	233.180
8	Hebbal	11436	13835	17699	57.180	69.175	88.495	7.719	9.339	11.947	114.360	138.350	176.990
9	Lottegolahalli	18039	21481	27652	90.195	107.405	138.260	12.176	14.500	18.665	180.390	214.810	276.520
10	Yeshwantpur	33905	42958	52641	169.525	214.790	263.205	22.886	28.997	35.533	339.050	429.580	526.410
11	Jalahalli	23066	30344	41814	115.330	151.720	209.070	15.570	20.482	28.224	230.660	303.440	418.140
12	Shettihalli	30418	41942	53647	152.090	209.710	268.235	20.532	28.311	36.212	304.180	419.420	536.470
13	Mydarahalli	16513	22495	30680	82.565	112.475	153.400	11.146	15.184	20.709	165.130	224.950	306.800
14	Chikkabanavar	14163	18222	26359	70.815	91.110	131.795	9.560	12.300	17.792	141.630	182.220	263.590
Total		**272174**	**346988**	**438234**	**1360.870**	**1734.930**	**2191.165**	**183.717**	**234.216**	**295.807**	**2721.740**	**3469.860**	**4382.330**

Table 8.53. Water Demand, Waste Water and Municipal Solid Waste (MSW) for Corridor 3 (Kengeri - White Field)

Sl. No.	Station Name	Water Demand (KLD)			Waste Water Generation (KLD)			Solid Waste Generation (Kg)		
		2025	2031	2041	2025	2031	2041	2025	2031	2041
1	Kengeri	187.565	248.465	321.53	25.321275	33.54278	43.40655	375.13	496.93	643.06
2	RV College	88	121.165	169.685	11.88	16.35728	22.90748	176	242.33	339.37
3	Jnanabharati	115.895	152.085	185.62	15.645825	20.53148	25.0587	231.79	304.17	371.24
4	Nayandahalli	45.365	57.02	67.725	6.124275	7.6977	9.142875	90.73	114.04	135.45
5	Krishnadevaraya	45.74	54.55	59.28	6.1749	7.36425	8.0028	91.48	109.1	118.56
6	Jagajeevanram Nagar	54.25	64.53	69.895	7.32375	8.71155	9.435825	108.5	129.06	139.79
7	KSR Bengaluru City	140.485	163.095	182.015	18.965475	22.01783	24.57203	280.97	326.19	364.03
8	Kumarapark (BDA)	76.51	96.89	112.355	10.32885	13.08015	15.16793	153.02	193.78	224.71
9	Bengaluru Cantt.	97.04	117.11	136.3	13.1004	15.80985	18.4005	194.08	234.22	272.6
10	Bengaluru East	74.15	90.745	111.82	10.01025	12.25058	15.0957	148.3	181.49	223.64
11	Baiyyappanahalli	48.195	62.53	75.585	6.506325	8.44155	10.20398	96.39	125.06	151.17
12	Krishanrajapuram	63.3	91.58	113.625	8.5455	12.3633	15.33938	126.6	183.16	227.25
13	Hoodi	44.275	65.075	84.93	5.977125	8.785125	11.46555	88.55	130.15	169.86

Sl. No.	Station Name	Water Demand (KLD)			Waste Water Generation (KLD)			Solid Waste Generation (Kg)		
		2025	2031	2041	2025	2031	2041	2025	2031	2041
14	White Field	5.22	8.24	10.68	0.7047	1.1124	1.4418	10.44	16.48	21.36
Total		**1085.99**	**1393.08**	**1701.045**	**146.60865**	**188.0658**	**229.6411**	**2171.98**	**2786.16**	**3402.09**

Table 8.54. Water Demand, Waste Water and Municipal Solid Waste (MSW) for Corridor 4 (Heelalige - Rajankunte)

Sl. No.	Station Name	Water Demand (KLD)			Waste Water Generation (KLD)			Solid Waste Generation (Kg)		
		2025	2031	2041	2025	2031	2041	2025	2031	2041
1	Heelalige	23.085	40.000	72.000	3.116	5.400	9.720	46.170	80.000	144.000
2	Bommasandra	21.785	37.750	67.950	2.941	5.096	9.173	43.570	75.500	135.900
3	Singena Agrahara	17.890	31.000	55.800	2.415	4.185	7.533	35.780	62.000	111.600
4	Huskur	67.015	84.600	110.975	9.047	11.421	14.982	134.030	169.200	221.950
5	Ambedkar Nagar	46.070	58.815	78.330	6.219	7.940	10.575	92.140	117.630	156.660
6	Karmelram	180.180	222.635	292.675	24.324	30.056	39.511	360.360	445.270	585.350
7	Belandur Road	75.110	92.960	115.625	10.140	12.550	15.609	150.220	185.920	231.250
8	Marathahalli	94.225	136.785	182.540	12.720	18.466	24.643	188.450	273.570	365.080
9	Future Station at Km 199/700	104.075	145.005	186.24	14.05	19.5755	25.1425	208.15	290.01	372.48
10	Kagadaspura	113.925	153.225	189.940	15.380	20.685	25.642	227.850	306.450	379.880
11	Benniganahalli	60.675	81.115	108.285	8.191	10.951	14.618	121.350	162.230	216.570
12	Channasandra	106.245	149.435	184.050	14.343	20.174	24.847	212.490	298.870	368.100
13	Horamavu	143.070	197.005	235.935	19.314	26.596	31.851	286.140	394.010	471.870
14	Hennur	222.300	306.640	381.160	30.011	41.396	51.457	444.600	613.280	762.320
15	Tannisandra	271.375	433.345	506.225	36.636	58.502	68.340	542.750	866.690	1012.450
16	RK Hegde Nagar	155.340	245.390	296.700	20.971	33.128	40.055	310.680	490.780	593.400
17	Jakkur	63.675	96.875	152.695	8.596	13.078	20.614	127.350	193.750	305.390
18	Yelahanka	76.710	105.000	172.705	10.356	14.175	23.315	153.420	210.000	345.410
19	Muddenahalli	41.895	52.745	73.355	5.656	7.121	9.903	83.790	105.490	146.710
20	Rajanukunte	35.000	48.990	72.310	4.725	6.614	9.762	70.000	97.980	144.620
Total		**1919.645**	**2719.315**	**3535.495**	**259.151**	**367.1095**	**477.2925**	**3839.29**	**5438.63**	**7070.99**

Table 8.55. Summary of the Water Demand, Waste Water and Municipal Solid Waste (MSW) Generation at 4 Corridors

Sl. No.	Corridor Name	Water Demand (KLD)			Waste Water Generation (KLD)			Solid Waste Generation (Kg)		
		2025	2031	2041	2025	2031	2041	2025	2031	2041
1.	Corridor 1 (KSR Bengaluru City - Devanahalli)	2127.143	2763.643	3873.925	287.166	373.093	522.983	4254.285	5527.285	7747.850
2.	Corridor 2 (Baiyappanahalli -Chikkabanawar)	1360.87	1734.93	2191.165	183.717	234.216	295.807	2721.74	3469.86	4382.33
3.	Corridor 3 (Kengeri - White Field)	1085.99	1393.08	1701.045	146.6087	188.0658	229.6411	2171.98	2786.16	3402.09
4.	Corridor 4 (Heelalige - Rajankunte)	1919.645	2719.315	3535.495	259.151	367.110	477.293	3839.290	5438.630	7070.990
Total		**6493.648**	**8610.968**	**11301.630**	**876.643**	**1162.484**	**1525.723**	**12987.295**	**17221.935**	**22603.260**

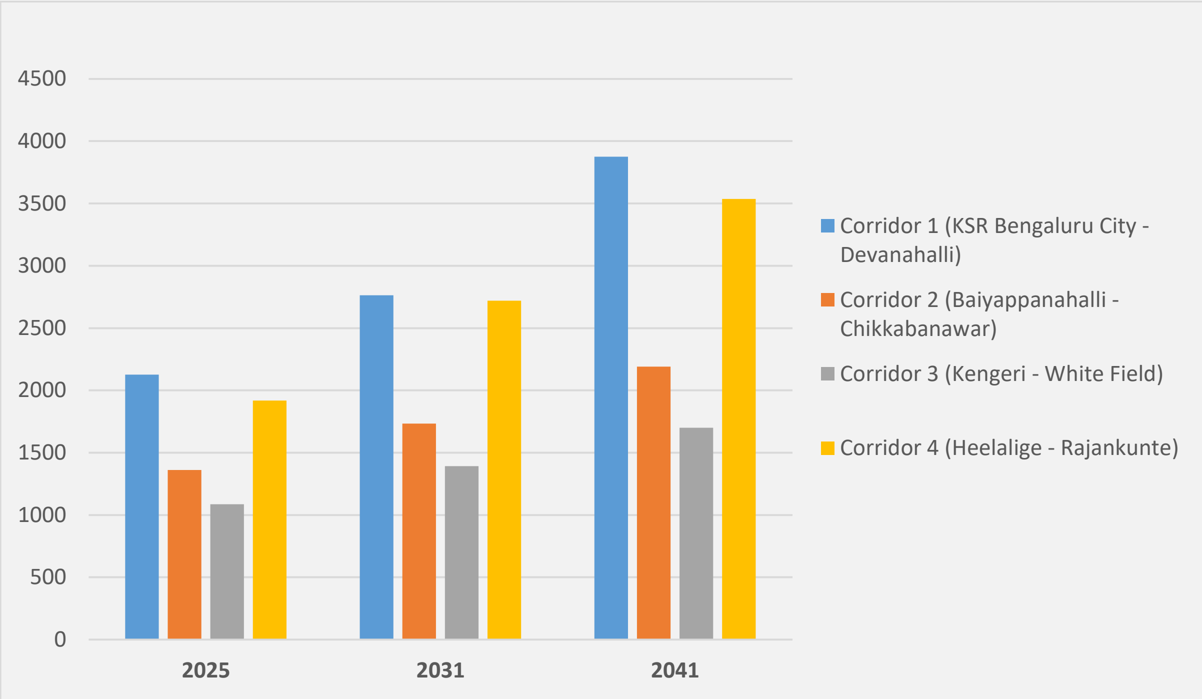


Figure 8.17. Water Demand (KLD) at 4 Corridors

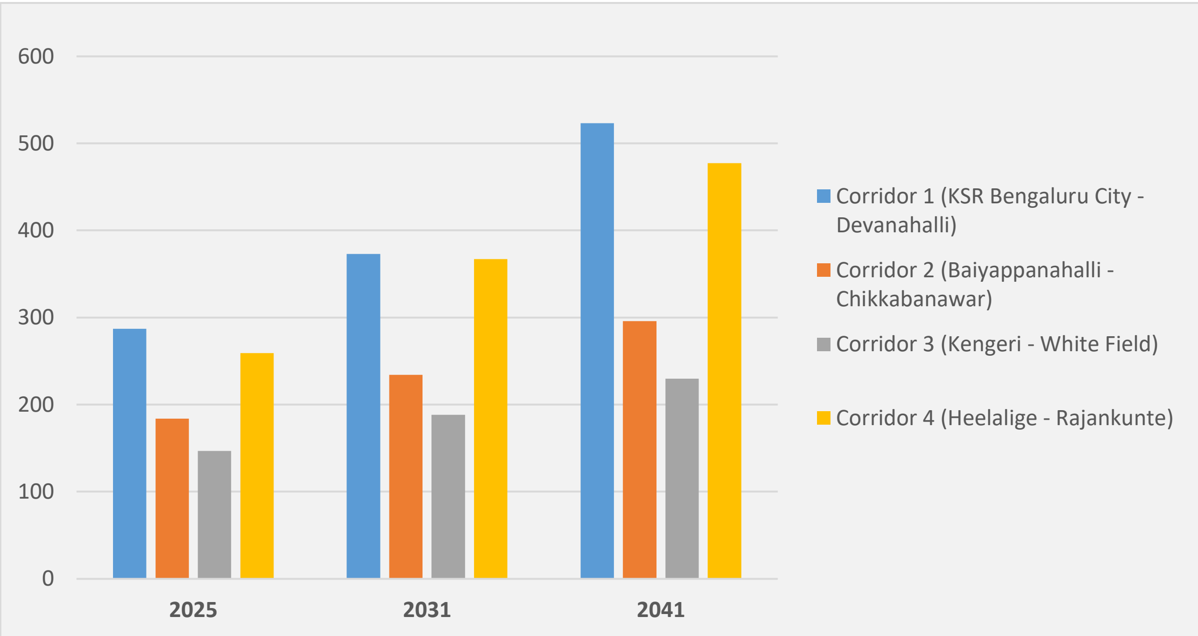


Figure 8.18. Waste Water Generation (KLD) at 4 Corridors

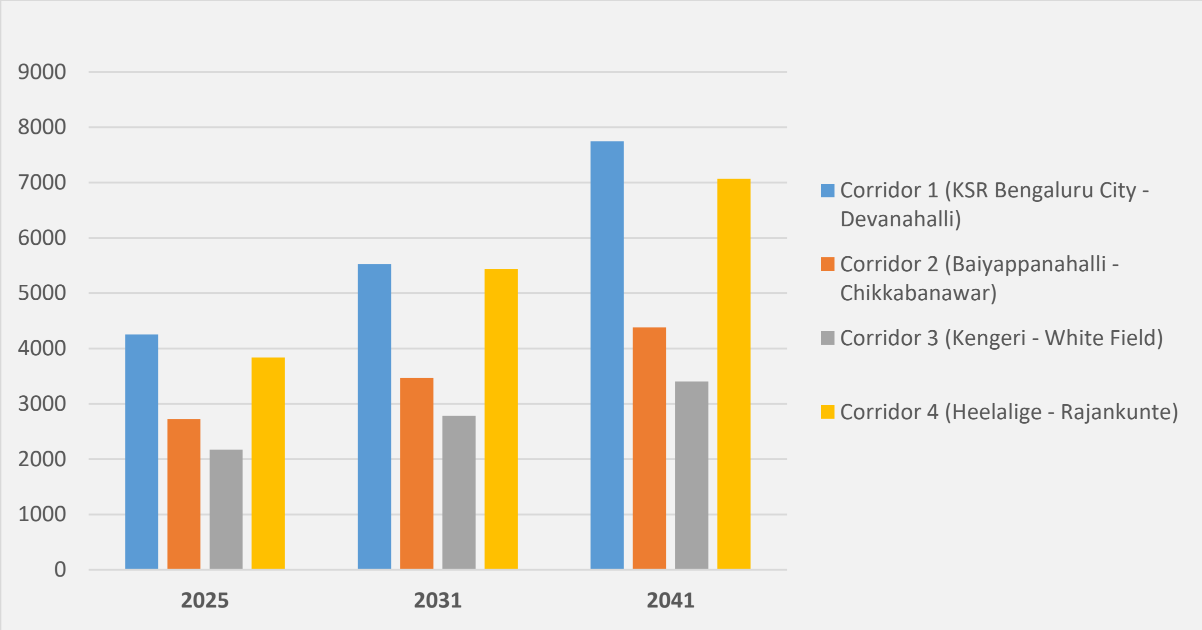


Figure 8.19. Solid Waste Generation (Kg) at 4 Corridors

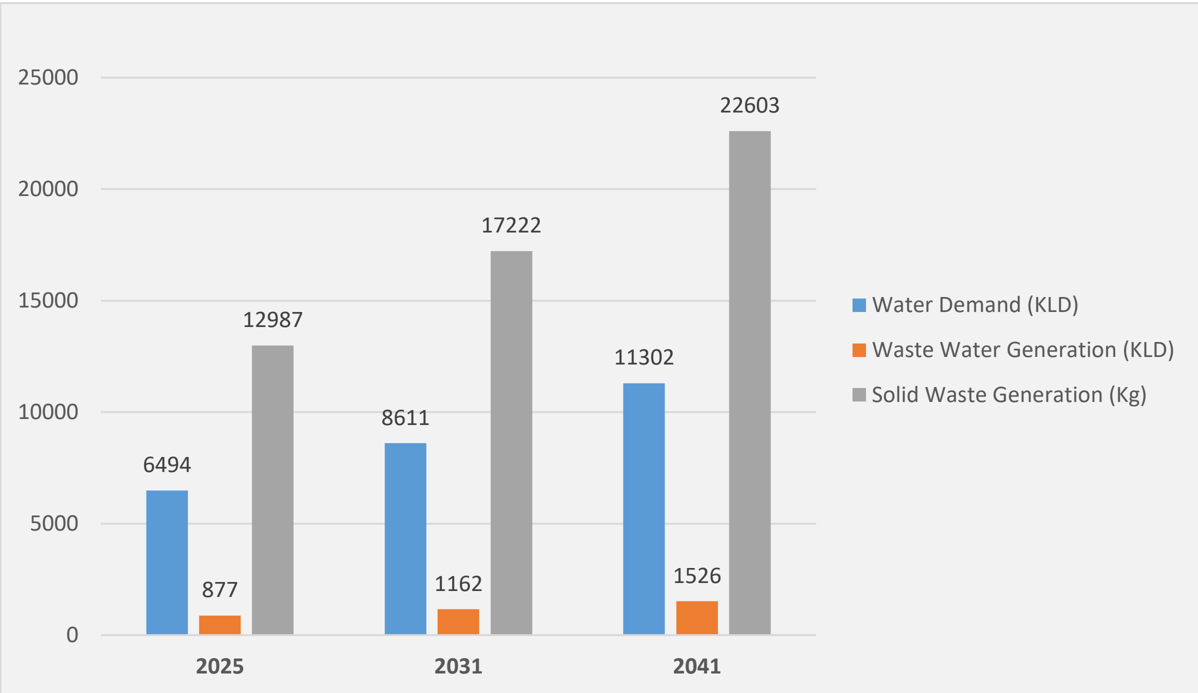


Figure 8.20. Total Water Demand (KLD), Waste Water Generation (KLD) and Solid Waste Generation (Kg) at 4 Corridors

Mitigation Measures : In accordance with the Railways Works Manual, 2000, adequate water supply and sullage and storm water drains will be provided. The water supply system shall be designed on the basis of water demand for drinking and sanitation purpose. Necessary measures will be taken to ensure zero or minimized wastage of water, wherever hydrants are provided. For multi-storeyed buildings, as per requirement, necessary static tanks may be provided for the fire-fighting arrangements in accordance with the specified regulations.

Water Supply:

The source of water supply at Depots is municipal water supply and ground water. This will be supplemented by re-use of treated water of effluent treatment plant which may be used for cleaning floor, washing and flushing purpose. Water supply system will be provided with overhead storage facilities and where no sewerage system exists in the vicinity.

All stations and depots will be provided with basic public amenities such as drinking water, water supply, sanitation and toilets. Drinking water; and water supply for air conditioning facilities, cleaning purpose and for the use of staff and passengers will be procured mainly from municipal water supply.

Liquid waste - sewage & Effluent disposal at stations and Depots :

Water Quality Management at Stations and Depots will be in accordance with Water and Waste Water Management Plan in compliance with Indian Standards and ESS 3 of World Bank and ESS 3 of EIB.

Open drains and soak-pits shall be implemented where water-borne sewerage exists in the vicinity. Required number of Latrines or urinals shall be provided as per specifications and guidelines mentioned in the Railways Works Manual, 2000 and CPCB/KSPCB regulations.

Other Measures include treatment and reuse of waste water by installing Bio-digesters at Stations and Effluent treatment plant for Depots. Treated water shall be reused for flushing, rail car cleaning and floor cleaning purpose.

Typical cross section for Bio-digesters is given in **Figure 8.11.** Sewage and Effluents from depots sites shall be collected and treated using Effluent Treatment Plant in the premises. Proper maintenance of Bio-digesters shall be followed.

Corridor 1 : No. of Bio-digester at Stations = 15 and No. of ETP at Depots = 1 (Major Depot at Akkupete)

Corridor 2 : No. of Bio-digester at Stations = 14 and No. of ETP = 1 (Major Depot at Soladevanahalli)

Corridor 3 : No. of Bio-digester at Stations = 14 and No. of ETP = 1 (Micro Depot at Kengeri)

Corridor 4 : No. of Bio-digester at Stations = 20 and No. of ETP = 1 (Micro Depot at Heelalige)

Bio-Digesters: Considering disposal of human waste as a major concern, K RIDE shall install eco-friendly DRDO approved zero waste bio-digesters at all stations for on-site disposal of human waste.

Defense Research and Development Organisation (DRDO) /Defence Research Development Establishment (DRDE) in association with Research Design and Standard Organisation (RDSO) have developed this technology. DRDO has developed different versions of bio-digester to take care of disposal of human waste. The bio-digesters have been extensively fitted in different types of rail coaches by Indian Railways with collaboration of DRDO. The technology has no dependence on the limited and costly conventional energy sources.

Salient features:

- Eco-friendly & cost-effective
- Minimal maintenance

- No need for sludge removal
- More than 90% organic matter reduction
- More than 99% pathogens reduction
- Generation of odorless & inflammable biogas
- Bio-digester can tolerate toilet cleaning agents to certain extent
- Technology transferred to industries for commercialization

The zero-waste bio-digester technology treats human excreta/waste at source by decomposing it into usable water and gas through anaerobic process. It does not have any geographical or temperature limitation. The bio-digester based eco-friendly sanitation technology will convert human faecal waste in to water and gas. The bio-digesters treat human waste by a biological process called composting under anaerobic environment (in the absence of Oxygen) by anaerobic bacteria. They decompose human excretory waste in the digester tank converting it into methane gas, carbon dioxide, and water. The anaerobic process inactivates the pathogens responsible for water-borne diseases and treats the fecal matter without the use of an external energy source. Organic waste will be segregated and treated by on-site bio-composter technique. Bio-digestion process is briefed below at the end of this sub-section.

Bio-toilets do not require sewage connectivity (sewerage networks) and because the process is self-contained and bio-toilets are maintenance free. The only by-products of the waste treatment process are pathogen-free water, which is good for gardening, and bio-gas, which can be used for cooking. The total quantity of Waste water generation and requirement of DRDO approved Bio-digesters with capacity and cost estimate for all stations at each corridor of the Suburban Rail Project are given below in **Table 8.56**.

Table 8.56. Provision of Bio-digesters at Suburban Railway Stations

Sl. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Cost of Bio Digester in ₹ Lakh	Cost of Bio Digester in ₹
Corridor 1 (KSR Bengaluru City - Devanahalli)					
1	KSR Bengaluru City	27.537	5	2.50	2,50,336
2	Srirampura	10.672	2	0.97	97,018
3	Malleswaram	21.889	4	1.99	1,98,991
4	Yeshwantpur	22.654	4	2.06	2,05,945
5	Muthyalanagar	18.649	3	1.70	1,69,536
6	Lottegolahalli	35.008	6	3.18	3,18,255
7	Kodigehalli	23.088	4	2.10	2,09,891
8	Judicial Layout	32.58	6	2.96	2,96,182
9	Yelahanka	29.099	5	2.65	2,64,536
10	Nitte Meenakshi	9.199	2	0.84	83,627
11	Betahalasuru	1.571	0	0.14	14,282
12	Doddajala	13.889	3	1.26	1,26,264
13	Airport Trumpet	4.788	1	0.44	43,527
14	Airport KIADB	12.984	2	1.18	1,18,036
15	Future Station @ Km 38/800	12.181	2	1.11	1,11,000

Sl. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Cost of Bio Digester in ₹ Lakh	Cost of Bio Digester in ₹
	Devanahalli	11.378	2	1.03	1,03,436
Total		**287.166**	**52**	**26.110**	**26,10,862**
Corridor 2 (Baiyappanahalli - Chikkabanawar)					
1	Baiyyappanahalli Terminal	8.626	2	0.78	78,418
2	Kasturi Nagar	9.218	2	0.84	83,800
3	Sevanagar	10.99	2	1.00	99,909
4	Banaswadi	7.753	1	0.70	70,482
5	Kaveri Nagar	15.199	3	1.38	1,38,173
6	Nagawara	22.266	4	2.02	2,02,418
7	Kanakanagara	10.075	2	0.92	91,591
8	Hebbal	7.719	1	0.70	70,173
9	Lottegolahalli	12.176	2	1.11	1,10,691
10	Yeshwantpur	22.886	4	2.08	2,08,055
11	Jalahalli	15.57	3	1.42	1,41,545
12	Shettihalli	20.532	4	1.87	1,86,655
13	Mydarahalli	11.146	2	1.01	1,01,327
14	Chikkabanavar	9.56	2	0.87	86,909
Total		**183.717**	**33**	**17**	**16,70,145**
Corridor 3 (Kengeri - White Field)					
1	Kengeri	25.321275	5	2.30	2,30,193
2	RV College	11.88	2	1.08	1,08,000
3	Jnanabharati	15.645825	3	1.42	1,42,235
4	Nayandahalli	6.124275	1	0.56	55,675
5	Krishnadevaraya	6.1749	1	0.56	56,135
6	Jagajeevanram Nagar	7.32375	1	0.67	66,580
7	KSR Bengaluru City	18.965475	3	1.72	1,72,413
8	Kumarapark (BDA)	10.32885	2	0.94	93,899
9	Bengaluru Cantt.	13.1004	2	1.19	1,19,095
10	Bengaluru East	10.01025	2	0.91	91,002
11	Baiyyappanahalli	6.506325	1	0.59	59,148
12	Krishanrajapuram	8.5455	2	0.78	77,686
13	Hoodi	5.977125	1	0.54	54,338
14	White Field	0.7047	0	0.06	6,406
Total		**146.60865**	**27**	**13**	**13,32,806**
Corridor 4 (Heelalige - Rajankunte)					
1	Heelalige	3.116	1	0.28	28,327
2	Bommasandra	2.941	1	0.27	26,736
3	Singena Agrahara	2.415	0	0.22	21,955
4	Huskur	9.047	2	0.82	82,245
5	Ambedkar Nagar	6.219	1	0.57	56,536
6	Karmelram	24.324	4	2.21	2,21,127

Sl. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Cost of Bio Digester in ₹ Lakh	Cost of Bio Digester in ₹
7	Belandur Road	10.14	2	0.92	92,182
8	Marathahalli	12.72	2	1.16	1,15,636
9	Future Station @ Km 199/700	14.05	3	1.28	1,28,000
10	Kagadaspura	15.38	3	1.40	1,39,818
11	Benniganahalli	8.191	1	0.74	74,464
12	Channasandra	14.343	3	1.30	1,30,391
13	Horamavu	19.314	4	1.76	1,75,582
14	Hennur	30.011	5	2.73	2,72,827
15	Tannisandra	36.636	7	3.33	3,33,055
16	RK Hegde Nagar	20.971	4	1.91	1,90,645
17	Jakkur	8.596	2	0.78	78,145
18	Yelahanka	10.356	2	0.94	94,145
19	Muddenahalli	5.656	1	0.51	51,418
20	Rajanukunte	4.725	1	0.43	42,955
Total		**259.151**	**49**	**23.56**	**23,56,189**

Note: Corridor 3's 5 stations ie., stations between Bengaluru Cant. and Whitefield is also consider for Bio-digester and separate bio-digesters are proposed for C1 and C4 Integrated Yelahanka Stations.

Anticipated influent & effluent waste water quality parameters from the bio-digesters are given in **Table 8.57** and typical cross section of a Bio-digester is shown in **Figure 8.21.**

Table 8.57. Waste Water Quality Parameters (Influent & Effluent)

Sl. No.	Parameter	Unit	Characteristics	
			Influent	Effluent
1.	pH	-	7.0 -7.5	7.0 -7.5
2.	Turbidity	NTU	70 -90	2-5
3.	Total Suspended Solids (TSS)	mg/l	90-120	50 -80
4.	Total Dissolved Solids (TDS)	mg/l	350 -450	100 -300
5.	Biochemical Oxygen Demand (BOD) at 5 days and 20°C	mg/l	70-120	2-4
6.	Chemical Oxygen Demand (COD)	mg/l	250 -300	15 -25
7.	Coliforms	MPN/100ml	300 -350	0-12

Source: DRDO Website

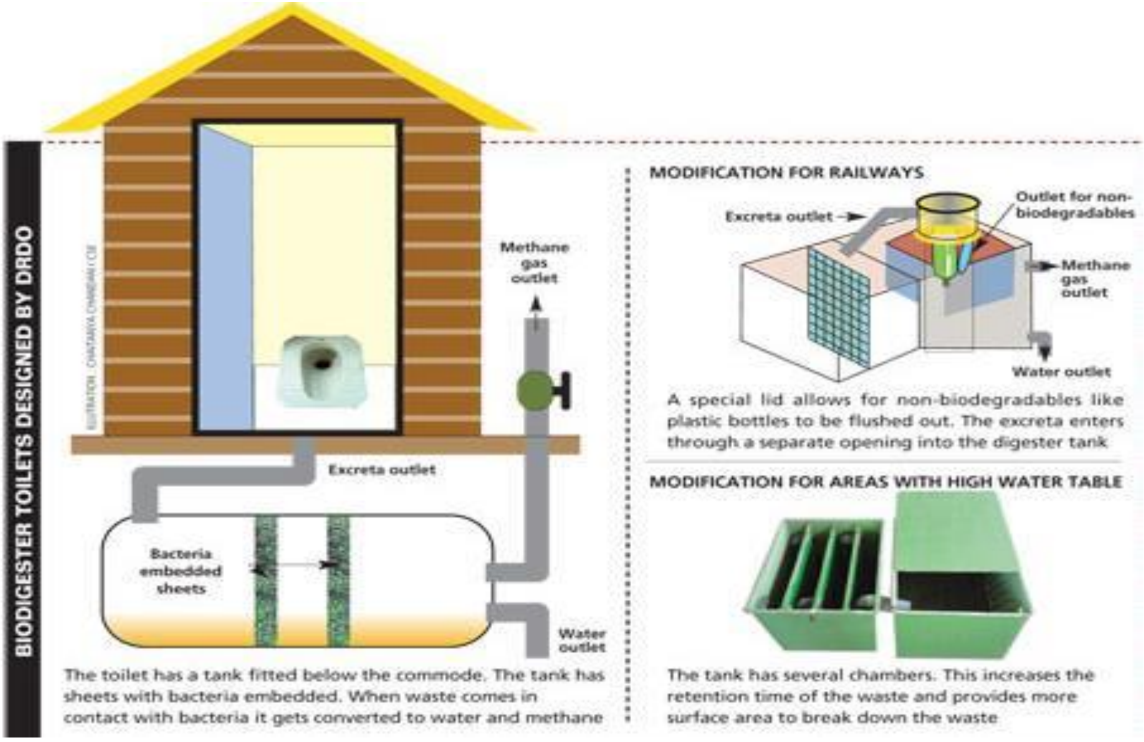


Figure 8.21. Typical Cross Section of Bio-digester

Septic Tanks shall be provided as per requirement according to KSPCB guidelines. The treated grey water will be used for flushing and floor cleaning purpose.

As the project will implement the above mentioned Water supply and Sanitation measures the Indian regulations and WBESF guidelines will be complied with.

***Bio-digestion process by Anaerobic bacteria :** Bacteria are active in temperatures ranging from 0°C to 55°C. To use it in a toilet, a tank was fitted below the commode to collect the excreta. The tank made of cement had sheets with bacteria embedded in it and free-floating bacteria. The bacteria cannot move out of the sheets but can multiply. When human excreta comes in contact with bacteria, it gets converted into methane and water through a series of steps of anaerobic digestion—hydrolysis, acidogenesis, acetogenesis and methanogenesis (Fermentative bacteria, Syntrophic bacteria, Acetogenic bacteria, Methogenic bacteria, etc.).

Faecal matter is composed of carbohydrates, protein and fats. In the first step, they are converted into simple sugars, amino acids and fatty acids. In the next step, these break to form carbonic acid, alcohols, hydrogen and water. In the third step, acetic acid, hydrogen and carbon dioxide are formed. In the last step, methane, carbon dioxide and water are formed. Methane can be used for cooking while water for irrigation. The best benefit is that once applied, the bacteria can work for a lifetime.

8.7.7.2. Water Supply at Depots

Water supply/demand will be there at Depot for different purposes. A three day cycle is assumed for train washing at depot. As per the Indian Railways Works Manual, 2000, the water demand for train washing is 3500 liters per day. The fresh water demand at stations & depot for the project year 2025, would be about 2,88,249 KLD required to be used for different purposes such as for train washing – 720 KLD, floor washing/cleaning – 2,80,000 KLD, for drinking purpose – 6494 KLD for passengers and official staffs at Stations and Depot and for sanitation purpose – 1012 KLD. It is suggested to use recycled water for other purposes like flushing urinals/closet, etc. In case of non-availability of recycled water supply from local Municipal sources may be utilized. Potable water requirement will be met from water supply by BBMP. Potable water requirement required for Stations are estimated in **Table 8.55**. Estimated water demands are as given in the **Table 8.58**.

Table 8.58. Water Demand Depots

Sl. No.	Depot	Projected for Years		
		2025	2031	2041
1	Projected Number of Trains	24	24	24
2	Water requirement (in KLD) for Car/train Washing (0.5 KLD /Car)	720	720	720
3	Floor Washing @ 0.5 litres/Sqm (2 Major and 2 Micro Depots + 64 Stations) =5,60,000 Sq.m.	2,80,000	2,80,000	2,80,000
4	Drinking Water Requirement in KLD @ 5 lit per person per day at 2 Major and 2 Micro Depots + 64 Stations.	6494.148	8611.468	11302.130
5	Sanitation purpose @13.6 litres per use (Minimum usage) at 2 Major and 2 Micro Depots + 64 Stations.	1,012	1,315	1,761
Total		**288249.708**	**290670.911**	**293807.353**

As per the requirement, the Reverse Osmosis (RO) technology may be used for conventionally treated water at Depot for specific purpose such as to use for washing of equipment and trains. This helps in the reduction of depletion of fresh water for washing purpose.

Mitigation Measure: The source of water supply at Depot is municipal water supply and Potable water shall be supplied for drinking purpose. This will be supplemented by re-use of treated water of effluent treatment plant. The fresh water demand at stations & depot for the project year 2025, would be about 2,88,249 KLD required to be used for different purposes such as for train washing – 720 KLD, floor washing/cleaning – 2,80,000 KLD, for drinking purpose – 6494 KLD for passengers and official staffs at Stations and Depot and for sanitation purpose – 1012 KLD.

Ground Water Recharge / Rain water Harvesting: In view of augmentation of storage of ground water, it is proposed to construct roof top rain water harvesting structure of suitable capacity in the Depot. Ground water shall be recharged through Rainwater harvesting at each depot. One Rainwater harvesting unit for each depot is proposed. The cost estimated is ₹ 91,700.00 +3000 surcharges (KPWD Schedule of Rates) for installation of rainwater harvest units during construction phase.

Residual Impacts: No adverse impact on the ecosystem.

8.7.7.3. Waste Water/Effluent Generation

The trade effluent or waste water generated due to Depot activities such as washing of trains is about 720 KLD (Depots) and domestic sewage of about 876.643 KLD at depots and stations. Waste water generation from Stations are estimated in **Table 8.55**. The waste water will be treated and recycled to use for flushing, floor cleaning and train car washing purposes etc.

Mitigation Measure: Implementation Bio-digester with Reed bed system approved by DRDO will help to handle human waste as well as waste water at Depot. The details of waste water generated and estimated cost of each depot is given in **Table 8.59.** The treated waste water may be reused for washing and flushing purpose in the depot area. Total estimated cost for waste water treatment is ₹ 7.18 Lakhs for each depot.

Table 8.59. Capacity and Estimated Cost of Bio-Digester & ETP at Depot

Sl. No.	Corridor No.	Depot Name	Domestic Waste Water in KLD	Waste Water from Car/Train Washing in KLD	Capacity of Bio Digester System in KLD	Estimated cost of Bio-Digester in ₹ Lakh	Estimated cost of ETP ₹ Lakh
Major Depots							
1	Corridor 1	Akkupete Depot	2.04	3.5	0.371	0.19	1.75
2	Corridor 2	Soladevanahalli Depot	2.04	3.5	0.371	0.19	1.75
Micro Depots							
1	Corridor 3	Kengeri Station	1.7	3	0.309	0.15	1.5
2	Corridor 4	Heelalige Station	1.7	3	0.309	0.15	1.5
Total = 4			**7.48**	**13**	**1.36**	**0.68**	**6.5**

Residual Impacts: No adverse impact on the ecosystem.

8.7.7.4. Solid Waste generation

As per the estimation for the projected year 2025, about 1.4 to 1.5 Tons/day of MSW and about 1 to 4.2 Tons/day (4.25 Tons/day in Corridor-1, 2.72 Tons/day in Corridor-2, 2.17 Tons/day in Corridor-3 and 3.84 Tons/day in Corridor-4) of MSW is likely to be generated from the Depot and Stations respectively. Solid waste generation from Stations are estimated in **Table 8.55**.The dry and wet solid waste shall be collected separately, segregated and stored in separate bins / barrels. Solid waste such as Paper, cotton waste, etc. will be reutilized, as far as possible after segregation. Finally, the total dry and wet solid waste will be handed over to BBMP authority for further Solid waste treatment and management. During operation phase, no hazardous substances are used.

Mitigation Measures: Solid waste generated from the Depot which includes mostly hazardous wastes - muck, oil & grease, paints, etc., will be handed over weekly to the approved agency, recycled/treated and disposed-off at designated waste disposal sites in accordance with KSPCB rules.

Municipal Solid Waste Management at Staitons & Depots will be in accordance with Solid Waste Management Plan (**Annexure 10.9**) and in compliance with Indian Standards and ESS 3 of World Bank and EIB Standard 3.

Separate colour coded garbage bins for wet and dry wastes collection will be provided at Depots. Organic waste shall be segregated and treated by in-situ bio composter technique.

Frequently, the municipal solid waste shall be cleared off by the conservancy staff; and handed over to BBMP authority for proper treatment and disposal.

Residual Impacts: There will be insignificant or no impact to the environment. No adverse impact on surrounding ecosystem is anticipated.

8.7.7.5. Oil Pollution

During maintenance of rolling stock in the Maintenance Depots/Workshop change of lubricants, cleaning and repair processes are routine activities. During these maintenance activities and Storage area for Oils & Grease there is the possibility of oil spillage. Care will be taken to ensure that there will be minimal oil spillage while transferring the contents to other containers or during cleaning and repairing activities. However, the spilled oil will be trapped / collected in oil/grease traps. The collected oil/grease would be disposed-off to authorised vendors/collectors, so as to avoid any underground/ surface water contamination.

Mitigation mearures: The maintenance at Depot/Workshop for rolling stock includes change of lubricants, cleaning and repair activities, during which there may be oil spillage or leakage. The oil and grease traps shall be provided to trap waste grease and oil; and disposed-off to authorised collecting agency, so that any underground/surface water contamination is avoided. These oil and grease traps need to be installed before effluent treatment plant.

Residual Impacts: No adverse impact on the ecosystem.

8.7.7.6. Noise Pollution

The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. No impact on the ambient noise is anticipated due to mild activities.

8.7.7.7. Surface Drainage

In case of filling in low-lying area of depot and station sites, the surface drainage pattern may change.

Mitigation Measures: Suitable drainage measures will be adopted to drain off the area properly in to the sewerage drain nearby water body. Monitoring of waste-water generated from the stations during the initial stages of project operation will be required to be carried out to confirm that the water does not contain any harmful pollutants. Drains shall be provided to collect the storm water in Depot. Rain water harvesting pits are provided at different locations in the drains and for surplus storm water; and the drainage system shall be connected to a nearby disposal site. K RIDE shall ensure that all drains (side drains, median drain and all cross drainages) are periodically cleared especially before monsoon season to facilitate the quick passage of rainwater & avoid flooding in low lying areas, as per the Contract Document & WB ESS 1 and EIB Standard 1.

Residual Impacts: No adverse impact on the ecosystem is anticipated. In order to verify this expectation, the effluent of the Depots will be monitored during the initial stage of operations.

8.7.7.8. Loss of Vegetation/ Biomass

About 17323 trees in Akkupete Depot and 22 trees in Soladevanahalli depot are affected due to proposed project. Trees affected in the Stations sites are incorporated in along with trees affected in alignment. Karnataka Forest Department is the nodal agency to issue approval for tree felling. After the joint tree inventory by the Forest Department, numbers of trees to be felled and translocated will be undertaken as at the suitable site jointly identified by forest department. Afforestation cost is given in the Environmental Management Plan.

Green Belt Development (plantation) as Compensation for loss of vegetation/Biomass

The green belt development (plantation) is one of the major operational activities of the proposed project during operation phase. The provision of green belt in the depot area harmonizes the depot with surrounding environment and acts as noise barrier; and air and noise pollution sink. It will check soil erosion. Compensatory afforestation cost at depot area is included in the compensatory afforestation cost of the project. Treated waste water can be used for watering the green belt.

8.7.7.9. Loss of Livelihood

There will be no loss of livelihood due to the depots, as land selected for depots are mainly open lands. Further, details are provided in SIA Report.

Residual Impacts: No negative impacts are predicted on ecosystem.

Above are the areas of concern regarding the required mitigation measures at Stations & Depots during operation phase of the project. Except the Waste water treatment and oil pollution measures, all other required measures shall be implemented at stations during operation stage of the project.

8.7.8. Risks & Impact on Air Quality due to inter modal operational vehicles

There are operational inter modal vehicles such as autorickshaws, taxis, two-wheelers or four wheelers to transport BSR commuters to reach nearby Suburban Railway Stations from source and Suburban Railway Stations to their destinations such as work place, residence, etc.

Air Pollution monitoring shall be carried out in accordance with Air (Prevention and Control) Act, 1981 and CPCB regulations and WB ESS 3 and EIB ESS 3.

Residual Impacts: No negative impacts are predicted on ecosystem.

8.7.9. Risks & Impact on Topography and Natural Drainage

The main effects on topography are due to elevation changes in the BSR may impact air pressure and temperature affect topography. Topography has a significant effect on climate. The lower the site elevation, the smaller the site relief, the lower the site roughness, and higher the likelihood that the site will experience urban flooding. Surface roughness is the topographical influencing factor with the greatest influence on urban flooding.

During extreme weather events particularly due to heavy rainfall transport infrastructure can be directly or indirectly damaged, posing a threat to human safety, and causing significant disruption and associated economic and social impacts. Flooding, especially as a result of intense precipitation, is the predominant cause of weather-related disruption to the transport sector. Surface water flooding is a risk because of its effect as the whole infrastructure rail and road networks and utilities, etc. in the vicinity gets affected disrupting much all aspects of modern life.

Flooding can strain transportation networks in both the short- and long-term through transportation delays, infrastructure damage, and recovery, and potentially affect economies.

In BSRP as the Suburban Rail network is designed to be at grade and at elevated levels, that too mostly within the RoW, impact on topography is very much negligible. However, chance of induced flooding may be predicted due to at grade BSR because of design issues and its impact on vulnerable community and road networks nearby. In such case, following are the mitigation measures need to be implemented.

Mitigation Measures: In case there is Flooding in BSR stations or Depots this will be may be mainly due to the encroachment of surface flooding in the vicinity of BSR lines. The flood risk level of the BSR system shall be extracted from the regional risk level map. The flood risk level of the concerned BSR line shall be analysed by PIA or concerned hired agency, if any, which enables timely enabling emergency response and the implementation of flood prevention measures to reduce casualties and losses before the onset of heavy rainfall and floods. Based on Hydrologic and hydrodynamic situations under different precipitation scenarios, a comprehensive risk assessment of the BSR system could be conducted by combining topographic, hydrological, and socio-economic data. Accordingly, a 250 to 500 m buffer range around the BSR line shall be determined to represent the BSR system's flood risk. Waterlogging points shall be identified in the risk assessment process.

Based on the severity of risks of flood, following prevention measures are required to be undertaken at stations and depots :

- Evacuating people from the vicinity of flood areas of BSR lines, stations or depots and providing proper secured alternative entry and exits
- Providing signals and alarms to alert people to not to enter into the vicinity of risky areas
- Providing Water stop plate and high steps;
- Opting for Floodwater harvesting system and pumping out to proper channels of the drainage system.
- Planting vegetation near affected BSR corridors to retain excess water, Terrace slopes to reduce slope flow, and building alluviums (man-made channels to divert water from flooding),
- Construction of dykes, dams, reservoirs or holding tanks to store extra water during flood periods.
- Construction of Embankments, flood walls and Natural detention basins.
- Implementing Channel improvement.
- Providing required PPE to ensure workers' Safety and providing health facilities to workers and arranging for health check-up for workers, as per requirement

Residual Impacts: No adverse impact on surrounding ecosystem is anticipated.

8.7.10. Soil Erosion at Closed Borrow Areas and Embankments

Accidental soil erosion may occur at closed borrow areas and embankments due to climatic change or any other local activities nearby.

Mitigation Measures: Visual Monitoring and inspection of borrow areas in case operated (if closed and rehabilitated), embankments and other places expected to be affected, shall be carried out once in every three months as per monitoring plan, to check soil erosion if any. And measures shall be necessitated to avoid residual impacts such as soil erosion and mosquito breeding at stagnated water. This will comply with WB ESS 3 and EIB Standards 3.

Residual Impacts: No negative impacts are predicted on ecosystem.

8.7.11. Pedestrian & Road Traffic Congestion around Stations

Commencement of Suburban Railway services results in passenger rush at stations which in turn results in congestion around stations.

Mitigation Measures: This passenger and road traffic congestion can be controlled by proper implementation of inter modal integration with other modes of transport to and fro source to destination.

Residual Impacts: No negative impacts are predicted on ecosystem.

8.7.12. Risks & Impacts on Operational and Community Safety

The most significant safety issue potentially affecting both crew and passengers is the threat of serious injury or the potential loss of life due to train collisions with other trains or with road vehicles, as well as the possibility of derailment due to these or other operational causes. Recommended management actions include the following :

- Implementation of rail operational safety procedures aimed at reducing the likelihood of train collisions such as a positive train control (PTC) system. If a full PTC system is not practical, automatic rail switches should be installed or, where manual switches remain, documenting when a manually operated switch in non-signalled territory is changed from the main track to a siding, and returned back to the normal position for main track movements. This information should be communicated to all crew members and the train dispatcher.
- Regular inspection and maintenance of the rail lines and facilities to ensure track stability and integrity in accordance with national and international track safety standards;
- Implementation of an overall safety management program that is equivalent to internationally recognized railway safety programs.

Residual Impacts: There will be insignificant impact to the environment. No adverse impact on surrounding ecosystem is anticipated.

8.7.13. Risks & Impacts on Community Health

Community health and safety impacts during operations include noise and dust, road and train accidents along the railway corridor. During construction, communities adjacent to the works and tracks may be exposed to risks of noise and dust, traffic disruptions, accidents, general construction hazards and personal safety, including sexual harassment. The COVID-19 pandemic also introduces potential risks of community exposure through contagion pathways such as meetings, stakeholder engagement sessions and construction sites, and from train travel in general. Emergency-response planning and monitoring for prevention and control of pollution or other risk incidents during operation shall be established.

During operation stage Safety Measures such as general rail operational safety, transport of dangerous goods, pedestrian safety, fire risk due to failure to manage vegetation in RoW, etc. shall be followed as per Indian Railways, as given in the **Annexure 10.18**.

During operation stage, as far as possible government security personnel shall be deployed at stations and depot and in running trains, as applicable.

Corporate Social Responsibility: Public shall be advised to construct the noise barriers such as walls, double glazed windows and tree plantation between the roads and their property. The public awareness is necessary regarding the human health through the newspapers and consultations and distribution of pamphlets during the operation stage.

Residual Impacts: No negative impacts are predicted on ecosystem.

8.8. Cumulative Impact Assessment

Cumulative Impacts are the overall effects caused by the totality of past, present and foreseeable future actions. Cumulative effects can result from incremental changes caused by the interactions between effects within a project and/or the interaction with the effects from other developments. With regard to railway schemes, cumulative effects are considered in the following ways:

- Multiple effects from the scheme, and from different schemes of the same or similar type, upon the same resource; such as the effect on a single community of noise from several transport sources.
- Different multiple effects from the scheme, and from other schemes, upon the same resource; such as land take and damage due to hydrological change, affecting several sites of the same habitat.
- Incremental effects arising from a number of small actions, including ongoing maintenance operations, having developed or developing over time

8.8.1.1. Project under Discussion

The budget announcement of BBMP, BDA and BMRCL as well as through the discussions with the officials of these agencies the consultants understand that there are few projects that are often discussed in several meetings with the stakeholder agencies and that are planned in the project region. Few of those projects are

- Bengaluru Metro Rail Phase 2A (Outer Ring Road) - Expected to complete by 2025
- Bengaluru Metro Rail Phase 2B (KR Puram to Kempegowda International- Expected to complete by 2025
- Satellite Town Ring Road (STRR)
- Peripheral Ring Road (PRR)

These projects are considered during the formulation of alternatives and relevant projects are integrated with the proposals of this study thus minimizing the cumulative Impacts.

During the study, it was understood that, small stretch of Metro Rail line – 2A and 2B are runs parallel to proposed BSRP railway alignment (Corridor 1 & 4) at Doddanekkundi , Benniganahalli, near Yelahanka and Doddajala areas. However, as per the information gathered, metro rail construction activities are almost nearing to completion at Benniganahalli, Yelahanka and Doddajala areas. In Doddanekkundi, the construction activities are just started. As per the Metro Annual plan, BMRCL is targeted to complete the construction by March 2025. The satellite town ring road and peripheral ring road alignments are not falling near BSRP corridors. Further, construction and project completion timelines of the remaining projects listed above are not announced till date.

Apart from the above projects, there are few augmentations such as development of underpasses, roads and construction of apartments, residential and commercial building projects, which will also happen during construction stage of the BSRP.

These subsequent sections describe the likely cumulative impacts of the above upcoming projects intervening resulting from the interaction with the current project.

8.8.1.2. Cumulative Impacts of Vehicular Traffic

There will be temporary direct adverse effects on traffic during construction phase at junctions. Simultaneous construction of the above identified projects, residential and commercial properties will result in the movement of vehicles used in construction activities and thus can increase traffic flow in the short term.

The program schedule for all the above projects is not currently known, so it is not possible to predict the level of disruption that may occur. However, if all these projects occur simultaneously, there could be significant cumulative impacts. Though it is very unlikely that all the projects will take off at a time, never the less the contractor should be aware of other project activities in the region and plan his activities in a way to reduce impact. Traffic management measures proposed in Chapter 8 of this document will ensure effects are insignificant. The junction improvements that will be taken up will also aid in reducing the cumulative impact of vehicular traffic at junctions.

8.8.1.3. Cumulative Impacts on Valued Environmental Components (VECs)

A valued Environmental Components (VECs) is an element of the environment that has scientific, economic, social or cultural significance.

As far as the wildlife, forests and geology are concerned the project has no direct impact thus the cumulative impact is also nil. Environmental impact on other valued environmental components like air, water, noise, vegetation and social aspects is significant; the cumulative impact could increase if any other projects are implemented simultaneously.

Impacts on air quality during the construction phase of the project will be considerable as the amount of work involved in improvement of the railway, construction and integration of stations and construction of depots is significant. However, any possible impacts will be transitory. Due to the proposed project, there will be some direct and indirect long-term impacts on the water resources (storm water drains) as well as sensitive noise receptors. The major impact in the project on flora involves the removal of trees to permit construction and to provide clear zone for safety of the road users. All these impacts can aggravate if other similar projects are implemented together.

The Project will reduce the use of personal vehicles, increase the transit mode share and will contribute to community re-development through the stimulation of future concentrated and mixed land use, as well as a positive business environment. It will contribute to environmental sustainability initiatives by reducing regional car trips, enhance community livability and reducing greenhouse gas (GHG) emissions. Project operation is expected to have a positive effect on air quality since the Project will use an EMU train which is exhaust-free and quieter compared to diesel and locomotive-drawn multiple units. As such, the Project's contribution to the cumulative impacts particularly during the operation would be positive.

During project operations, due to existing high background noise levels along portions of the alignment caused by the existing volume of road traffic in the area and vicinities, receptors may experience a low to moderate noise impact close to the proposed stations and maintenance depots. This will be mitigated by an operating schedule of day time and erection of site specific noise attenuation panels at the stations such that the Project's contribution to cumulative impact on noise is considered not significant. Vibration levels associated with project operations (i.e., train passing by) will be largely imperceptible.

On the socio economic front the project has both positive and negative impact. As there is very minimum impacts of land acquisition, since BSRP alignments and stations are proposed within Indian Railway Land. There is insignificant impact on livelihood and economic activities of the project area. On the other hand accessibility and connectivity increases. Thus, the time of travel between project localities shall reduce significantly. With the advent of the Suburban railway the vehicle operating and congestion of roads is expected to go down substantially.

Based on the foregoing, the Project along with related infrastructure development projects within the area will result in positive long-term benefits in air quality, public health, safety, and travel time savings and connectivity. No adverse residual effects to human health will occur as a result of project construction or operation. While exposure to elevated noise levels, fugitive dust and gaseous emissions will occur in proximity to project work sites during construction, due to their short-term, localized nature, these effects are expected to be minor. Project operations will benefit the general public by contributing to the long-term improvement of air quality in the area. By providing a viable alternative to the use of private vehicles, it will also reduce traffic volumes, relieve traffic congestion, and improve community livability.

8.9. Environmental Enhancement Measures

The proposed project is environmental friendly with fuel efficiency and reduced environmental pollution. In the long term, compensatory afforestation and Green belt development will enhance environment of the project area.

8.10. Inference

The environmental impact assessment of the project with potential negative impacts discussed in above sections from Section 8.2 to Section 8.9 reveal that though impacts appear to be significant they can be mitigated by following a proper Environmental Management Plan (EMP) with stringent strategic actions during project implementation.

The project emit major negative impacts on environment such as Air Pollution, Water Pollution and noise pollution mainly during construction of Suburban Railway project in already highly populated and polluted city like Bengaluru. In turn, the negative environmental impacts affect human health. There is dire requirement of adequate care and attention to be given for every environmental concern in all directions during planning and construction of suburban railway project. In addition, special emphasis on required measures needs to be given for predicted distinct circumstances or emergency situations. By proper planning and execution, the adverse environmental impacts, health and safety hazards can be minimized or reduced at construction sites. An Environmental Management of potential negative impacts with mitigation measures is discussed in the **Chapter 10** – Environmental Impact Mitigation & Management Plan (EMP) and an Action Plan is provided for its implementation by the Contractor and K RIDE during project Construction and Operation phases.

Chapter 9. Project Benefits

9.1. Positive Environmental Impacts

Beneficial or positive impacts of the BSRP on the environment are discussed in this Section. The proposed project also yields beneficial or positive impacts on natural and social environment along with the negative impacts on Environment. The Suburban rail system after construction and commissioning will certainly reduce the pollution level and add convenience to the public, but such project may grossly aggravate the pollution problem during construction stage, especially in respect of noise and air pollution which are generally at their peak. To compound the issues further, suburban rail alignment generally passes through densely populated areas and high vehicular traffic zones, at certain areas where there is already high pollution level. Higher the compression of implementation period higher is the pollution level due to intense construction activity increasing pollution levels. Numerous positive impacts identified for this project are listed below and discussed in under the following headings:

- Employment Opportunities
- Benefits to Economy
- Direct benefits to passengers
- Reduction in Traffic Accidents and Safety
- Reduction in Traffic Noise
- Reduction of plying vehicles and Traffic congestion on Road
- Saving in Road Infrastructure
- Low energy Consumption
- Reduced Air pollution
- Reduction in GHG Emission including Carbon-Di-Oxide
- Clean Development Mechanism (CDM) and Carbon Credits
- Other Benefits

9.1.1. Employment Opportunities

Employment opportunities are highly open during construction stage of the project. Aftermath of COVID situation has affected the workers to the maximum. About 6000 workers, especially skilled and unskilled labours will be benefitted (directly or indirectly) with the employment opportunity from this project. The tentative based on the nature of work is assessed to be 60% unskilled labour and 40% skilled labours. However, details will be provided regularly through quarterly progress reports, once the contractor is on board.

During operation stage, about 18 - 20 persons per km length of the corridor will be benefited with employment opportunity. During project operation, overall 3000 persons will be benefited directly and indirectly with operation & maintenance, Ticketing, security jobs, etc. and other related activities and trades.

9.1.2. Benefits to Economy

The project will facilitate movement of people from different parts of city. These corridors will yield benefits in terms of growth in economic activity due to better accessibility; reduction in vehicle operating costs, cost of road construction and maintenance, loss of productivity due to health disorders resulting from pollution and accidents, savings in travel time and improvement in quality of life due to reduction in road travel and certain socio-economic benefits. In this study only savings in fuel consumption and reduction in air pollution have been quantified.

9.1.3. Direct Benefits to Passengers

Direct benefits to commuters of suburban trains include reduction in Vehicle Operating Costs (VOCs) including fuel consumption and maintenance cost of vehicles, 50 - 75% reduction in travel time, improvement in quality of life, improvement in productivity due to reduced travel and improvement in health disorders causing due to their exposure to pollution if they travel in other modes and reduction in road accidents.

9.1.4. Reduction in Traffic Accidents and Safety

There is a great reduction in number of accidents and fatality is noticed after the execution of Bengaluru Metro Phase I & II by BMRCL in Bengaluru. As the population of the Silicon city is getting increased day by day, the implementation of BSRP Railway project also provides improved safety and substantial reduction in the number of accidental deaths. This may happen due to shifting of commuters from road to suburban rails.

The Suburban railway project leads to accident reduction which in turn results in the following:

- Savings in terms of capital loss related to fatality and cost incurred towards major or minor injury of victims in accidents due traffic congestion and accidents.
- Savings in damage cost to vehicles involved in accidents.

9.1.5. Reduction in Traffic Noise

During operation, there will be 6-12 % reduction in Vehicular trips and 3 dB reduction in noise levels in ambience as predicted, irrespective of the absolute number of vehicles operated. Further, there may be reduction of 10% to 50% in traffic volume and about 10% reduction in ambient noise at the tune of 0.5 dB & 3.0 dB in due course of time.

9.1.6. Reduction of Plying Vehicles and Traffic Congestion on Road

As there will be shift of trips from road vehicles to suburban trains, naturally there will be comparative reduction in number of plying vehicles along the project corridors. The reduction in number of vehicles on road due to modal shift of passengers to this Suburban Railway System in turn enhances the benefits to economy as discussed above under Section 9.1.2. The project ensures greater traffic carrying –capacity as much traffic as 7 lanes of bus traffic or 24 lanes of car traffic (either way). As per BSRP Feasibility Report 2019, the details of modal shift from road to suburban with reduction in number of trips on road are presented in the **Table 9.1**.

Table 9.1. Estimated Demand and Modal Share-in 'With' and 'Without' Suburban Rail System Scenario

Mode	Trips (With Suburban Rail System)				Trips (Without Suburban Rail System)				Vehicular Reduction due to Suburban Railway System BSRP			
	2025	2031	2041	2051	2025	2031	2041	2051	2025	2031	2041	2051
Metro	2300000	3000000	3400000	3853333	2300000	3000000	3400000	3853333	0	0	0	0
Bus	4903884	5645251	6756421	8077355	5254835	6126120	7381477	8889486	350951	480869	625056	812131
Car	853522	945308	1129932	1345178	997312	1139580	1388665	1689850	143790	194272	258733	344672
Two Wheelers	3954510	4524018	5413394	6467447	4300427	4995900	6031492	7277004	345917	471882	618098	809557
Auto	839763	929058	1110468	1321846	983480	1123200	1369100	1666481	143717	194142	258632	344635
Suburban Railway	984374	1341165	1760518	2310994	0	0	0	0	0	0	0	0
Total	**13836053**	**16384800**	**19570733**	**23376154**	**13836053**	**16384800**	**19570733**	**23376154**	**984375**	**1341165**	**1760519**	**2310995**

Source : BSRP – Feasibility Report, 2019

Reduced number of vehicles on road leads to reduction in traffic congestion. As a result, there will be smoother operations of passenger trips of other mode vehicles owing to reduced congestion on roads. The proposed project will reduce journey time and hence congestion and delay in reaching destination.

9.1.7. Saving in Road Infrastructure

In case of non-introduction of Suburban Railway System, there will not be saving due to road infrastructure and development costs that would be required to cater to increase in traffic. With less number of vehicles on roads, expenditure on road maintenance is expected to reduce. Approximately, a lump-sum expenditure of 145 Crores / year is assumed. About 10% of road infrastructure will be saved.

9.1.8. Low Energy Consumption

During operation, there is reduced fossil fuel consumption. The reduction in energy consumption is about 20% per passenger km in comparison to road-based systems. The energy consumption to meet the traction and non-traction power requirement is based on traffic demand for different horizon years. The consumption of electricity is a significant part of O&M activities for Bengaluru Suburban Rail corridors.

There will be a reduction in number of vehicle trips on implementation of this project. Therefore, it is estimated that both petrol and diesel consumption will also get reduced. There is an inter-fuel substitution of petrol and diesel to electricity that could result in savings of foreign exchange and a reduction of air pollution.

9.1.9. Clean Development Mechanism (CDM) and Carbon Credits

9.1.9.1. Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM) was recognized in the Kyoto Protocol to operationalize the United Nations Framework Convention on Climate Change (UNFCCC) by committing reduction in CO_2 emissions. CDM projects such as Suburban railway project are an alternative to existing modes of transport viz buses, taxis, passenger cars; automatize three & two wheelers which has serious effects on urban eco system due to congestion and emission of greenhouse gases / other air pollutants. The suburban railway project result in passenger ridership shift from road-based transport to suburban railway system and provides alternate mode of public transportation. Suburban Railway network System is a more efficient, faster, safer and more reliable mode of green transport and complements as well as substantially replaces other modes of transport. It improves the resource efficiency of transport passengers as emissions per passenger kilometer are reduced compared to a transport situation without the suburban rail system.

The ex-ante estimate of reductions of Carbon dioxide in crediting period i.e. 2025 will be 19,66,166 tonness of CO_2e per year; six years later i.e. in 2031 will be 23,01,512 tonnes of CO_2e per year and ten years later i.e. in 2041 it will be 27,24,768 tonnes of CO_2e per year. The annual average emission reduction estimated over the crediting period is 23,30,816 tonnes CO_2e. The BSRP will contribute in a global initiative of reducing the global warming effect by ensuring reduction in emissions of CO_2 and other greenhouse gases.

9.1.9.2. Carbon Credits

A carbon credit is a financial instrument and permit that allows the project proponent or Industrial owner of a State or Country to emit a certain amount of carbon dioxide or other greenhouse gases. The emission reductions generated by different mechanisms are collectively referred to as 'Carbon Credits'. One Carbon Credit is the emission reduction or avoidance of one ton of carbon dioxide or the equivalent (tCO_2e) in other greenhouse gases from the atmosphere. A carbon credit is a financial instrument that represents a reduction or the avoidance of one ton of carbon dioxide equivalent from the atmosphere.

Carbon credits were devised as a mechanism to reduce greenhouse gas emissions. Carbon dioxide is one of the major greenhouse gases, which directly deplete the ozone layer. To reduce the overall greenhouse gas emissions International Emission Trading (IET) Mechanism has been followed under Kyoto Protocol. Under IET mechanism, countries can trade in the international carbon credit market. Countries with surplus credits can sell the same to countries with quantified emission limitation and reduction commitments under the Kyoto Protocol.

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. This sets legally binding targets for 37 industrialized countries to limit or reduce overall GHG emissions by at least 5% below 1990 levels during the period 2008-2012. In the Doha Amendment to the Kyoto Protocol December 2012 new commitments to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020 were committed from 1 January 2013 to 31 December 2020.

The climate change study has shown clearly that in order to avert the worst impacts of climate change and preserve a livable planet, global temperature increase needs to be limited to 1.5°C above pre-industrial levels. Currently, the Earth is already about 1.1°C warmer than it was in the late 1800s, and emissions continue to rise. To keep global warming to no more than 1.5°C – as called for in the Paris Agreement – emissions need to be reduced by 45% by 2030 and reach net zero by 2050.

Carbon credits have different prices, depending on the location and market where they are traded. In 2019, the average price for carbon credits was $4.33 per ton. This figure spiked to as much as $5.60 per ton in 2020 before settling to an average of $4.73 the following year.

Carbon credits are measured in units of certified emission reductions (CERs). Each CER is equivalent to one ton of carbon dioxide reduction. Therefore, 1966166, 2301512 and 2724768 annual Carbon credits will be achieved through this project in the 2025, 2031 and 2041 respectively. In economic terms, it is evaluated as ₹ 1,27,792 lakhs (19,66,166 Carbon Credits X 80.72 Euros X 80.52 ₹), ₹ 149588 lakhs (23,01,512 Carbon Credits X 80.72 Euros X 80.52 ₹) and ₹ 1,77,098 lakhs (27,24,768 Carbon Credits X 80.72 Euros X 80.52 ₹) for the years 2025, 2031 and 2041 respectively.

According to Clean Development Mechanism (CDM), one ton of CO_2 increase will yield one Carbon credit and 80.72 Euros (1EUR = ₹ 81.52 as on 02nd August 2022) as on Date per Carbon credit as per 2022 statistics. In current carbon markets, the price of one carbon credit can vary from a few cents per metric ton of CO_2 emissions to $15/mtCO_2e$ or even $20/mtCO_2e$ for afforestation or reforestation projects.

Compensatory afforestation in the ratio 1:10 is about 325720 trees. The reduction of CO_2 from the atmosphere by the mature plants after 5 years (if 5 year old plants from Forest Nursery are planted during project Construction and nurtured well) would be 71,00,696 Kg and Carbon Credits calculated may be 7100 and costs 5,73,168 Euros or ₹ 461.51 lakhs. The O_2 production after 5 Years would be 72,54,940 Kg/Year and the cost would be ₹ 435,296,400/- or ₹ 4,352.96 lakhs. Thereby, the impact on Biological/Ecological aspects and Climate Change will be compensated and help to balance Carbon Credits.

CDM objectives: The clean development mechanism was designed to meet dual objectives:

- to help developed countries fulfil their commitments to reduce emissions, and
- to assist developing countries in achieving sustainable development.

CDM Benefits: Benefits of CDM projects include investment in climate change mitigation projects in developing countries, transfer or diffusion of technology in the host countries, as well as improvement in the livelihood of communities through the creation of employment or increased economic activity.

Transport projects such as MRTS including the proposed Suburban Railway Project – BSRP contribute to reductions in GHG emissions and have potential for Carbon finance – Carbon Credits.

9.1.9.3. Carbon Credits for Bengaluru Suburban Railway Project

The Carbon Credits for Bengaluru Suburban Railway Project are calculated with the measures falling under the following:

- Reduction in emissions per km by use of regenerating breaking system & electric vehicles
- Reduction in emission per unit transported modal shift from two, three and four wheelers

9.1.9.4. Reduction in Emissions per Km by use of Regenerating Breaking System & Electric Vehicles

The operation of BSRP is dependent on low GHG emitting rolling stocks with regenerative braking system. The project adopts regenerative braking technology fitted rolling stocks in place of conventional electro-dynamic rheo-static braking technology. This replacement of conventional braking technology with regenerative braking technology enhances the reduction in consumption of equivalent grid electrical energy being utilized by the powering trains. This helps in conservation of electrical energy and further result in reduction in GHG emissions. This GHG emission reduction is a greater beneficial impact of the proposed project.

The net annual Energy requirement for Traction and auxiliary power for all the corridors of BSRP is given in **Table 9.6**. Rolling stock proposed for the suburban has regeneration features and it is expected that 30% of total traction energy. Hence, the total regeneration energy for all the corridors in Year 2025 is 25,50,00,000 kWh.

Energy consumption (Traction and Auxiliary - Traction & power supply incl. OHE, ASS, etc.) and reduction due to regeneration energy for year 2025 are estimated based on the grid electrical energy (Electricity from grid) and results are given in **Table 9.2** and **Table 9.3**.

Table 9.2. Traction and Power Supply including OHE and ASS for BSRP Corridors in 2025

Sl. No.	Activity	kVAh	kWh
1	Traction and Power Supply including OHE, ASS, etc.,	30,00,00,000	25,50,00,000

Source: BSRP Feasibility Report, 2019

Table 9.3. Energy Consumption during Suburban Railway Operations in 2025

Activity	Units
Traction and Power Supply including OHE, ASS, etc., (kWh)	25,50,00,000
Regeneration Energy (30% of total Energy) (kWh)	7,65,00,000

9.1.9.5. Reduction in Emissions due to Trans-modal Shift

The reduction in vehicles during project operation due to shift from other modes to Suburban rail system, results in reduced emission of pollutants including GHG and CO_2. Estimation of vehicular emissions for with and without suburban railway project is presented in **Table 9.4**. Total reduction in GHGs due to introduction of BSRP is presented in **Table 9.5**. The details of the trans-modal shift with CO_2 emission and CO_2 reduction with and without BSRP are as given in the **Table 9.6**.

Table 9.4. Estimation of Vehicular Emissions (GHGs) for with and without BSRP

Particulars	Total Vehicular Emission with BSRP (in Tonnes/year)			Total Vehicular Emission without BSRP (in Tonnes/year)		
	2025	2031	2041	2025	2031	2041
Total Vehicles	984375	1341165	1760519	13836053	16384800	19570733
CO	1305.36	1778.49	2334.59	18347.71	21727.56	25952.36
HC	256.41	349.35	458.58	3604.02	4267.91	5097.78
NO_X	1030.01	1403.34	1842.14	14477.49	17144.40	20478.03
PM	56.82	77.41	101.62	798.62	945.73	1129.62
CO_2	150598.63	205183.60	269340.18	2116765.02	2506695.48	2994108.44

Table 9.5. Reduction in CO2 and GHGs in the Region due to Introduction of BSRP

Reduction in GHG (in Tonnes/year)				
Year	2025	2031	2041	2051
Total Vehicles	12851678	15043635	17810214	21065159
CO	17042	19949	23618	27934
HC	3348	3919	4639	5487
NOX	13447	15741	18636	22042
PM	742	868	1028	1216
CO2	1966166	2301512	2724768	3222739

Table 9.6. Estimation of CO_2 Emissions and Reduction in CO_2 with and without BSRP

Activity	2025	2031	2041
Total CO_2 Emission of Vehicles without BSRP (Tonnes/year)	2116764.97	2506695.54	2994108.38
Reduction in CO_2 emission with BSRP (Tonnes/year)	150598.58	205183.65	2,69340.17
% of CO_2 Reduction	92.9%	91.8%	91.00%

9.1.9.6. Reduction in Air pollution

Compared to other modes of transport, the suburban is least polluting and can be classified as an environment friendly technology since no air emissions are involved in running and operating the suburban trains. The production of air pollutants from other modes of transportation are highlighted in **Table 9.7** and reduction of air pollutants corresponding to the reduction of daily vehicle kilo meters are presented in **Table 9.8**.

Table 9.7. Mode Wise Emission Factors as per EURO II Norms (Gram/Km)

Vehicle Type/ Pollutant	CO	HC	NOX	PM	CO_2
2-wheeler	1.4	0.7	0.3	0.05	28.58
Auto	2.45	0.75	0.12	0.08	77.89
Cars (incl. cabs)	1.39	0.15	0.12	0.02	139.52
Bus (incl. BRT)	3.72	0.16	6.53	0.24	787.72

Source: Appraisal guidelines for Metro Rail Project Proposals MoHUA, GOI 2017

Table 9.8. Reduction in Air Pollutants due to Vehicular Reduction (Tons/Day)

Mode	2025					2031					2041				
	CO	HC	NOX	PM	CO_2	CO	HC	NOX	PM	CO_2	CO	HC	NOX	PM	CO_2
Metro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bus	0.131	0.006	0.229	0.008	27.645	0.179	0.008	0.314	0.012	37.879	0.233	0.010	0.408	0.015	49.237
Car	0.020	0.002	0.002	0.000	2.006	0.027	0.003	0.002	0.000	2.710	0.036	0.004	0.003	0.001	3.610
Two Wheelers	0.048	0.024	0.010	0.002	0.989	0.066	0.033	0.014	0.002	1.349	0.087	0.043	0.019	0.003	1.767
Auto	0.035	0.011	0.002	0.001	1.119	0.048	0.015	0.002	0.002	1.512	0.063	0.019	0.003	0.002	2.014
Suburban Railway	0	0	0	0	710.37	0.000	0	0	0	710.45	0.000	0	0	0	710.48
Total	**0.234**	**0.043**	**0.243**	**0.012**	**742.129**	**0.320**	**0.058**	**0.333**	**0.016**	**753.900**	**0.418**	**0.077**	**0.433**	**0.021**	**767.108**

Source : BSRP – Feasibility Report, 2019

9.1.9.7. Reduction in GHG Emission and Carbon-Di-Oxide

Rail is considered as a low-carbon transportation mode. Besides the high level of electrification, energy efficiency in rail transport is one of the main reasons for the low carbon footprint of rail.

The reduction in plying vehicles due to project implementation will be helpful in reducing CO_2 emission. Low consumption of energy during project operation also reduces CO_2 emission. Reduction in emission of CO_2 which is a GHG component, contributes to the global environmental protection in terms of reducing ozone depletion and global warming in addition to the compensatory afforestation which will be undertaken during project implementation. The reduction in CO_2 emission from 2025 to 2041 is provided in the **Table 9.9**.

Table 9.9. Reduction in CO_2 Emission due to the Suburban Railway Project

Mode	CO2 Emission (Tons/Day) due to Vehicular Reduction		
	2025	2031	2041
Metro	0	0	0
Bus	27.645	37.879	49.237
Car	2.006	2.71	3.61
Two Wheelers	0.989	1.349	1.767
Auto	1.119	1.512	2.014
Suburban Rail	710.37	710.45	710.48
Total	**742.129**	**753.90**	**767.108**

Source : BSRP – Feasibility Report, 2019

The Sources of GHG Emissions during the Life Cycle of a Rail Project is given below in **Table 9.10**.

Table 9.10. Sources of GHG Emissions during the Life Cycle of a Rail Project (applied from ADB, 2010)

Suburban Rail Project's Stages			
Sources of Carbon Dioxide	Construction	Maintenance	Operation
Materials	Embodied Carbon		N.A.
Machinery Use	Direct GHG Emissions		N.A.
Transportation	Direct GHG Emissions		N.A.
Vegetation Removal	Sequestration/Restoration Potential Lost		
Road Use	Direct GHG Emissions		N.A.

GHG emissions calculation from ADB Guidelines – Construction and Operation Phases -Rail emits about one-fifth of trucks' GHG emissions, and with IR planning to become a net-zero carbon emitter by 2030, it has the potential to eliminate 7.5 million tons of carbon dioxide and other greenhouse gases each year.

9.1.9.8. Economic Benefits of Adopting Climate Risk Measures

The main benefit of adaptation measures to BSRP is climate change resilient railway infrastructure and operation, ensuring connectivity of transport network with implications to economic prosperity and welfare. Besides, the auxiliary benefits of adaptation measures are contribution to sustainable development and climate change mitigation (transport mode shift towards rail leading to reduction in greenhouse gas emissions (GHGs)). Also other synergies and co-benefits of adaptation measures beyond the environmental field are desirable. For instance, structural protection measures may, apart from protecting railway track, also protect settlements or other infrastructure such as roads or energy supply. Adaptation shall be therefore considered as a permanent transition policy on the very long-term.

9.1.10. Other Benefits

The Quantification of some of the social benefits has not been attempted because universally acceptable norms do not exist to facilitate such an exercise. However, it has been considered appropriate to highlight the same, as given below:

- Reduced road stress
- Better accessibility to facilities in the influence area
- Economic stimulation in the micro region of the infrastructure
- Increased business opportunities
- Overall increased mobility
- Facilitating better planning and up-gradation of influence area
- Improving the image of the city

9.1.11. Inference

Project specific positive impacts discussed above equally weigh and manage to neutralize the negative impacts to at its maximum.

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Chapter 10. Environmental Management Plan

10.1. Overview

Based on the base line studies of the project as discussed in **Chapter 5** and potential negative environmental impacts and their assessment as discussed in **Chapter 8**, strategic Environmental Management Plan (EMP) has been framed for the ease of the project execution. In context of Environmental Safeguards the prime factors of consideration for EMP include protection, conservation and preservation of Environment. Management of Environment is possible with the stipulation of necessary safeguards during project execution i.e. during Pre-Construction, Construction and Operation stages.

Environmental Management Plan (EMP) guides to measure and achieve compliance with the environmental protection and mitigation requirements of a project. Environmental Management Plan provides more specific Environmental Mitigation measures to be followed by contractors during construction phase of a project.

This Chapter provides Management Plan for Environmental Protection including required preventive safeguard/mitigation measures for the negative impacts of the project on Environment during project construction and operation, which reduce or mitigate adverse environmental impacts to acceptable or tolerance limits. Along with Environmental Mitigation Measures the EMP also provides investment components for proper functioning of EMP. This Chapter has been sub-divided into the following:

1. Disaster management
2. Emergency Preparedness and Response Measures /Management
3. Institutional Strengthening/Capacity Building for Management and Training
4. Grievance Mechanism
5. Environmental Management Action Plan (EMAP) and Environmental Monitoring Plan (EMoP) for Implementation

Prior to this, it is very essential to understand the roles and responsibilities for project related Environmental Approvals/Clearances/Permits and the same is briefed below.

10.2. Approvals/Clearances

The roles and responsibilities to obtain project specific Environmental Approvals/Clearances/Permits during pre-Construction and Construction Period are summarised in **Table 10.1**. The Project Implementation Authority (PIA) will hold the total responsibility to ensure that all required Clearances/Approvals/Permits are in place during project pre-construction stage and Construction Stage.

Table 10.1. Roles and Responsibilities to Obtain Project Specific Environmental Approvals/ Clearances/ Permits

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
Pre-Construction Phase						
1.	Forest Clearance under Forest (Conservation) Act	Forest (Conservation) Act, 1980 and amendments	Diversion of forest land for Akkupete Depot	PIA/EMU	8-12 months	Forest Department & MoEFCC
2.	Permission for felling of trees and compensatory Afforestation	The Karnataka Preservation of Trees Act, 1976 and amendments	Felling of trees along proposed BSRP alignment & Stations	PIA/EMU	6-8 months	BBMP Forest wing/Forest Department
3.	Prior permission to be obtained under The Ancient Monuments and Archaeological Sites and Remains Act	The Ancient Monuments and Archaeological Sites and Remains Act, 1958 and it's Amendment, 2010	Construction of Station and Rail alignment at Devanahalli	PIA/EMU	4-6 months	National Monument Authority
4.	Construction Railway within buffer zone of Lakes	Karnataka Tank Conservation and Development Authority Act, 2018	Crossing/ abutting in buffer zone of Lakes	PIA/EMU	2-3 months	Karnataka Tank Conservation and Development Authority
5.	Consent to Establish & Operate under Air and Water Acts	Water(Prevention and Control of Pollution)Act, 1974 & Air(Prevention and Control of Pollution) Act,1981	Railway Locomotive Workshop	PIA/EMU	2-3 months	Karnataka Pollution Control Board
6.	Building Permissions for Depot, stations and property development	Respective Building bylaws	Before Construction	PIA/EMU	2-3 months	BBMP / Municipal Corporation
7.	Utility/traffic diversion	Respective Acts and Rules	Before Construction	PIA/EMU	2-3 months	Local Offices of respective Authorities such

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
						as RTO, BESCOM, BWSSB, Telecom Dept., etc.
8.	Consent to Establish construction yards, labour camps, stations and Depot (since non-residential)	Water(Prevention and Control of Pollution)Act, 1974 & Air(Prevention and Control of Pollution) Act,1981	Before Construction	Contractors/PIA /EMU	2-3 months	Karnataka State Pollution Control Board (KSPCB) and Development Authority for land use clearance
9.	Sites to establish labour camps, pre-casting and material yards	Air(Prevention and Control of Pollution) Act,1981	Before Construction	Contractors/PIA /EMU	2-3 months	BBMP / Municipal Corporation
		Land use Master Plan and DC&PR	Before Construction	Contractors/PIA /EMU	2-3 months	
Construction Phase						
10.	Consent for Establishment and Operation of Hot Mix Plants (HMP), Crushers, Batching Plants, etc.	Water(Prevention and Control of Pollution)Act, 1974 & Air(Prevention and Control of Pollution) Act,1981	Construction	Contractors	2-3 months	Karnataka State Pollution Control Board (KSPCB)
11.	Consent for Establishment of labour camps		Construction	Contractors	2-3 months	BBMP / Municipal Corporation
12.	Permission for drawl of ground water for construction (not recommended)	Environment (Protection) Act, 1986	Construction	Contractors	2-3 months	Regional Director, Central Ground Water Board and Municipal Corporation
13.	Permission to store and Authorization for Disposal of Hazardous Waste	Hazardous Waste(Management and Handling and trans boundary movement) Rules, 2016	Construction	Contractors	2-3 months	Karnataka State Pollution Control Board (KSPCB)

Sl. No.	Required Clearances/ Approvals/ Permits	Applicable Rules / Regulations	Applicability	Responsible Agency/ Authority	Time Required	Approval Authority
14.	Consent for disposal of waste water from construction sites and sewage from labour camps	Water (Prevention and Control of Pollution) Act, 1974	Construction	Contractors	2-3 months	Karnataka State Pollution Control Board (KSPCB)
15.	PUC certificate for vehicles for construction	Environment (Protection) Act, 1986	Construction	Contractors	1-2 months	Transport Department of Karnataka
16.	Labour employment, safety, health/welfare measures and labour license	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Construction	Contractors	2-3 months	District Labour Commissioner
17.	Permission for management of C&D waste and muck	Construction and Demolition Waste Management Rules, 2016	Construction	Contractors	2-3 months	BBMP/Municipal Corporation and Karnataka State Pollution Control Board (KSPCB)
Operation Phase						
18.	Consent for Operation to Operate Depot	Environment Protection Act, 1986	After construction	PIA /EMU	2-3 months	Karnataka State Pollution Control Board (KSPCB)
19.	Installation and operation of DG sets at stations	Air (Prevention and Control of Pollution) Act, 1981	After construction	PIA /EMU	2-3 months	Karnataka State Pollution Control Board (KSPCB)

10.3. Environmental Management Plan (EMP)

Environmental Management Plan (EMP) for implementation includes the Environmental Management Action Plan (EMAP) and Environmental Monitoring Plan (EMoP). Environmental Management Action Plan (EMAP) is prepared considering project specific location, environmental factors, risks & impacts and mitigation measures; applicable Disaster Management plan and Emergency Preparedness Action Plan in line with Indian and World Bank laws/regulations, EIB's Environmental and social guidelines and responsible agencies/organization for implementation, monitoring and approval authorities for Construction Stage and operation stage of the project; and same is presented below in **Table 10.2**. Disaster Management plan and Emergency Response/Preparedness and Management are briefed in the following paragraphs.

EMAP is for overall management of minor and major, temporary and long term, moderate impacts on environment and people. Disaster Risk Management (DRM) is part of EMAP. However, for the better understanding and implementation, the Plan is separately provided. Emergency Response Plan (ERP) is part under DRM. However, for the better understanding and implementation, all these Plans are separately provided. Disaster Management plan and Emergency Response Plan are briefed in the following paragraphs followed by Institutional Strengthening for EMP Implementation, Training, Grievance Redress Mechanism Environmental Management Action Plan (EMAP) and Environmental Monitoring Plan.

10.4. Disaster/Risk – Incident Management

Disaster is a major hazard and unexpected event due to sudden failure of the system, external threats, internal disturbances, earthquakes, fire and accidents leading to loss of life, injury, total or partial destruction and damage to buildings, environment and public. The first step is to identify the causes which develop/ pose unexpected danger to the structural integrity due to construction. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. These need to be looked into with care.

Disaster risk is the combination of the severity and frequency of a hazard, the number of people and assets exposed to the hazard, and their vulnerability to damage. Focal point of the United Nations system for disaster risk reduction (UNISDR) is to reduce disaster risk rather than managing disasters. The overarching objective of UNISDR is prevention and reduction of existing disaster risk and strengthening resilience through successful multi-hazard disaster risk management. The main action in reducing risk lies in reducing exposure and vulnerability. Disaster/Risk/Incident Management Plan shall be in accordance with EHS guidelines and National and International Guidelines. During Construction stage, Environmental Specialist. of General Consultant will update DRMAP, in case of anticipated emergency. The Contractor will implement and Environmental Spcialist of General Consultant will assist in monitoring DRMAP and EMP Implementation Unit of K RIDE is the Approval authority. During operation stage EMU, KRIDE will be solely responsible for execution of DRMAP or EMU, KRIDE may hire agency to execute DRMAP and themselves monitor the Actions required and taken by the agency.

Disaster Risk Management includes the following four important actions:

Reduction and Prevention: Measures to reduce existing and avoid new disaster risks, for instance relocating exposed people and assets away from a hazard area. In case of mass transit like Suburban trains such measures are not required.

Mitigation : The lessening of the adverse impacts of hazards and related disasters. For instance implementing strict land use and building construction codes. This aspect is accounted for in design and construction of the project.

Transfer : The process of formally or informally shifting the financial consequences of particular risks from one party to another, for instance by insurance. This is not yet available.

Preparedness : The knowledge and capacities of governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from the impacts of hazard events or conditions, for instance installing early warning systems, identifying evacuation routes and preparing emergency supplies.

Risk Assessment and Disaster Management process comprises the following stages:

- Description of the system that is at risk
- Identify the potential hazards or sources of risk (the list of initiating events or scenarios of events leading to the undesired outcome–technological and human)
- Risk analysis to estimate the likely hood of the scenarios or events occurring and each scenario's consequence
- Compare and rank the various risk drivers
- Action plan in response to the identified major risks
- Regular monitoring, review and updating of the process. For example, the system at risk needs to be defined as to include inter-modal integration.
- Examples of potential hazards are fire risk or security alarms or failure of train controlormotivepowerorpassengerdoors/escalators/platformscreendoorsontrainsorin stations; staff training and work environment; inadequate maintenance.

Disaster Risk Management Action Plan includes the following measures :

Procedures and Records: Evaluation of progress and effectiveness of EMP and EMoP, response to inquiries, complaints and requests for information surveillance, incident reporting, corrective and preventive actions, emergencies, training and emergency exercises, response to emergencies shall be carried out.

Identification of resources: Sources of repair equipment, personnel, transport and medical aid for use during emergency shall be identified.

Emergency systems: Back-up systems for ventilation, communication and train control, lighting, etc. shall be established.

Evacuation procedures: Evacuation procedures will be prepared in consultation with local administration and notified. To ensure coordinated action, an Emergency Action Committee shall be constituted.

Communication System : Primary and back-up system shall be put in place at emergency situations. The damage areas shall be clearly identified and provided with temporary and full proof communication system.

Review and Updating : Drawing inputs from the incident reporting system the Action Plan shall be reviewed at pre-decided intervals and upon occurrence of defined ``trigger events`` and suitably updated.

Maintenance of Incident/ Risk/Disaster Record : Proper maintenance of Incident Records shall be taken care. Required preventive measures shall be under taken to avoid repetition of risks/hazards.

Disaster Risk Management Manual may be prepared and made readily available at all stations of Suburban rail corridors for ready reference and timely action by the staff / personnel of Suburban services / SPV personnel. As suggested in the Feasibility Report, Self-propelled road-cum-railcar – (or accident relief train equipped to handle any track failure or derailment of train) should be stabled in the depot sheds, manned round the clock to be moved in any emergency to the affected spot. The rail-cum road- car should be a multi-utility vehicle. Hence, the following equipment is suggested to be readily available in the road-cum-rail car in good fettle:

- Track grinding equipment
- Re-railing equipment
- Auxiliary hand pump
- High pressure hoses
- Telescopic jacks
- Floodlights
- Traversing jack
- Re-railing bridge Pulling device
- Towing equipment
- Air compressor
- Vetter airbag

Institutional framework for Disaster Risk Management is depicted in **Figure 10.1**.

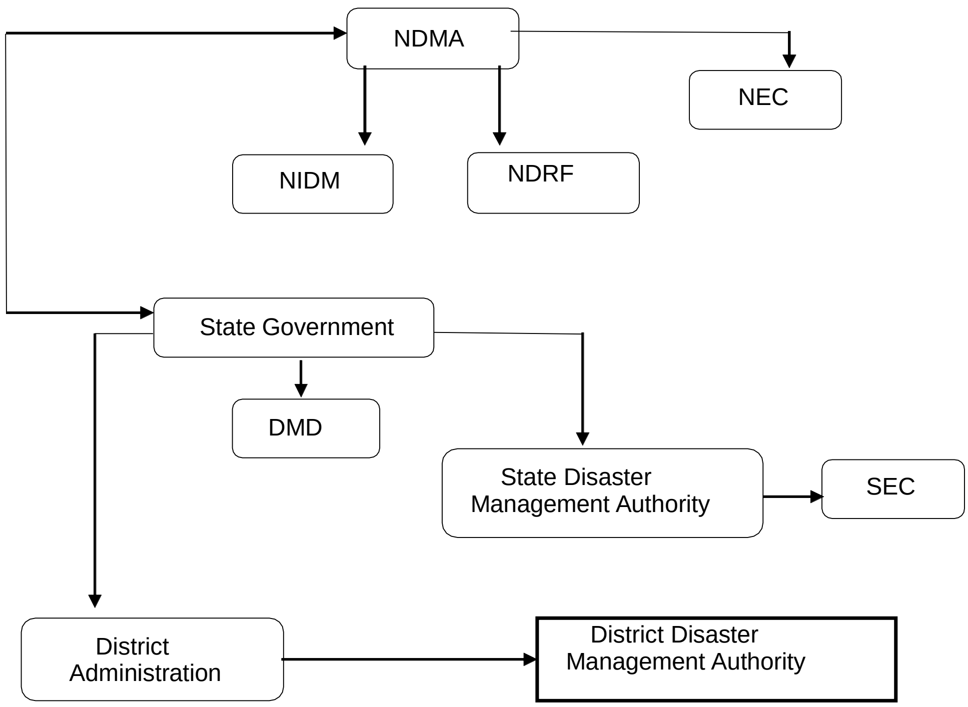

Figure 10.1. Institutional Framework for Disaster Management

No Railway official is nominated either in the National Executive Committee (NEC) or State Executive Committee (SEC), though they can be co-opted as per need.

During Construction stage, Senior Environmental Specialist or Environmental Specialist of General Consultant will update DRMAP, if required in case of anticipated emergency. Contractor will implement and Senior Environmental Specialist or Environmental Specialist of General Consultant will assist KRIDE in monitoring DRMAP implemented by the Contractor and EMPIU of KRIDE will approve the records and reports as and when required.

During operation stage EMPIU, KRIDE will be solely responsible for execution of DRMAP or EMPIU, KRIDE may hire agency to execute DRMAP and Themselves monitor the Actions required and taken by the agency.

10.5. Emergency Response /Preparedness and Management

Emergency Management involves steps such as Prevention, mitigation, preparedness, response and recovery. The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape, ventilation shafts, etc. The aim of Emergency Response Plan is to identify areas, population and structures likely to be affected due to a catastrophic event of accident. The action plan should also include preventive action, notification, warning procedures and co-ordination among various relief authorities. During operation stage, EMP Implementation Unit, K RIDE will be solely responsible for execution of DRMAP or EMP Implementation Unit, K RIDE may hire agency to execute DRMAP and Themselves monitor the Actions required and taken by the agency. These are discussed in the following sections.

10.5.1. Emergency Response Actions for Disaster Risks

Following emergency response actions shall be taken at suburban railway stations and Depot for disaster risks :

Preventive Action

Once the likelihood of a disaster is suspected, action has to be initiated to prevent a failure. Engineers responsible for preventive action should be aware of availability of repair equipment, materials, labour and expertise for use during emergency.

Reporting Procedures

The level at which a situation will be termed a disaster shall be specified. This shall include the stage at which the surveillance requirements should be increased both in frequency and details. The Engineer-in-Chief should notify the officer for Exit points for the public and nearest medical facilities.

Communication System

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

Emergency Action Committee

To ensure coordinated action, an Emergency Action Committee should be constituted. Chairman cum Director, K RIDE will be the Chairman of this Committee. The committee may comprise of:

- Head of operations,
- Head of technical services,
- Head of security,
- Fire brigade,
- Police representatives, and

- NGO

Environmental & Social NGOs, who are active in this field are entrusted in these meetings. Representatives of NGOS will be engaged once the project is commenced at full-fledge. Emergency Action Committee will prepare the evacuation plan and procedures for implementation based on local needs and facilities available. The plan should include:

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

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

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

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

10.5.2. Emergency Provisions for Disaster Risks

To manage the disaster risk the following measures shall be undertaken at Suburban stations and Depot :

10.5.2.1. Emergency Lighting

The emergency lights operated on battery power should be provided at each station. The battery system should supply power to at least 25% of the lights at the station, platforms and viaducts for a period of 2 hours.

10.5.2.2. Fire Protection

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

- Fire prevention measures,
- Fire control measures,
- Fire detection systems,
- Means of escape /evacuation,
- Access for fire man, and
- Means of firefighting.

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

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

- A minimum of 30 minutes supply of water is to be assured in the case of fire. The pumps/overhead tanks shall have the capacity to discharge the water at the rate of 1100 litres per minute at a head of 21 m at nozzle mouth.
- The storage capacity in an underground or overhead tank may be divided into two parts i.e. dead storage and running storage. Firefighting pumps shall be provided with a diesel pump as a standby arrangement, in case of power failure.
- Fire of electrical origin, water cannot be used until the electric system has been made dead and earthen. For electrical fires, non-aqueous extinguishers like chemical dry powder or CO_2 gas are utilized for firefighting. Fire extinguishers with these agents shall be liberally provided at static installations and on the rolling stock.
- Generally there are often more casualties from smoke inhalation than from burning. Smoke needs to be transported away from the site of the fire. In order to achieve this, fresh air has to be introduced and exhaust gases should be sucked out.
- Openings, including ducts and passages, between MRTS – Suburban Railway property and any adjoining structures which allow free access into the MRTS – Suburban Railway property will be protected by fire doors, fire shutters, fire dampers, etc. as appropriate. Fire detection and alarm systems will be provided as per the prevailing state of art technology.

Fire Prevention and Safety Measures

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

Fire Prevention

Fire prevention can be carried out by following measures :

- Use of non-combustible or smoke retardant materials wherever possible,
- Rolling stock is provided with fire retarding materials, low smoke zero halogen type electric cable is also provide,

- Provision of layout which permits ease of maintenance for equipment and cleaning of the station premises,
- Provision of special storage spaces for combustible materials such as paint and oil,
- Prohibition of smoking in fire prone areas,
- Good housekeeping.

Safety Measures

Following provisions are required from fire safety point of view:

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

Fire Alarm and Detection System

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

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

Smoke probe units shall be installed in rooms/compartments. When an alarm point is operated, the fire pump shall start to operate automatically. A station fire control and indicating panel shall be provided/ installed in the station controllers room, for the control, indication and monitoring of the whole detection and firefighting systems. While designing the firefighting system, the zone of Bengaluru regional Fire Services shall be taken into account for linking with the same.

Fire Control Measures

Control of the spread of fire and smoke will be achieved by partition of fire risk areas, planning for smoke extraction, and arrangement for smoke containment. Partition is aimed at limiting the extent of a fire. The openings must be capable of being sealed in the event of fire. With the exception of station public areas, a fire compartment will not exceed 1500m^2.

Partition of the public areas in stations is not practicable for operational reasons. The fire resistance period of this separated area should be about 3 hours.

Access for Fireman

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

Provision for Emergency Doors

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

10.5.3. Emergency Response Action for Structural Failures during construction and Community Safety

The individual stages of risk management can be used to analyze the risk of the structural failures. These stages are as follows:

Step 1 : Risk identification—the threats need to be identified and analysed based on the analysis of reports of similar projects implemented before. The data need to be presented on radar charts and analyzed in detail.

Step 2 : Hazard classification—classification should be made on the basis of the causes of the structural failures. Two main groups should be distinguished—(i) disasters caused by random causes (mainly due to the force of nature) and (ii) those caused by man (human errors). The failures from the second group (human errors) were classified into three subgroups closely related to the life cycle of a building, namely—design, construction and exploitation.

Step 3 : Risk assessment and measurement—based on the Failure Mode and Effects Analysis (FMEA) method, and more precisely on the determination of the probability of a given threat (P), severity of its result(S), difficulties in its detection (D). These data made it possible to determine the Risk Priority Number (RPN). This number indicates which of the threats (causes) identified in steps 1 and 2 are the most critical from the point of view of the structural failures.

Step 4 : Risk monitoring and response methods—in the fourth stage, so-called counter- measures (preventive actions), i.e. actions which is aimed at reducing the risk of the structural failures in the analyzed groups of causes, should be considered. As mentioned before, the Failure Mode and Effects Analysis (FMEA) method should be used to analyze the process of managing the risk of the structural failures.

Following are the action plans to for the preparedness :

Mechanical resistance and stability

The design and construction of the facility must take into account the loads that, both during construction and exploitation will not lead to collapse of the whole or part of the facility; major deformations to an inadmissible degree; damage to other parts of the facility or its equipment; damage by an event to an extent disproportionate to the original cause.

Safety in case of fire

The design and construction of the facility must assume the risk of a fire breakout. Buildings/Structure must be designed in such a way that the load-bearing capacity of the structure is maintained for some time during a fire. The designer and contractors are obliged to meet the technical and construction requirements relating to fire protection. The design, taking into account the possibility of a fire, must ensure restrictions on the spread of fire and smoke in the building and to other objects, the possibility of evacuating people at risk, the safety of rescuers.

Hygiene, health and the environment

The facilities must not pose a threat to employees, users or neighbors throughout their entire life cycle. They must not emit harmful volatile, aqueous or solid substances in any way.

Safety and accessibility in use

The facilities must be safe for its users. There must be no risk of falls, burns or electric shock. Moreover, Contractor must ensure safe use of access for people particularly those with disabilities at buildings or any structure.

Protection against noise

Protection against noise is one of the seven basic requirements. People want to live quietly, have a quiet neighborhood and work quietly. Unnecessary noise is distracting, stressful and a source of discomfort. The acoustic measures should be implemented.

Energy economy and heat retention

It is very important to equip buildings ensuring energy economy and heat retention. Optimum energy consumption also applies to the construction and demolition phase.

Sustainable use of natural resources

Throughout the life cycle of the facilities (design, construction, demolition), it is important to ensure sustainable use of resources (sustainable design), sustainable construction and sustainable demolition. Sustainable design includes the reduction of energy, water, raw materials, greenhouse gas emissions and waste production (Czajkowska and Ingaldi 2019). There are many ways to reduce the negative impact on the environment in the construction industry. One of the solutions is use of passive houses, energy-efficient houses, the use of safe building materials, modernization of heating systems, recycled materials, etc.

10.6. EMP Implementation Monitoring and Institutional Strengthening Mechanism

During project implementation construction activities of the Contractors need to be regularly/ periodically monitored till the project is set forth for operation and further, operational monitoring is required during operation phase of the project. The regular or periodical monitoring is required to ascertain whether activities are going according to the approved plans.

Project monitoring and evaluation is used to measure a project's progress. It's important because it helps the Project Implementation Authority (PIA) keep tabs on a project and identify potential problems and to resolve so that project progress is not impacted. It provides necessary feedback for project management team to keep the program on schedule. The supervision and reporting process with respect to implementation status of environmental mitigation measures during construction will initiate from the Contractor at the lowest rung who will report to the Project Implementation Authority (PIA) through the General Consultant (GC).

10.6.1. Establishment of Environmental Management Unit for Efficient EMP Implementation

Environment Management Unit shall be established by the Project Authority at the initial stage of the project implementation. This unit shall have an Senior Environmental Officer and two Environmental Specialists as PIU members from PIA, K RIDE. The task of the division will be to monitor implementation of environmental mitigation measures and environmental monitoring and it should report directly to Chief Engineer of the Project Authority. Progress of the division shall be reviewed by an Independent Environmental Advisor/Auditor once in a year. The Environmental Auditor should be an experienced expert familiar with environmental management in similar projects. Cost for the first five years (including 10% annual increase) is given in **Table 11.7.**

Roles of Environmental Auditor:

The objective of an Environmental Auditor is to detect any existing or potential environmental compliance problems or management system deficiencies and to make recommendations for implementation. Progress of the EMP implementation will be reviewed by an Environmental Auditor, as an External expert. Environmental auditor assesses the management / performance of implementation of EMAP and EMoP to ensure stipulated EIB, KfW and World bank standards of environmental control are being complied with.

Environmental Auditor will prepare the periodical Environmental Audit Report in compliance with stipulated standards of National and funding agency Environmental and Social Safegaurds, as applicable.

He will also provide inputs during EMP Training sessions to ensure the the implementing organization is complying with stipulated standards of National and funding agency Environmental and Social Safegaurds in due diligence. Budget for appointing environmental auditor to perform the above activities on intermitent basis is estimated to 20 lakhs (4 quarter x 100000 x 5 years).

During project execution – construction and operation phases, the EMP implementation comprises of the following key activities to be monitored by EMU of PIA:

- Implementing various mitigation and enhancement measures within the time frame recommended

- Overseeing the implementing various mitigation and enhancement measures and fine tuning/advocating more measures, if needed, depending on site conditions;
- Project level monitoring of key performance indicators to evaluate the implementation of EMP measures at the recommended intervals.
- Periodical reporting of status of EMP implementation and monitoring results and key performance indicators and
- Constant evaluation of EMP measures implemented based on the data available from project level monitoring and status reports submitted by Environmental Specialist of General Consultant and providing directions accordingly.

10.6.2. Reporting of EMP Implementation

The implementation of EMP during construction phase by the Contractors will be followed by their reporting to Environmental Specialist of the GC who will monitor the implementation of EMP at project site during construction and report to PIA. During operation, the employed monitoring agency will supervise or take care of implementation of mitigation measures and report to the EMU of PIA.

During both construction and operation phases, the employed independent environmental monitoring agency (third party) will carry out EMoP implementation activities and report to the EMU of PIA with suggestions, as required.

Environmental Audit Reports shall be prepared by Independent Environmental Advisor/Auditor and submitted to PIA.

Periodical Environmental Monitoring Reports shall be preparted by PIA with the support of Sr. Environmental Specialsit of General Consultant and will be submitted to funding agency.

10.6.3. Capacity Building

The above mentioned activities have to be carried out in coordination by various agencies that will be involved in the implementation of suburban rail project. It is also to be noted that all these activities will be carried out concurrently or at regular intervals and at different duration and location. This makes it pertinent that all agencies involved work within a predefined setup. The coordination model proposed during construction and operation phases is presented in **Figure 10.2** and **Figure 10.3** respectively. The identified agencies and their sphere of work are presented in following section.

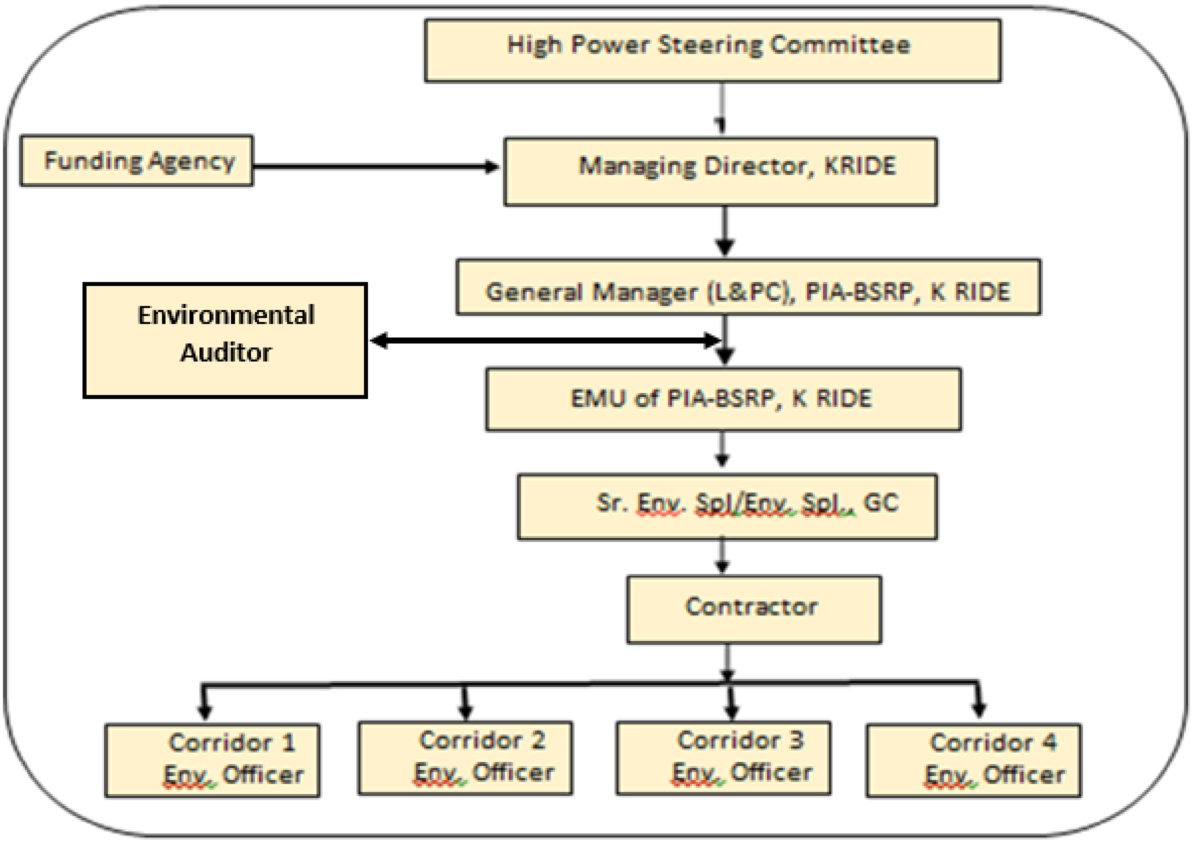

Figure 10.2. EMU's Institutional Mechanism for EMP Implementation during Construction Phase

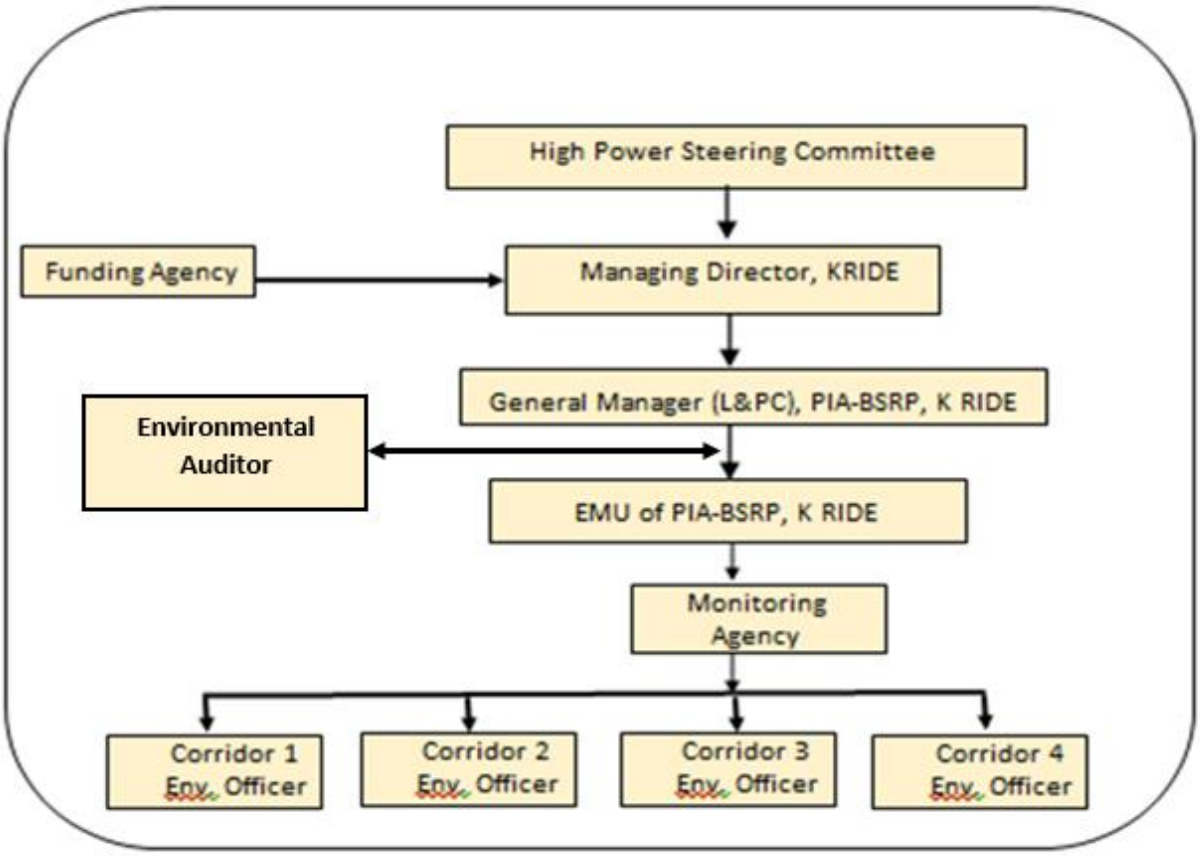

Figure 10.3. EMU's Institutional Mechanism for EMP Implementation during Operation Stage

Project Implementation Authority (PIA): The responsibility of implementing environmental mitigation measures lies with the PIA. PIA in this project will be Rail Infrastructure Development Company Karnataka Limited (K RIDE). The responsibility also includes various tasks such as notifying various affected parties such as the resident and commercial establishment, facilitate there location of people, notify other utility departments such as telephone, water supply, sewerage, etc. which used the road for providing public utility services.

Environmental Management Unit: K RIDE will set up an Environmental Management Unit (EMU) which shall look after the monitoring and implementation of the environmental mitigation measures in the EMP and address the grievances of environmental and social issues of the project and ensure compliances with World Bank Frameworks, EIB's Environmental and Social Standards, guidance note, General EHS guidelines and Railway specific EHS Guidelines and GIIPs and applicable State and National laws.

The PIA's Environmental Management Unit comprises staff and structure is shown in **Figure 10.4**.

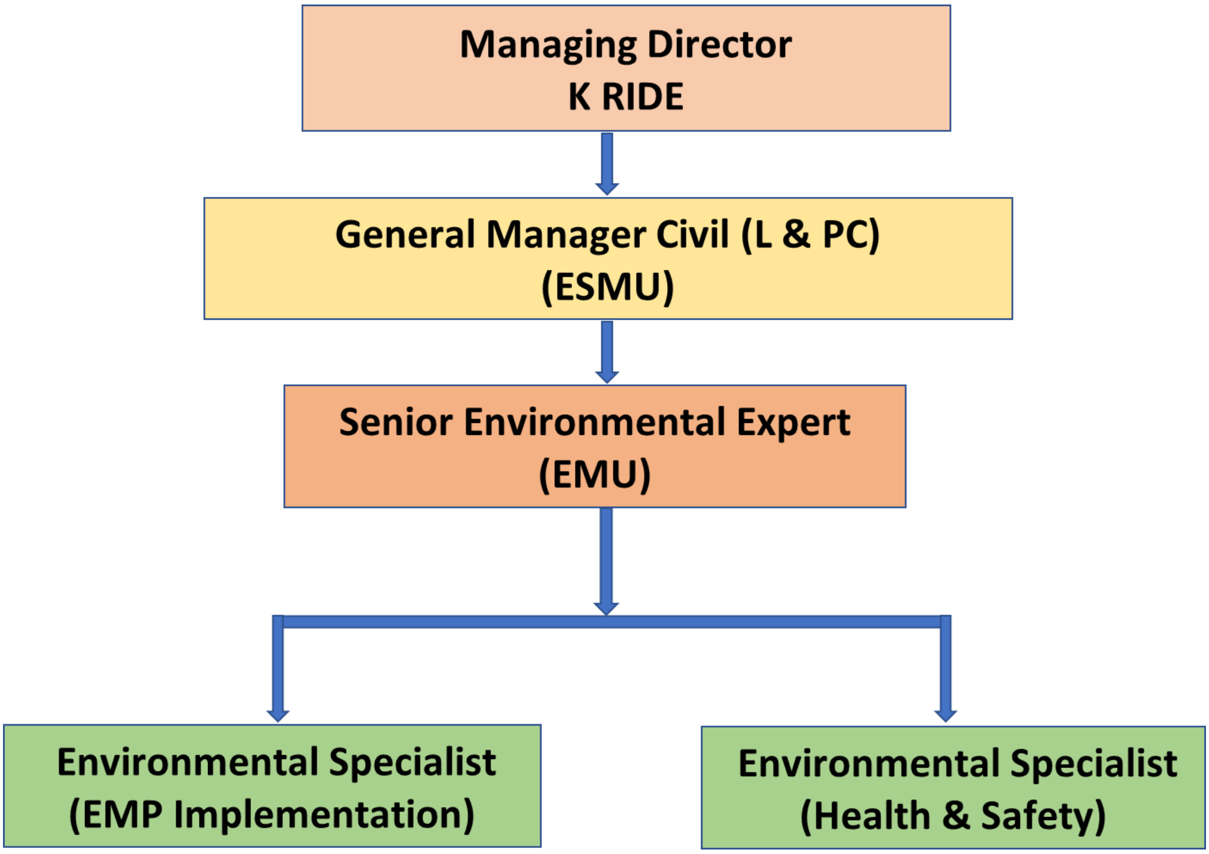

Figure 10.4. PIA's Environmental Management Unit's Organization Structure

Senior Environmental Expert (Sr.EE) of EMU reports to General Manager Civil (L&PC) (ESMU) who is responsible for management of environmental and social issues of the project. Sr. Environmental Expert of EMU will be assisted by Environmental Specialist (2 nos), who shall be responsible to look after all the environment issues related to the project during the project preparation, implementation and operation periods. Environmental and Social Management Unit will be supported by the technical and field staffs for the project implementation with the assistance of the Environmental Specialist of Design Consultant & Contractor.

It is envisaged that the Environmental Management Unit will be responsible for:

- Ensuring approvals/permission/NOC obtained from regulatory bodies/authorities for various components at different project stages
- Monitoring implementation of the EMP measures in consonance with the timeline for the project as per the approved budget;
- Maintaining interaction with the stakeholders, public and various statutory authorities pertaining to environment, land acquisition, rehabilitation and resettlement of K RIDE project;
- Interacting regularly with the Environmental Expert of Design Consultant & Contractor on the status of the environmental mitigation and enhancement measures;
- Inspecting project site on regular basis to monitor the mitigation measures being implemented by the Contractor;
- Document and disseminate good practices, minimize and resolve bottlenecks during the implementation of EMP.

Responsibility of Senior Environmental Expert:

He is familiar with the Indian environmental legislation, environmental monitoring, EMP implementation aspects etc. The Environmental Expert shall oversee day to day implementation of the environmental management plans pertaining to the construction contract for various BSRP Corridors and is also responsible for monitoring reports to funding agencies. Additional recruitment if needed will be undertaken as necessary on contract basis. He will be responsible for obtaining regulatory clearances. He will coordinate with PIA to conduct necessary training program for the workers, engineers and office staffs. Briefing the Contractor about the requirements of the Environmental Specification and/ or EMP, as applicable, advising the Engineer about the interpretation, implementation and enforcement of the Environmental Specification and other related environmental matters, monitoring and reporting on the performance of the contractor/project in terms of environmental compliance with the EMP to the GM (L&PC) and MD K RIDE and KfW & EIB and providing technical advice relating to environmental issues are also the responsibility of the Senior Environmental Expert. As required by the Funding Agecny, the periodical Monitoring and Compliance Report will be prepared by Sr. Environmental Expert of PIA with the Assistance of Sr. Environmental Speciasit of GC. The EMU of PIA will review and then submit the Environmental Compliance Report (ECR) to Project Director (PD), finally the will be submitted to the Funding Agency for approval.

Sr. Env. Expert of EMU, PIA, BSRP will be responsible to report to the Funding Agency, regarding EMP compliances during operation stage.

Responsibility of Environmental Specialist (EMP Implementation) of EMU;

The main duties of the Environmental Specialists will include:

- Collection and dissemination of relevant environmental documents including amendments to environmental protection acts issued by the Government and various agencies such as the World Bank and other organisations.
- Co-ordination with non-government organisations (NGOs), community groups, government departments, etc. on environmental issues and obtaining the necessary clearances from the regulatory authorities.
- Monitoring the environmental aspects of the project during construction to ensure that the environmental requirements of the contract and the mitigation measures proposed in the EMP are implemented.
- Development of guidelines or a code of good practice on low-cost environmental measures that can be implemented in the railway construction and maintenance programs for the PIA.
- Development of environmental training activities for contractors and supervisory consultants staff.
- Assistance to local governments in the restoration of the environmentally degraded portions of any existing Right-of-Way, which may revert to their control due to the construction of realignments.
- Promotion of the policies adopted for the development of aesthetics of stations, Depot & along rail alignments.

- Coordinating with the EO of PIA and report to GM (L&PC) on all matters related to implementation of the Environmental Management Plan.
- Laison with institutional stakeholders such as Forest Dept., Pollution Control board, Ground Water Dept., Urban Local Body, Lake Authority etc., for approvals and smooth implementation of Environmental Management Plan.
- Issuing completion certificate for constructed railway works (Stations, Deports & suburban Railway alignments) for payment.

Responsibility of Environmental Specialist (Health & Safety) of EMU;

The main duties of the Environmental Specialists will include:

- Collection and dissemination of relevant health and safety documents issued by the Ministry of Railways and other funding agencies such as the World Bank, KfW and other organisations.
- Co-ordination with non-government organisations (NGOs), community groups, government departments, etc. on environmental health and safety issues and addressing suitable manner.
- Advising the Engineer and preparing the environmental health and safety inputs for the monthly progress report.
- Development of guidelines or a code of good practice on low-cost environmental health and safety measures that can be implemented in the railway construction and maintenance programs for the PIA.
- Development of environmental training activities for contractors and General Consultants staff.
- Assistance to local governments in the restoration of the environmentally degraded portions of any existing Right-of-Way, which may revert to their control due to the construction of realignments.
- Assistance with the rail safety components (Stations, Deports & suburban Railway alignments).
- Ensuring and reporting of construction health and safety, labour health and safety and community health and safety as per WB's Environmental Health and Safety guidelines at railway construction site, stations, Depot, sub-stations and project associated facilities such as batching mix plant, disposal sites, etc.,

General Consultant (GC): The PIA will get the EMP implemented through the General Consultant (GC) appointed for managing engineering and construction related activity. The PIA will deliver the responsibility of the implementation as per the contract agreement. In order to effectively discharge the duties GC will have an Sr. Environmental Specialist /Officer in the project management unit. The Sr. Environmental Specialist /Officer will work for a full time basis at the site office. The environmental Specialist /Officer must possess minimum 3 years experience in the environmental management of suburban or metro or likely projects. The GC will monitor periodically the EMP implementation activities and its compliance and review monthly reports of Contractor;

The GC will review and approve the Environmental Compliance Report (ECR) submitted monthly by the contractor and forward the ECR to PIA after approval.

Project Contractor: Project contractor will implement the EMP measures, enhancement measures and measures as directed by PIA and GC. The responsibility to implement the EMP measures will be built in to the contractual agreement. The contractor shall submit a monthly progress report to the GC in compliance to the environmental mitigation measures mentioned in EMAP.

Ministry of Environment, Forests & Climate Change: The Ministry of Environment, Forests & Climate Change (MoEFCC) is the nodal agency in India to plan, promote, co-ordinate and oversee the implementation of environmental and forestry programmes. Principal activities undertaken by the Ministry of Environment, Forests & Climate Change consist of conservation & survey of flora, fauna, forests and wildlife, prevention & control of pollution, afforestation & regeneration of degraded areas and protection of environment, in the frame work of legislations.

Authorities will be consulted and reported as per the Acts and Rules. All the activities of the proposed Project including its execution and operation will have to comply with the present environmental regulations by MoEFCC and their amendments from time to time and to submit the compiance repots, as required by Ministry. There will be no specific and direct involvement of the Ministry in EMU.

Central and State Pollution Control Boards: Central Pollution Control Board (CPCB) is a statutory authority attached to the MoEFCC and located in New Delhi. The main responsibilities of CPCB include inter alia the following.

- Plan and implement water and air pollution control programs;
- Advise the Central Government on water and air pollution control programs;
- Set air and water standards; and
- Co-ordinate with the State Pollution Control Boards.

Karnataka State Pollution Control Board (KSPCB) is the regulatory body in the state of Karnataka to enforce various environmental legislations of the Government of India. While regulatory powers are delegated to KSPCB from CPCB, the administrative control of the board rests with the State Environment and Forest Department. More specifically, the functions of the board are listed below.

- Implementing the provisions of EP, Water and Air Acts
- Advise State Government in respect to suitability of particular area for industrial development
- Assess the quality of environment in terms of ambient air and water quality through monitoring
- Issue and enforce consent orders for industrial pollution control
- Oversee, supervise and regulate water, air, solid, bio-medical and hazardous waste management in urban areas

In performing the above duties the board is headed by a Chairman who is supported by a Member Secretary and a Chief Environmental Engineer. The Chief Environmental Engineer is supported by District Environmental Engineers in each District of the state.

KSPCB will be the key agency for monitoring and ensuring the implementation of the various environmental regulations applicable to the project. In addition to issuing consent to establish to the project, the agency will also be responsible for the monitoring of implementation of EMP and its implications and to submit the compiance repots, as required by SPCB. However, there will be no specific and direct involvement of the PCB in EMU.

Karnataka State Forest Department: Karnataka State Forest Department is a nodal agency which is authorized to conserve and protect forest and wildlife of the State. As pet the Forest Act and Karnataka tree preservation act, the department has delegated powers to process Forest clearance and accord tree felling permission. The department has a responsibility to monitoring and ensuring the implementation of the regulations with respect to forest and preservation of trees applicable to the project.

10.7. Training

To ensure effective implementation of the EMP, environmental, health and Safety training will be provided by engaging third party independent consultant to staff involved in the project management, engineering supervision, K RIDE and project workers during construction phase. The training during construction phase will be conducted before commencement of the construction and focus on:

1) National, local and International (including compliance with lenders' E&S standards) regulations on environmental protection;
2) Good management practice related to minimize environmental impact;
3) Related requirements of environmental, health and, safety (EHS); and
4) Environmental mitigation measures included in the EMP.

During operation stage, K RIDE will incorporate environmental protection into its management system and provide staff training on Environmental Management System (ISO 14001) and Occupational Safety and Health Management System (OSHMS), in compliance with the lenders' standards.

The training for engineers, managers and workers will be imparted by K RIDE on regular basis to

- Monitor implementation of approved EMS by Contractor
- Monitor environmental status during operation and
- Monitor disaster management during operation.

The cost is estimated to be ₹ 12.20 Lakhs for each corridor as given in **Table 11.6.** The curriculum for all the corridors will be same. One Assistant Environmental Engineer for each corridor (is considered and cost is distributed equally among the each corridor).

10.8. Grievance Redressal Mechanism in BSRP

Grievance Redressal Cell shall be set up to mitigate, manage, and resolve potential or realized negative impacts, and to ensure that the project proponent (K RIDE) meet their obligations in terms of international human rights law. GRM enables project proponent to learn about and resolve concerns related environmental and social aspects including implementation of mitigation measures, ensuring workers and community health and safety, payment of compensation, resettlement and rehabilitation, restoration of loss of livelihood activities, assistance to the vulnerable people, replacement of common property resources, etc., as stated in the Environmental Management Plan (EMP) & Resettlement Action Plan (RAP) before they escalate. GRMs should permit a peaceful and timely resolution of problems, assuring stakeholders that their concerns have been heard and that the institutionalized mechanism will yield a fair and impartial outcome.

All grievances related environmental and social issues (implementation of EMP measures & compensation for land and resettlement assistance) will be addressed by the General Manager (Land & Project Co-ordination), K RIDE. Grievances received at the corporate office of K RIDE, will be sorted according to subject matter and will be informed the respective offices/agencies to resolve it.

Labour grievance mechanism shall be developed during construction phase to resolve the labour issues, health and safety issues as per applicable regulations. The representatives from the Contactor, labour, General Consultant and K RIDE form the parts of Labour Grievance Unit.

Grievance redress will be carried out at two levels: namely first level and the appellate level. Grievances of affected persons will be first brought to the attention of K RIDE (through contractor, Environmental and social field officers of K RIDE, Environmental monitoring consultant, Resettlement Plan implementation Consultant, etc.) and land acquisition office, KIADB. At this level, the time taken to address a matter may vary from 15 days to one month, depending on the matter. Land related cases take longer than one week as it may require providing legal documents, change of alignment or dropping the properties from acquisition etc. All these matters require consultation with planning and design section, before a decision can be reached, thus the process can extend up to a month.

In cases where the affected person is not satisfied with the decision of the land acquisition office or the field level office / corporate office of the K RIDE, the person can approach the Grievance Redress Committee (GRC). The GRC will convene within 15 days of receiving the matter. The grievance redress process is given in **Figure 10.5**. The composition of the GRC is:

Director (Projects and Planning),	Chairman
General Manager (L & PC)	Convener
General Manager (F & A)	Member
Chief Public Relations Officer	Member
Tahsildar	Member
Community Representative (PAP - Male)	Member
Community Representative (PAP – Female)	Member
Team Leader of Resettlement Plan Implementation Consultant	Member
*Team Leader of Environmental Monitoring Consultant	*Member

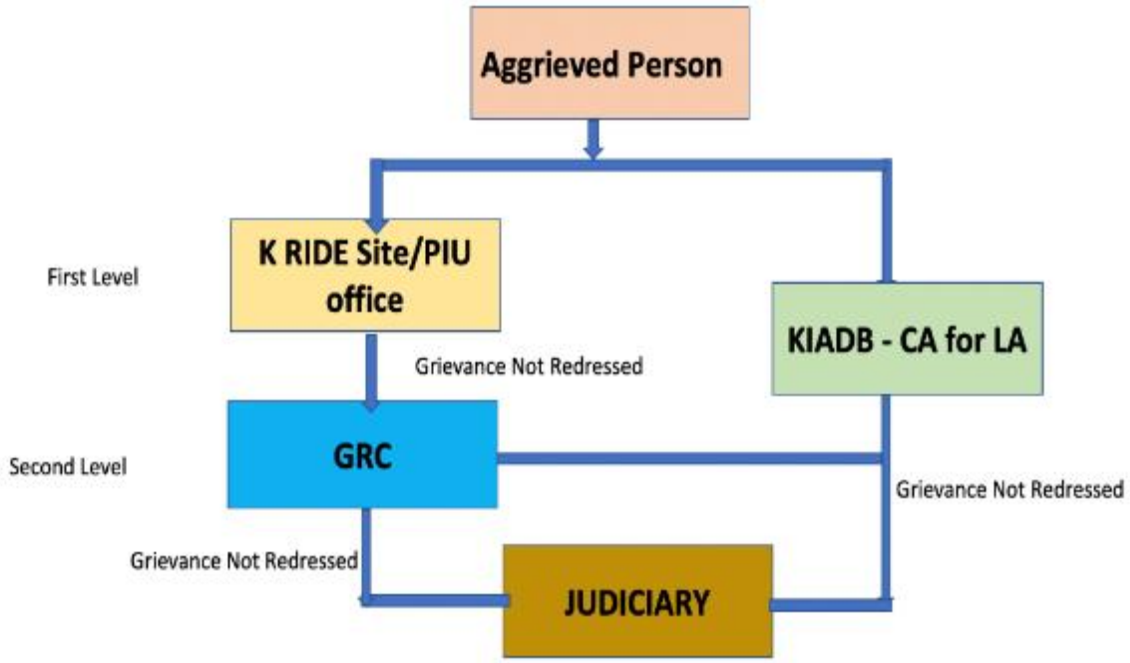

Figure 10.5. Grievance Redress Process

The main responsibilities of the GRC are:

- to provide support to affected persons on problems arising out of eligibility provided entitlements compensation and assistance provided;
- to record the grievance of the disadvantage community & PAPs and resolve them within the stipulated time frame;
- to report to the aggrieved parties about the development regarding their grievances and decision of K RIDE and
- address problems and complaints arising out of land acquisition and relocation of utilities.
- Address environmental, health and safety issues and complaints raised during construction phase
- K RIDE shall monitor overall activities of GRC.

10.8.1. Registration of Grievances

Grievances can be submitted as the written application in English or Kannada at the K RIDE field office, corporate office, or land acquisition officer. Careful documentation of the name of the complainant, date of receipt of the complaint, address/contact details of the person, location of the problem area, and how the problem was resolved will be undertaken. The Project Implementation Authority (PIA), K RIDE will have the overall responsibility for timely grievance redress on environmental & social safeguards issues and for registration of grievances, related disclosure, and communication with the aggrieved party. The aggrieved person also has the option of opting for judicial review/intervention by the courts at any point in time.

The project may be established a grievance redressal cell at PMU headed by a Public Relation Officer solely responsible for handling the grievance of the people. The team will be responsible for directing the aggrieved person to the concerned official through appropriate mode of communication. On receiving any complaints, a unique number may be generated (MIS based) which will be the reference number for the caller, and s/he can trace the progress of his/her grievance / query through that number. Any complaint lodged will be addressed within 15 days of receiving the complaint in general and non-risky situations. Immediate corrective action shall be taken under emergency situations.The system may have escalation matrix, i.e. if the grievance / query remains unattended or there is no response from the concern officer for a specified period of time than the system will escalate the grievance / query to the next level and the notification will be sent to the Public Relation officer and the petitioner.

The project will also commit itself to proactive disclosure and sharing of information with the key stakeholders, including the communities/beneficiaries. The Disclosure/ sharing of information is concerned with information on grievances/ complaints received, progress & results. The environmental monitoring and resettlement plan implementation consultants (would be appointed by K RIDE) staff will be responsible for assisting illiterate community members and other stakeholders in registering their grievances.

10.8.2. Process Flow of Grievance Redressal Mechanism

The grievance redress mechanism will be planned around the following process flow.

- **Step 1:** Public Grievance is received by the redressal officer at field level or PMU and the officer will enter the details of the complainant.
- **Step 2:** A confirmation will be sent through auto generated SMS, with a reference number to the person on receipt of the complaint.
- **Step 3:** Once the complaint is registered, the concerned officer/consultants will receive an SMS notification, with a deadline of 15 days to resolve the grievance. The public relation officer will monitor the complaint status by option of choosing the following actions:

    1) View (Complaint will be viewed)
    2) Action (what are the actions that have been taken to resolve the complaint)
    3) Assign / forward (the action will be forwarded)
    4) Resolve (The Problem is solved in the stipulated time period)
    5) Escalate (The complaint will be escalated to the appropriate authority)

- **Step 4 - Taking Action:** A window of 15 days will be provided to the field level officers of K RIDE/consultant/Contractors site representative concerned to resolve the issue and submit their responses. In case of non-response, SMS alert will be issued to remind the officers about the action pending.
- **Step 5 - Resolving the grievance:** Once the grievance is addressed and updated information is placed in the software, the grievance is labelled as resolved. An SMS will be accordingly issued to the complainant. If any grievance is not resolved within 15 days an SMS alert will be issued to the Public Relation Officer, PMU and the concerned officer will take appropriate action (elevate the same for the consideration of GRC) to solve the grievance.

- **Step 6 - Meetings and decision-making process of the committee:** It is suggested that grievance committee shall meet regularly (at least twice in a month) on a pre-fixed date. The committee will fix responsibilities to implement the decisions of the committee. This will not only help proper assessment of the situation but also in suggesting corrective measures at the field level itself. The committee shall deliver its decision within seven days of the sitting.

10.8.3. Functions of GRC

It includes complaint handling system at Field level and GRC at PIA . Functions of the GRC include Field level complaint handling system; and Meetings and decision-making process of the committee with in time required action. The complaints received from community members and other stakeholders of any concerns or complaints, or grievances should be taken up in the grievance redressal process. The concerned officer should maintain a register of all petitions received with details of date of receipt of the petition, the date of hearing, if any, date when it was considered by the committee, along with nature of complaint/concern, action taken, and date of communication sent to petitioner. Communication in writing should be sent to the aggrieved person about the date, time and venue of the GRC sitting and make it known that s/he is entitled for personal hearing and that representation through the proxy will not be entertained. Communication will also be sent through Environmental & Resettlement Plan Implementation Consultants so as to ensure that the petitioner is informed about the date of GRC sitting.

Copies of petitions received 1-week prior to the committee's sitting should be sent to the Chairman and the member along with an explanatory note from appropriate authority and/or environmental and resettlement plan implementation consultants, as the case may be, to enable the Chairman and member to scrutinize the petitions in detail. Petitions received during the week of the committee's sitting, shall be taken up during the sitting and resolved.

10.8.4. GRC Response

The GRC will hear grievances once in 15 days. The GRC will inform the complainant of their decision within three days of the hearing of the grievance.

There is no cost involved in approaching the project authorities or the GRC in registering grievances. The grievance redress mechanism is accessible to not only the affected persons, but the community as a whole.

Detail address of Grievance Redressal Officer is given below.

Rail Infrastructure Development Company (Karnataka) Ltd.,

"Samparka Soudha", 1st Floor, (Opp. Orion Mall),

Dr. Rajkumar Road, Rajajinagar 1st Block,

Bengaluru – 560 010,

Karnataka.

Since the project is in design phase, only K RIDE office address has been given for submitting the Grievances. As and when the project progress, more channels of communications will be provided such as Email Id, Toll free number, Whatsapp /Telegarm number, Facebook, Instragram, twitter, etc.,

10.8.5. Internal Grievance Redressal Mechanism

Internal Grievance Redressal Cell shall be implemented by Contractor to handle grievances of Construction Workers at site and Employees at Office level. Similarly, Employees' grievance shall also be managed by GC and PIA, K RIDE via Internal Grievance Redressal Mechanism. Following strategies are implicated in the Grievance Redress Mechanism. Grievance Redressal Cell shall remain same as mentioned earlier.

10.8.5.1. Grievance Management of workers and Employees

Employee Grievance is a formal complaint raised by an employee against a fellow employee or manager, or even against the employer. Employees usually file grievances for workplace harassment, discrimination, nepotism, concerns regarding team management or regarding terms of the employment.

Employee grievance refers to the discontentment of an employee with the corporate and its management. A company or employer is expected to provide an employee with a safe working environment, clear knowledge of job responsibilities, adequate compensation, respect etc. However, employee grievance is caused when there is a gap between what the employee expects and what he receives from the employer.

Employee grievances may or may not be justified. However, they need to be tackled adequately by the leadership team because they not only lower the motivation and performance of the employee but also affects the work environment. Employee grievances if left unchecked can lead to large disputes within the company. It can also drop the motivation levels of other employees. Any company must have a proper channel for employee grievance redressal.

Employee Grievance should be handled in a proper and well defined manner. If an employee voice is raised or someone reports a matter associated with a policy or one thing he or she isn't pleased with or needs to criticism against, a framework outlined in policy ought to be used.

Complaints or Grievances can be submitted as the written application in English or Kannada at the Employer's Office by the Complainant. The Complaint or the Grievance Application should include Complainant's Name, Address, position/Designation, Date, time and details of grievance event, source of grievance, grievance causative person with his Designation and other details, if any. The complaint should be submitted to the concerned and designated person in the Employer's Office along with needed documents such as photographs, letter, or videos, etc.

The Complaint Register should be maintained in the Employer's office with designated person to register complaints/grievances. The complaint registering person should document the complaint with all details including Complainant's Name, Address, position/Designation, Date & time of receiving complaint, location of the problem area/section/Department, Date, time and details of grievance event, source of grievance, grievance causative person with his Designation and other details, if any and mention the action to be taken by the concerned person, and Date and time required to address the complaint. The acknowledgement should be given to the Complainant.

At the next level, the complaint details should be immediately passed on to the concerned person for necessary action along with required Date and time to close the complaint. Any complaint lodged will be addressed within 15 days of receiving the complaint in general and non-risky situations. Immediate corrective action shall be taken under emergency situations. Complaint or Grievance may be resolved through verbal or written actions or through communication or other actions, as required. When once the issue is resolved, the details of action taken, date and time, the satisfaction of the Complainant, etc. should be recorded in the Complaint Register. The system may have escalation matrix, i.e. if the grievance / query remains unattended or there is no response from the concern officer for a specified period of time than the system will escalate the grievance / query to the next level and the notification will be sent to the Public Relation officer and the petitioner.

The Employer direcly or indirectly related to the Project will have the overall responsibility for timely grievance redress on environmental & social safeguards issues and for registration of grievances, related disclosure, and communication with the aggrieved party. The aggrieved person also has the option of opting for judicial review/intervention by the courts at any point in time, if the issue is not resolved properly. Whenever required, the Complaint Register along with other documents may need to be submitted to the internal or external Auditors during Inspections.

Flow Chart may be followed as given under Section 8.5.2, with slignt modifications, if required.

These are the most common grievances in the workplace include:

- **Workplace Harassment**: This includes bullying, discrimination and micro-management. Not everyone in your team will get along all the time. Friction is likely to occur. But that doesn't mean you shouldn't ignore it or dismiss it as a common occurrence. Let your employees know that such behavior is not tolerated.
- **Compensation**: Employees might sometimes feel that their work deserves a higher pay. There can be issues wherein they think they should receive the same compensation as someone else. Or could be about reimbursements.
- **Workload and employee burnout**: When employees end up doing more work than they were initially expected to, most likely because of taking up the work of a resigning/terminated employee., or staff redundancy. They are often frustrated wondering how this would benefit them.
- **Work conditions**: Cleanliness and safety are the two most important things your employees will be concerned about.

Effectively handling Employee Grievances:

- **Have an informal chat with disgruntled employee**: Have a small discussion with the employee to understand where exactly the issue is stemming from. It is essential to make them feel heard. If the employee still insists on pursuing a formal grievance procedure, written statement can be requested and action can be taken.
- **Set up a Grievance Redressal system**: Employees should know that they can voice their concerns. Grievance policy should be in place accessible by all the employees. Employees should know point of contact or communication and confidentiality should be assured. Most importantly, a timeline shall be provided to act on the grievances.

- **Acknowledge the issue**: When someone has an issue, the most important thing is to make them feel heard. The solution may not be handy, but it is necessary to let them know that the issue will be taken care of, in a fair, transparent and timely manner.
- **Grievance investigation**: An investigation committee should be set up to address the concerns of the employee. Incident should be enquired and employees should be communicated properly, if necessary and employees should be allowed to provide evidence for their claims.
- **Take an informed decision**: After inquiry and evidence submission, a thoughtful and informed decision should be undertaken. Decision can be taken to accept (full or partial) or reject the claims entirely. No verbal decision should be made. The decision should be in writing and steps should be given on how the employee should handle such a situation henceforth.
- **Provide scope for appeal**: If the employee is unhappy with the decision of the committee, they should be given a chance to appeal. The appeal should be acknowledged and parties who were not a part of the initial decision should also be included. The evidence should be shared with them, helping them to take an unbiased decision.
- **Take care of the root cause**: It is important for employers to ensure that the issues do not repeat themselves. As a result, the root cause should be identified and uprooted entirely.

10.8.6. Handling/Management of Supply Chain Workers

Social risks in supply chains are anything that could impede human rights, welfare and safety, or community development. Contractors should also engage in public-private partnerships or multi-stakeholder initiatives that harness collective attention and resources to grapple with these broader challenges to industry.

Strategies for construction workforce management -

1) Collaborating and communicating properly with workers.
2) Applying Technological Means for Management, Data collection and Analysis
3) Recruiting qualified workers
4) Motivating of construction workforce.
5) Handling logistics properly.
6) Improving workplace safety.
7) Addressing Underperformance Issues
8) Caring about the health of the workers.
9) Managing manpower properly.
10) Managing on-site disputes wisely.
11) Optimize workday.

Applicable laws and Acts for Supply Chain Workers :

International Labour Organization (ILO), the Factories Act, 1948, The Occupational Safety, Health and Working Conditions Code, 2019, Social Security Code, 2020 and the Industrial Relations Code, 2019 and the Wage Code, 2019 and wage related laws such as the Minimum Wages Act, 1948; the Payment of Wages Act, 1936; the Equal Remuneration Act, 1976; the Payment of Bonus Act, 1965 along with the Indian Labour Conference ("ILC") in 1957 and reiterated in the 44th and 46th ILCs in 2012 and 2015.

Child Labour: (Similar as presented under Section 8.5.1.4 – Same repeated here) Child labour Age is up to 18 for developing countries,– Labour Rights and up to 18 as per ILO standards for hazardous work (C 138 - Minimum Age Convention, 1973 (No. 138)]. The Child Labour is totally prohibited in the project. No child under the age of 14 shall be employed or permitted to work in any sort of works related to project, as per the Child Labour (Prohibition and Regulation) Act, 1986. Whoever employs any child or permits any child to work in contravention of the provisions of Section 3 shall be punishable with imprisonment for a term which shall not be less than three months but which may extend to one year or with fine which shall not be less than ten thousand rupees but which may extend to twenty thousand rupees or with both, as per Section 14 of the Child Labour (Prohibition and Regulation) Act, 1986. If the Contractor is found guilty of breaching the Act, he shall be treated as per the Child Labour (Prohibition and Regulation) Act, 1986 and the relevant procedure shall be followed by the K RIDE.

Forced Labour: Vulnerable Forced labour and specifically debt bondage may be the case while supply chains employ migrant workers. As conflict, climate change and soaring food and energy prices drive higher numbers of people into poverty, the risk of forced labour is also increasing in low or middle income group of community. Contractor should be able to identify forced labour risks in their supply chains or take adequate steps to address such risks.

Forced Labour Risk Assessment: This step involves doing a due diligence on different aspects of labor rights compliance. These aspects may include:

- Presence of management systems for internal and supply chain labor rights compliance
- Labor relations and legal history
- Fair Wages
- Working hours
- Equal Employment Opportunities
- Social Security and Welfare
- Health & Safety
- Child & Forced Labor
- Employee Unions

Human rights abuses — such as forced labor, a form of human trafficking or modern slavery, shall be totally banned in the BSR project. Human rights of forced labour are respected and required actions shall be taken in favour of forced labour, in case any malpractice is noticed.

Fixed Weekly working Hours : As per ILO conventions, fixed working hours shall be 10 hours in any 24 hour period and 77 hours in any 7 day period or weekly working hours of 48 hours or less. Hours of rest may be divided into no more than 2 periods one of which shall be at least 6 hours in length. These limits serve to promote higher productivity while safeguarding workers' physical and mental health.

Occupational Health and Safety of Supply Chain Workers:

- **Awareness**: Workers will need to strengthen their awareness of risks, preventing accidents, and making their tasks safer. Managers and Supervisors will also need a strong understanding of current operations and the associated risks. Adopting required measures in place to create a safer environment is only the first step in a long process. Consistent mindfulness is necessary to continue that safety day-to-day.

- **Right reporting system**: The right reporting system allows workers to point out a problem, share it with the community, and take action. Other workers can avoid a hazardous area, for example. The proper protective gear can be issued or assigned. Maintenance and clean-up crews can take action faster and know where they're needed. All of these teams work together to improve general safety. Communication and Adopting Safety Culture need to be practiced.
- **Leveraging Technology**: By leveraging technology a physical commitment is made to safety while helping to empower workforce at the same time. The system will notify a person when there's a potential danger, giving him ample time to take action or be more mindful of the situation. In a way, it automates and democratizes safety culture, but there's definitely something to be said about the reliability of the related systems. Contractors must continue to maintain these technologies so that the workforce knows they're indeed trustworthy and working as intended.
- **Securing the Resources**: Depending on the environment, safety culture may also require physical resources like personal protective equipment, cleaning supplies, new components or parts, and so on. It's imperative for Contractors to secure the budget for such a thing, but also to secure the resources too. For supply chain safety, in particular, there should be a dedicated team for this. They should regularly assess risks and threats and then work collaboratively with live teams to take action.
- Out-dated or damaged gear should be replaced. Malfunctioning equipment should be serviced promptly, or replaced. Dangerous conditions should be dealt with, as soon as possible, and making sure the related supplies are available should be up to the safety task force. Most importantly, these teams should work in tandem to secure proper safety for all, not independently.
- **Creating Fail Safes**: Contractor should consider how safety is handled with automated machinery or equipment. A machine itself is generally inspected and serviced, but also there's usually a failsafe in place. That could be a rail or guide that engages seconds before a disaster. Or, it could be a program built into the software to power down the machine at a moment's notice.
- Fail safes are designed to be the last line of defence in the safety culture. Analysis shall be made on do the Contractors have people in place to monitor a dangerous situation and alert everyone involved? What kind of fail safes do you have in place for your operation? Are there devices, technologies, or roles you can implement to reduce accidents or risk? All those fail safes should be identified, analysed, rectified wherever needed and implemented in adherence with related policies and procedures.
- **Safety Culture Practice**: Safety culture needs to be practiced by everyone in the working team - from the executive team to the supply chain floor. Everyone should understand what's required, how to secure their safety, and how to protect each other. From there, it's about putting the policies, hardware, and resources in place to preserve that safety, all while maintaining it and keeping everything in good working order. It just highlights how important safety really is in the grand scheme of things and goes to show just how much of an impact it can have on standard operations.

10.8.6.1. Risks and Impacts of Supply Chain Workers

Along with other fatal impacts, the aftereffects of the pandemic COVID-19, there was scarcity of labours in supply chain system from the year 2020. It has resulted in Labour uncertainty, self-restriction of dis-satisfied labour to work, delay and disrupted vital processes of serving and delivering, manufacturing, marketing and operations, distribution and delivery. It is getting improved these days. Flexible manufacturing systems or optimized production technology have been adopted for a stable supply-chain.

It has already exposed the vulnerabilities of many global organizations, especially those such as Contractors in Indian Infrastructure Projects like BSRP, who have a high dependence on supply-chains to fulfil their need for raw materials or finished products.

Post COVID-19 impacts on Supply Chain : These include the following:

- Direct impact on manufacturing and retail;
- Procurement and supply chain disruptions;
- Disruption leading to increase in inflation;
- Impact on delivery timelines and consequent delay re-negotiations;
- Stability of business;
- Labour and human resources management, to name a few.

Impacts on Construction Contracting Companies due to supply-chain disruptions :

Impacts are categorised as Short term and long term impacts. Following are the impacts addressed :

Short term impacts

- Unstable supply sources with global disruptions, considering for alternate supply sources;
- Increase in the lead time for customer deliveries;
- Cancelation or limiting new customer orders/ adapting to changed consumer behaviour;
- Re-negotiating customer contracts;
- Re-integrating of geographically diverse manufacturing and logistics sources;
- Implementing disaster recovery plans.

Long term impacts

- Alteration of entire design of the supply chain, anticipating deep risks.
- Adapting greater geographical diversification, critical onshore functions for imports relying on warehousing and logistics.
- Implanting automated technologies such as robotics to reduce the risk of production and transportation epidemics.
- Implementation of more pragmatic approaches to lean supply chains and just-in-time inventory management.
- Cultivating technology based approach as opposed to process based.

Mitigation Measures:

Gaps in the Supply Chain shall be compensated with an efficient and tightly controlled inventory management system.

The ISO 28000 standard provides a best practice framework to reduce risks for people and cargo within the supply chain. It helps manage and mitigate potential security within the logistics area, targeting threats such as terrorism, fraud and piracy.

Technological advancement and adaptation to the newest equipment and techniques available had making way. The planning included:

- Material Requirement Planning,
- Flexible Manufacturing Systems,
- Inventory management

The following vital tools and the principles of best practice shall be followed by the Supply Chain system to support profitable growth and build or maintain a competitive advantage.

- Integrating supply management systems
- Creating tools for clarity and collaboration
- Supporting improvements in supplier performance
- Suppressing cycles and maximising inventory yield
- Collating and analysing meaningful data
- Scalable solutions

Other than the above practices, the following supply-chain solutions are weaved in future delivery systems for the BSRP :

10.8.6.2. Alternate Sources of Supply

Primary suppliers are undergoing logistical issues. Organizations are hedging risks by seeking alternate sources of supply of products. Some of these alternate sources, could be smaller set ups requiring support themselves.

Technology has introduced flexibility and operational logistical issues are being outsourced to third party suppliers. Adapting to digital supply chain management practices involving predictive analytics, real-time productive planning, clean-sheet models for warehousing/transportation/inventory used for managing targets will replace the traditional ways. Global Logistic companies are increasing their use of digital technologies, to boost to track movement closely with real time data.

Costs can be contained by keeping the alternate sources of labour or suppliers close to the place of business.

10.8.6.3. Third Party Supply Chain

A third party supply chain involves a separate entity / service provider to assist with one of the crucial steps in the supply chain. Now-a-days third party organisations are solely responsible for organizing supply of raw materials or finished products and are providing warehouse storage facilities.

Warehousing business has several compliance and legal adherence protocols which can be to a degree met with ease by entities in the business of logistics and warehousing. With labour stability being challenged in India, data management and securitisation becomes imperative for logistic companies.

10.8.6.4. Delivery Business Models

An important aspect of labour in the post COVID -19 pandemic era will be dependence on policies of contact-less delivery and contact tracing for staff. This helps in avoiding any disrupts in the supply chain.

10.8.6.5. Product scheduling and staggering shifts

The concept of product scheduling helps determine which products need to be prioritized in the event there is acute raw material and labour shortage. This eases the strain on the current limited workforce to deliver only the prioritised products instead of all.

Technology based payment systems will have to be integrated into the system. A staggered shift pattern arranges shifts of employees to arrive at different times. Both of these methods, if applied together with a large work-force employed to constantly rotate shifts – stabilizing the function would be possible.

Pandemic management through workforce requirements, having preventive health protocols of tying up with a health centre for easy access Medical Doctor, quick health check-up kiosks on site, sanitization exercise undertaken at regular frequencies, educating workforce on guidelines to be followed in event of ill health.

10.8.6.6. Transportation

Since trucking is the most common form of transportation in India, alternatives like rail can also be relied upon for cargo.

10.8.7. GRM during Covid-19 & Omicron Pandemic Situation

Covid-19 and Omicron pandemic has severely affected the global economy from the year 2020 onwards. Many countries imposed lockdown to regulate the spreading of the virus to its people. Still the situation is grim where many countries are fighting against it. Recently World Health Organisation has cautioned the world on increasing cases in European and Central Asia countries. Again, spreading of Covid-19 or Omicron viruses cannot be ruled out in India. In such cases, if lockdown imposed by State Govt., project authority should come up with mechanism to receive the grievances in online and address the same through either telephone discussions or virtual meetings.

10.8.8. Community Participation during Project Implementation

The Community Participation during Project Implementation is considered part of GRM to understand the local problems and to get local opinion and suggestion regarding the implementation of the project. The effectiveness of the Environmental Management Plan & Resettlement Action Plan (RAP) is directly related to the degree of continuing involvement of those affected by the project. Several additional rounds of consultations with PAPs will form part of the project implementation. EMP measures will be implemented in close coordination with public, local public and NGOs. Consultations during resettlement plan implementation will involve providing support for PAPs to receive compensation and resettlement and rehabilitation assistances. Another round of consultation will occur when compensation and assistance are provided. During public consultations, issues related to environmental health and safety issues, land acquisition, compensation, income restoration, employment generation, information flow, grievance redress, safety, role of administration etc will be discussed. The EMP & RAP addresses all issues raised during public consultation and recommends institutional strengthening measures as well.

The following set of activities will be undertaken for effective implementation of the plan:

- Project Implementation Authority (PIA) will conduct information dissemination sessions in the project area and solicit the help of the local community/ leaders and encourage the participation of the project implementation.
- Consultation and focus group discussions will be conducted with the vulnerable groups like women, families of BPL, Scheduled Castes to ensure that the vulnerable groups understand the process and their needs are specifically taken into consideration.
- The Project Authority will organize public meetings and will appraise the communities about the progress in the implementation of project works and payment and assistance paid to the community. Regular update of the program of environment and social components of the project will be placed for public display at the project offices.
- Taking into consideration the risks of HIV/AIDs during the project construction period and road safety issues.

Stakeholder Engagement Plan (SEP) for the project has been prepared considering environmental and social stakeholders; and has been incorporated as part of Social Impact Assessment.

10.9. Environmental Management Action Plan (EMAP)

Environment Management Unit (EMU) is intended to facilitate implementation, tracking and reporting on Environment Management Action Plan and Environment Monitoring Plan proposed for the project. The Environmental Management Action Plan (EMAP) is the synthesis of all proposed mitigation and monitoring actions, set to a time-frame with specific responsibility assigned and follow-up actions defined. It contains all the information for the proponent, the contractor and the regulatory agencies to implement the project within a specified timeframe.

The main objectives of this EMAP are:

- To ensure compliance with Funding Agency's applicable safeguard policies, and regulatory requirements of Karnataka and India;
- To formulate avoidance, mitigation measures for anticipated adverse environmental impacts during construction and operation, and ensure that socially acceptable, environmentally sound, sustainable and good practices are adopted; and
- To stipulate monitoring and institutional requirements for ensuring safeguard compliance.

This EMAP consists of a set of mitigation, monitoring and institutional measures to be taken for the project to avoid, minimize and mitigate adverse environmental and social impacts and enhance positive impacts. The plan also includes the actions needed for the implementation of these measures. The major components of the Environmental Management Action Plan are:

- Identification of potential impacts for each environmental components;
- Proposing appropriate mitigation measures which is proven as per local and international standards
- Environmental monitoring and monitoring of EMP implementation during project implementation and operation to mitigate potentially adverse impacts;
- Identification of executing and supervising organization/authority for the proper implementation of proposed mitigation measures.

Identification of potential Impacts with appropriate mitigation measures and roles and responsibilities of the organisations/ authority for Implementation of Environmental Management Action Plan (EMAP) are summarized in **Table 10.2.** Environmental Monitoring Plan (EMoP) for construction and operation phase with other particulars is given in **Table 10.3** and **Table 10.4**. The budget/cost estimate are provided separately in **Table 11.9** under Chapter 11. A typical EMU organization chart is depicted in **Figure 10.4**.

Table 10.2. Environmental Management Action Plan (EMAP)

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
Design Phase								
D.1	Land acquisition, Displacement of people and private property acquisition and related impact on environmentally sensitive areas	Project Corridors - Wherever existing RoW is less than proposed RoW	Alignments are designed to utilise Government and Indian Railway lands to the maximum and to avoid or minimize impacts on private land or properties, in accordance with Land Acquisition Act, 1894 and Rehabilitation and Resettlement Act, 2013 and WB ESS 5 and EIB Standard 6. Accordingly, RAP is prepared including (i) the analysis of number, status, eligibility of PAPs and related mitigation measures following lenders standards, (ii) consultation activities with community members, including discussion of corrective and remedial actions with the PAPs (iii) GRM's availability. EMAP are prepared to minimize, mitigate and control the potential environmental impacts during various project phases.				Design consultant & Special Deputy Commissioner, KRIDE.	PIA, K RIDE
D.2	Change in Land Use and Impact on land	Project Corridors	The compensation for land is detailed in Social Impact Assessment Study Report. Impact on Private land comprises of residential land, commercial land and vacant land. As per RAP notice shall be given in advance to the encroachers (and squatters, if any) present in the Corridor of Impact, who need to be relocated. All R and R activities shall be undertaken as per the relevant acts and also comply with WB's ESS 5 and EIB's ESS 6. Entitlements as per K RIDE entitlement framework shall be completed before the commencement of construction.				Special Deputy Commissioner, KRIDE & PIA, K RIDE.	PIA, K RIDE
D.3	Impact on Forest Land	Akkupete Depot site near Devanahalli	Identification of forest land for Akkupete Depot. Clearing of vegetation at proposed Akkupete depot site shall be undertaken	There are no diversion of forest land in Corridor 2, 3, and 4.			Design consultant & Bengaluru Rural Forest Division	PIA, K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			manually through Bengaluru Rural Forest division as per statutory guidelines laid out under Karnataka Preservation of Tree Act, 1976 and amendments and Forest Conservation Act, 1980. Compensatory afforestation and its maintenance for loss of trees will be undertaken by Bengaluru Rural Forest division as per these above Acts/guidelines. Tree Management Plan is prepared in accordance with the Forest					

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			(Conservation) Act, 1980 and in compliance with WB ESS 6 and EIB Standard 4.					
D.4	Impact on Biological/Ecological Environment	Project Corridors and Depots	Transplantation of trees shall be carried out by the BBMP Forest Wing and Forest Authority in consultation with K RIDE. Tree removal shall be carried out in accordance with the Karnataka Forest Act, 1963 (Karnataka Act 5 of 1964) amended with Karnataka Forest Rules, 1969, The Karnataka Preservation of Trees Act, 1976 and The Karnataka Preservation of Trees (amendment) Act, 2014, Forest Conservation Act 1980 and ESS 6 of World Bank and ESS 4 of EIB. Compensatory afforestation and its maintenance for loss of trees will be undertaken by Bengaluru Rural Forest division as per these above Acts/guidelines. The Forest Department will be responsible for the Afforestation Programme and Tree Maintenance during project implementation.				Bengaluru Rural & Forest division & BBMP	PIA, K RIDE
D.5	Impact on Flora and Aquatic Bodies causing loss of trees and water bodies	Throughout the corridor	Alignments are designed to avoid or minimize impacts and are in line with ESS1 and ESS 6 of World Bank and ESS 1 & 4 of EIB and The Karnataka Preservation of Trees Act, 1976 and amendments and Karnataka Tank Conservation and Development Authority Act, 2014 and amendment Act, 2018.				Design consultant	PIA, K RIDE
D.6	Visual intrusion	Throughout the corridor	Aesthetic structures of viaduct and stations are designed on elevated sections.				Design consultant	PIA, K RIDE
D.7	Impact on Archaeological Monuments	Corridor 1	Corridor 1: Impact on legally protected Archaeological	No Central or State protected Archaeological Monuments or Cultural Heritage sites are present in Corridors 2, 3 and 4.			Design consultant	PIA, K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			Monuments - Devanahalli Fort and Tippu Sultan's Birth Place at Devanahalli, due to proposed alignments. Measures shall be implemented in accordance with ESS 8 of World Bank, EIB ESS 10 and The Ancient Monuments and Archaeological sites and Remains Act, 1958 amended in 2010 (as per the stipulated conditions of ASI).					
D.8	Social Impacts	Project Corridors	The acquisition of land and private properties shall be carried out in accordance with the R & R Plan /RAP and entitlement framework of the Project in accordance with EIB's ESS 6 & WB's ESS 5, Karnataka Industrial Areas Development Act, 1966 (KIADA) and Government of Karnataka Revenue Department resolutions.				Special Deputy Commissioner, K RIDE	PIA, K RIDE
D.9	Project Design	Impact on Natural resource, conservation of water & energy.	Project design should incorporate green building measures such as energy efficient design and optimisation of resources, conservation of water, greening of building, etc., to make the project environmentally sustainable with minimum carbon footprint during its operation. Measures such as using of fly ash bricks and manufactured sand & wood, using locally availably natural materials, solar lighting system, lightings with sensors,				Design consultant	PIA, K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			design with proper ventilation and natural lighting system, reuse of treated water, rainwater harvesting, appropriate waste management components, increasing greening options inside and outside the Station buildings etc.					
Pre-construction Phase (Activities to be carried out by Executing Authority in collaboration with other concerned Govt. Organizations)								
P.1	Information Disclosure	K RIDE's Website, Project site and at certain selected public locations.	EMP/EMoP measures proposed for implementation shall be disclosed to stakeholders; upon feedback, measures shall be revised, if necessary. Information disclosure and consultation/ engagement activities will be done according to the SEP and in compliance with WB ESS 10 and EIB ESS 2. K RIDE has to ascertain that acquisition of land in the post design phase are addressed and integrated into the EMP and relevant contract documents.				PIA, K RIDE	PIA, K RIDE
P.2	Land Acquisition & Displacement and Change in Land Use	Project site	The acquisition of land and private properties shall be carried out in accordance with the R & R Plan /RAP and entitlement framework of the Project in accordance with WB's ESS 5 and EIB's ESS 6, Karnataka Industrial Areas Development Act, 1966 (KIADA) and Government of Karnataka Revenue Department resolutions. As per RAP notice shall be given in advance to the PAP (including encroachers and squatters, etc.,) present in the Corridor of Impact, who need to be relocated. All R and R activities shall be undertaken as per the relevant acts and also comply with WB's ESS 5 and EIB ESS 6. Entitlements as per K RIDE entitlement framework shall be completed before construction starts. It is ensured that no private property will be acquired and no PAPs will be displaced prior to RAP approval.				PIA, K RIDE and Revenue Dept. and collaborating agencies	PIA, K RIDE
P.3	Forest Land Diversion	Project Corridor 1	Diversion of 18.6Ha of forest land for proposed depot at Akkupete, which shall be diverted in compliance with the Forest	There is no diversion of forest land in Corridor 2, 3, and 4.			Bengaluru Rural Forest division	PIA, K RIDE

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			(Conservation) Act, 1980 and in compliance with WB ESS 6 and EIB Standard 4.					
P.4	Impact on Flora - Tree Removal - Loss of trees	Trees along the Project Corridors falling within proposed RoW	Trees shall be removed from the Corridor of Impact before the actual commencement of the work with the permission from the BBMP Forest Wing/state Forest Department. Cutting shall be undertaken only when the implementation of the project in that particular location of cutting is confirmed. This will be in line with Karnataka Preservation of Trees Act, 1976, Forest Conservation Act 1980, Tree Management Plan and ESS 6 of World Bank and EIB's ESS 4.				State Forest Dept./BBMP in consultation with K RIDE	PIA, K RIDE & State Forest Dept.
			Stacking, transport and storage of the wood shall be done as per the relevant norms.					
	Preservation/ Conservation of Flora/ Trees	Project Corridors with green cover and trees present at the toe line of the carriage way and trees of valuable species having ecological value.	All efforts shall be made to preserve/save trees. Specific attention shall be given for protecting large trees, green tunnels and locally important trees (religiously important etc.). Details of the trees affected due to the proposed project corridors are given in (Section 5.9.2 of EIA Report) Tree cutting shall be preceded only after all the legal requirements including attaining of In-principle and Formal Clearances from the Forest Dept. are completed and subsequently a written order is issued to the Implementing Agency. Tree preservation will be line with Karnataka Preservation of Trees Act, 1976, Forest Conservation Act 1980, Tree Management Plan, EIB's ESS 4 and ESS 6 of World Bank.					
			Compensatory afforestation for the tree cut and translocated trees shall be carried out by BBMP forest Wing/ Forest Dept. as per the statutory guidelines of Forest Conservation Act, 1980 and Karnataka Preservation of Trees Act, 1976, Tree Management Plan, EIB's ESS 4 and ESS 6 of World Bank.					

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P.5	Relocation of Community Utilities and Common Property Resources	Throughout the Project corridors	All community utilities and properties i.e. hand pumps, open wells, water supply lines, sewer lines and telephone cables shall be relocated before only when construction of corridor activities commence. Prior approval will be obtained from the concerned authority, before shifting of these community utilities. This will be in line with ESS 10 of World Bank and EIB's ESS 2.				Contractor	PIA, K RIDE (GC during Construction Phase)
P.6	Relocation of affected Cultural and Religious Properties	Throughout the Project corridors at stretches especially nearby settlements	All religious property resources such as shrines, temples and mosques within the project corridor shall be relocated. Total number of cultural properties affected in BSRP corridors is given in the Section 8.3.8. of EIA Report. A list of Common property resources affected due to project corridors are presented as **Table 8.11**. If there is any relocation of the religious structures may happen then it shall be identified in accordance with the choice of the community. K RIDE in consultation with local people shall finalize those. The relocation shall be completed before the construction starts in these sites. This will be in line with ESS 1 & 5 of World Bank and EIB's ESS 1 & 6.				Contractor	PIA, K RIDE (GC during Construction Phase)
P.7	Preliminary Site measures	Throughout the Project corridors	Environment, Health and Safety (EHS) Manual shall be prepared in line with national Regulations, World Bank ESS guidelines 1, 3, & 4 and EIB's ESS 1, 3, & 9.				Contractor	PIA, K RIDE
P.8	Man Power for Environmental Management and Monitoring	Throughout the Project corridors	Institutional requirements I.e., employing Environmental, Health and Safety Experts for implementation of EMP and EMoP shall be executed. This will be in line with ESS 1 of World Bank and EIB's ESS 1.				Contractor	PIA, K RIDE
Pre-Construction Activities (to be carried out by Contractor under supervision of GC)								
P.9	Preventive measures to avoid impacts on Environment	Throughout the Project corridors wherever changes are required	Field Verification and Modification of the Contract Documents - Joint Field verification shall be carried out by the Environmental Specialist of GC and the Contractor to ascertain any possibilities of saving trees, environmental and community resources; which shall be taken up by the construction contractor. Assessment of Impacts due to Changes/Revisions/additions in the Project Work -The Environmental Specialist of GC shall assess impacts and revise/modify the EMP and other				Contractor	Environmental Specialist of GC & PIA, K RIDE

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			required sections of the project document/s in the event of changes/revisions (including addition or deletion) in the project's scope of work. This will be in line with WB ESS 1 to 10 and EIB ESS 1 to 2.					
P.10	Plant establishment	Plant Site/Location - Crushers and Batching Plant's Location	Preventive measures shall be taken up in line with Air (prevention of control of pollution) Act, 1981 and The Noise Pollution (Regulation and Control) Rules, 2000 and WB ESS 1 & 3 and EIB ESS 1 & 3.				Contractor	Environmental Specialist of GC & PIA, K RIDE
			All construction plants shall be sited sufficiently away (500m) from settlements and agricultural operations or any commercial establishments. Such plants shall be located at least 500m away from the nearest dwelling preferably in the downwind direction, if the settlement is too near.					
			The Contractor shall submit a detailed layout plan for all such sites and approval of Environmental Specialist of GC, prior to the establishment and obtain approval. Guidelines and reporting format for siting of Construction Camp is presented as **Annexure 10.2** and **Annexure 10.17** respectively.					
			Arrangements to control dust pollution through provision of windscreens, water sprinklers, and dust extraction systems shall have to be provided at all Plant work sites.					
			Specifications for crushers, hot mix plants and batching plants shall comply with the requirements of the relevant emission control legislations. Consent for the Establishment and Operation from KSPCB shall be obtained before establishment and operation respectively and a copy should be submitted to the GC and K RIDE.					
			In case of water scarcity the Water sprinkling shall be limited to one time in the morning. To balance this deficient information boards shall be erected at appropriate locations with a message "Dust prone area" and required precautions shall be taken care.					
P.11	Usage of Construction Vehicles, Equipment and Machinery	Applicable to all vehicles used in	All vehicles, equipment and machinery to be procured for construction shall confirm to the relevant Bureau of India Standard (BIS) norms. Maintenance of all construction vehicles shall be taken care.				Contractor	Environmental Specialist

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		the construction	Required Mitigation measures shall be undertaken in accordance with Air pollution Control Act, 1981, Noise Rules and Motor Vehicle Act, 1988. The discharge standards promulgated under the Environment Protection Act, 1986 and Motor Vehicles Act, 1988 and WB ESS 3 shall be strictly adhered to.					of GC & PIA, K RIDE
			The silent/quiet equipment available in the market shall be used in the Project.					
			The Contractor shall maintain a record of PUC for all vehicles and machinery used during the contract period which shall be produced to EO, K RIDE's verification whenever required.					
P. 12	Construction Materials							
P.12.1	Construction Materials - Crusher materials	Stone Crusher locations or procurement directly from the supplier	Contractor shall finalize the quarry for procurement of construction materials after assessment of the availability of sufficient quantity of materials, quality and other logistic arrangements or he can directly procure crusher materials from the supplier. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the Indian regulations and WB ESS 1 & 6 and EIB Standard 1 & 4. Contractor shall also work out haul road network and report to Environmental Specialist of GC and GC shall inspect and in turn report to K RIDE before approval.				Contractor	Environmental Specialist of GC & PIA, K RIDE
P.12.2	Construction Materials - Borrow Earth	Borrow Areas	Finalising soil borrowing earth and all logistic arrangements as well as compliance to environmental requirements, as applicable, shall be the sole responsibility of the Contractor and shall be in line with EPA 1986 and ESS 1 & 6 of World Bank and EIB ESS 1 & 4.				Contractor / Environmental Specialist of GC	PIA, K RIDE
			The Contractor shall not start borrowing earth from selected borrow area until the formal agreement is signed between landowner and Contractor and a copy is submitted to the GC.					
			Locations finalized by the Contractor shall be reported to the Environmental Specialist of GC for approval and he/she shall report to K RIDE.					

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			Planning of haul roads for accessing borrows areas shall be undertaken during this stage. The haul roads shall be routed to avoid agricultural areas as far as possible and shall use the existing village roads wherever available.					
			The environmental personnel of the GC shall be required to inspect every borrow area location prior to approval. The GC should include the Request for Inspection form for borrow area approval from the environmental point of view. Guidelines and reporting format for siting, operation and re-development of borrow area is presented as **Annexure 10.4.** Reporting format for borrow area management plan is presented as **Annexure 10.19**.					
P.12.3	Construction Materials - Borrow earth	Borrow Sites	Contractor shall finalize the quarry for procurement of construction materials after assessment of the availability of sufficient quantity of materials, quality and other logistic arrangements. Contractor shall be solely responsible to obtain and maintain all the legal records of approvals, as per the regulations and WB ESS 1 & 6 & EIB ESS 1 & 4.				Contractor	Environmental Specialist of GC & PIA, K RIDE
			Contractor shall also work out haul road network and report to Environmental Specialist of GC and GC shall inspect and in turn report to K RIDE before approval.					
P.12.4	Construction Materials - Sand / M-Sand	Approved Sand Mines or Crusher sites	The Sand shall be procured from approved sand mines. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand. Procurement shall be in compliance with WB ESS 1, 3 & 6 and EIB ESS 1, 3 & 4.				Contractor	Environmental Specialist of GC & PIA, K RIDE
			As a substitute, M-Sand may be used, wherever feasible. The Contractor shall obtain copy of the Lease Agreement of the supplier and submit to GC before procuring the sand.					
P.13	Construction Water Procurement	Project Work Sites	The contractor shall use ground/surface water as a source of water for the construction and may set up own bore well facility for construction work and shall follow stipulations as per the contract document and EPA, 1986. This will be in line with ESS 1, 3 & 6 of World Bank & EIB's ESS 1, 3 & 4.				Contractor	Environmental Specialist

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			To avoid disruption/disturbance to other water users, the Contractor shall extract water from fixed locations and consult Environmental Specialist of GC before finalizing the locations.					of GC & PIA, K RIDE
			The Contractor shall provide a list of locations and type of sources from where water for construction shall be extracted.					
			The Contractor shall need to comply with the requirements of the State Ground Water Department for the extraction and seek their approval for doing so and submit copies of the permission to GC and K RIDE.					
P.14	Pre-casting yards and Material stockpiling	Casting Yards & Storage Areas	Mitigation measures include careful planning, timing of casting operations and storage in casting yards and camps. Pre-casts will be properly stock piled in Cast yards. The Construction materials such as steel, bricks, concrete materials, etc. will be stock piled and stored properly in a fenced or closed Store yard. Precautionary measures shall be taken to reduce and mitigate dust generation at Store and Cast yards. The unwanted or unused balance materials will be removed for use, if required; if not will be disposed properly after the completion of works. The unwanted or unused balance materials, if suitable will be utilized for borrow areas or open pit or trench filling. The activities shall be in line with ESS 1 & 3 of World Bank and EIB ESS 1 & 3.				Contractor	Environmental Specialist of GC & PIA, K RIDE
P.15	Construction Camp Locations – Selection, Design and Layout	Construction Camp	Siting of the construction camps shall be as per the guidelines and details of layout to be approved by GC Resident Engineer and Environment Specialist, shall comply with Occupational Safety and Health Standards, Part 1910.142 and in line with ESS 1, 3 & 6 of World Bank and EIB ESS 1, 3 & 4.				Contractor	Environmental Specialist of GC & PIA, K RIDE
			Construction camps shall not be proposed within 500m from the nearest settlements to avoid conflicts and stress over the infrastructure facilities with the local community.					
			Contractor's camps shall be identified at least 2km away from the Forest Reserves.					

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			Location for stockyards for construction materials shall be identified at least 300m away from watercourses.					
			The Sewage Treatment Plant and solid waste treatment for the camp shall be designed, built and operated. Guidelines and layout for setting-up of Construction Camp is presented as **Annexure 10.2.** And Reporting format for identification and establishment of Construction camp are presented in **Annexure 10.16** and **Annexure 10.17** respectively.					
P.16	Labour Procurement	Throughout Project Corridors and Plant Sites	Labour procurement shall be in accordance with labour laws and Contract Document as per the Child Labour (Prohibition and Regulation) Act, 1986, ILO (C 138 - Minimum Age Convention, 1973 (No. 138), The Factories Act, 1948, The Building and Other Constructions Workers (Regulation of Employment and Conditions of Service) Act, 1996 (BOCW Act, 1996), The Industrial Relations Code 2020, The Code on Social Security 2020, The Occupational Safety, Health and Working Conditions Code, 2020 and The Code on Wages 2019 and in line with ESS 2 of World Bank and EIB ESS 8. The Child Labour is totally prohibited in the project. No child under the age of 18 years (as per ILO standards for hazardous work) shall be employed or permitted to work in any sort of works related to project. Contractor shall not employ, use or benefit from child labour or forced labour. The Contractor shall comply with the minimum age requirements defined under the aforementioned laws and guidelines. Labours employed or engaged in the project works shall be regular monitoring of health, working conditions and working hours. Children shall not be employed informally, even when this is socially or culturally acceptable practice in the sect.				Contractor	Environmental Specialist of GC & PIA, K RIDE

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			For unskilled labour the Contractor shall preferably employ local communities to give maximum benefits to the local community.					
P.17	Provision for Temporary Land	Construction camps and borrow areas	The Contractor as per prevalent rules shall carry out negotiations with the landowners for obtaining their consent for temporary use of lands for construction camp/construction/borrow areas etc. in line with Occupational Safety and Health Standards, Part 1910.142 and WB ESS 6.				Contractor	Environmental Specialist of GC & PIA, K RIDE
P.18	Orientation Training for Implementing Agencies and Contractors	Throughout the project implementation period.	The K RIDE shall organize Orientation Sessions and regular training sessions by engaging third party independent consultant at all stages of the project. This shall include on-site training (general as well as in the specific context of a sub-project). These sessions shall involve all staff of K RIDE involved in the implementation of EMP, Environmental Specialists of GC and Contractors. The training shall be conducted as per EMP and other training plan/s developed by Environmental Specialists of GC/K RIDE.				Contractor	Environmental Specialist of GC & PIA, K RIDE
Construction Phase								
C.1	Site Clearance							
C.1.1	Clearing and Grubbing (C & G)	Throughout the corridor	Vegetation shall be removed from the construction zone before commencement of construction. All works shall be carried out such that the damage or disruption of flora other than those identified for cutting is minimal. Only ground cover/shrubs that impinge directly on the permanent works or necessary temporary works shall be removed with prior approval from the Sr. Environmental Specialist of GC.				Contractor	Environmental Specialist of GC and PIA, K RIDE
C.1.2	Tree Felling/Removal	Throughout the corridor	The Contractor, under any circumstances shall not cut or damage trees and forest reserves. Trees identified under the project shall be cut only after receiving clearance from the BBMP Forest Wing/Forest Dept./DoEF/MoEFCC (as applicable) and after the receipt of K RIDE's written permission in this regard. This will be in line with ESS 1 & 6 of World Bank and EIB ESS 1 & 4.				Contractor	Environmental Specialist of GC and PIA, K RIDE

<table>
<tr><th rowspan="2">Sl. No</th><th rowspan="2">Implementation Activity and Environmental Impact Issue</th><th rowspan="2">Location</th><th colspan="4">Mitigation Measures with Applicable Laws/Acts/Guidelines</th><th rowspan="2">Planning and Executing Organization</th><th rowspan="2">Supervising Authority /Project Proponent</th></tr>
<tr><th>Corridor 1: KSR Bengaluru City – Devanahalli</th><th>Corridor 2 : (Baiyappanahalli - Chikkabanawar)</th><th>Corridor 3: Kengeri - White Field</th><th>Corridor 4: Heelalige - Rajankunte</th></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td><td colspan="4">Vegetation only with girth size of over 30 cm shall be considered as trees and shall be compensated, in the event of K RIDE's instruction to undertake tree cutting.</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>Translocation of trees less than 30cm and trees as suggested by BBMP Forest Wing/Forest Dept. shall be carried out adequately.</td><td colspan="3">Translocation of trees less than 30cm and trees as suggested by BBMP Forest Wing shall be carried out adequately.</td></tr>
<tr><td colspan="4">Compensatory afforestation for the tree cut and translocated trees shall be carried out by BBMP forest Wing/ Forest Dept. as per the statutory guidelines of Forest Conservation Act, 1980 and Karnataka Preservation of Trees Act, 1976. A Tree Management Plan is prepared in line with the State's Tree Act and World banks guidelines and is attached as Annexure 10.44.</td></tr>
<tr><td rowspan="3">C.1.3</td><td rowspan="3">Disposal of Construction Wastes and Debris from dismantling structures and work zones</td><td rowspan="3">Work zones and Disposal sites</td><td colspan="4">Construction Waste and Debris shall be disposed as per Guidelines provided in EMP and complying with the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB and ESS 1 & 3 of World Bank and EIB ESS 1 & 3.</td><td rowspan="3">Contractor</td><td rowspan="3">Environmental Specialist of GC and PIA, K RIDE</td></tr>
<tr><td colspan="4">The pre-identified disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan shall be prepared by the Contractor for disposal of debris in consultation and with approval of Environmental Specialist of CSC. In the case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB.</td></tr>
<tr><td colspan="4">Surplus materials and other debris generated due to dismantling of the existing structures along the corridors shall be suitably reused in the proposed construction zone, subjected to the structure suitability of the materials and approval of the Resident Engineer and Sr. Environmental Specialist of GC as follows:</td></tr>
</table>

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			○ For filling and leveling of School grounds and proposed parking areas.		
			○ Earth from cutting shall be used as embankment fill material.		
			Existing base and sub-base material shall be recycled as sub-base of the haul road or access roads.		
			The existing bitumen road shall be utilized as haulage routes for transportation of materials.		
			The Contractor shall suitably dispose-off unutilized debris materials either through filling up of borrows areas located in wasteland or at pre-designated disposal locations, subject to the approval of the Environmental Specialist of GC.		
			All arrangements for transportation during construction including provision, maintenance, dismantling and clearing debris, shall be considered incidental to the work and shall be planned and implemented by the Contractor as approved and directed by the Environmental Specialist of GC.		
			Reuse and Recycling of materials shall be carried out as follows :		
			○ Segregation and temporary storage of reusable and recyclable materials at identified locations. Transportation of recyclable materials to construction sites.		
			○ Sale of metal scrap and other saleable waste.		
			○ Identification of intended transport means and route.		
			○ Obtaining permission wherever required, for treatment of the hazardous component and its disposal.		
			○ Concrete material shall be broken in to coarse size and reutilized in filling.		
			The pre-designed disposal locations shall be a part of Waste Disposal Plan in consultation and with approval of Environmental Specialist of GC. Debris generated from pile driving or other construction activities shall be disposed such that it does not flow into the nearby surface water bodies or for mud puddles in the area.		

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			The Contractor shall identify dumping sites as per the Debris Disposal Plan prepared using the Guidelines provided in the **Annexure 10.8**; The identified locations shall be reported to the Environmental Specialist of GC. These locations shall be checked on site and accordingly approved by Environmental Specialist of GC prior to any disposal of waste materials. Reporting format for identification and site selection and management of Debris disposal site is presented in **Annexure 10.21** and **Annexure 10.22** respectively.					
C.1.4	Soil erosion and fugitive dust generation	Work zones and Disposal sites	Suitable measures and construction methods shall be implemented as per EHS Plan and in line with WB ESS 3 and EIB ESS 1 & 3.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.					
			The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of temporary berms, temporary mulches, seeding or other methods as necessary to control erosion shall be implemented.					
			Mitigation measures include careful planning, timing of cut and fill operations and re-vegetation in accordance with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 1, 3 and 6 of World Bank. In general, construction works shall be stopped during monsoon season.					
			The pre-identified disposal location shall be part of Comprehensive Waste Disposal Plan Solid Waste Management Plan to be prepared by the Contractor in consultation and with approval of Environmental Specialist of GC.					
			Careful planning, timing of cut and fill operations and re-vegetation shall reduce the Soil Erosion and dust generation. Guidelines for preparation of Comprehensive Waste Management Plan are provided in **Annexure 10.9**. Guidelines on topsoil conservation					

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			and reuse and slope stabilization measures are provided in **Annexure 10.1** and **Annexure 10.3**.					
			Contractor shall dispose the muck/dry soil generated at construction sites at a mutually agreed location by K RIDE and Contractor.					
C.1.5	Muck and other Construction Wastes Disposal	Work zones and Disposal sites	The pre-identified disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan to be prepared by the Contractor in consultation and with approval of Environmental Specialist of GC. In the case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB, also in line with WB ESS 3 and EIB ESS 1 & 3.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			Location of disposal sites shall be finalized prior to initiation of the works on any particular section of the corridor.					
			The Environmental Specialist of GC shall approve these disposal sites after conducting a joint inspection on the site with the Contractor.					
			Contractor shall ensure that any spoils or material unsuitable for embankment fill shall not be disposed-off near any water course or agricultural land, orchards and Natural Habitats like Grasslands. Such spoils from excavation can be used to reclaim borrow pits and low-lying areas located in barren lands along the project corridor (if it so desired by the owner/community and approved by the Environmental Specialist, GC).					
			Non-bituminous wastes shall be dumped in borrow pits covered with a layer of 30cm soil to ensure that borrow pit is restored to original use. No new disposal site shall be created as part of the project, except with prior approval of the Environmental Specialist of GC.					
			All waste materials shall be completely disposed and the site shall be completely cleaned and certified by Environmental Specialist of GC before handing over.					
			Contractor shall carry out the reconciliation for the disposed soil and quantities shall submit to K RIDE on quarterly basis.					

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			Dry wheel wash facilities shall be provided at exit gate, from where soil disposal shall be carried.					
			Sufficient staff shall be made available at site to control the disposal of muck/soil from site such as a supervisor, labors for wheel cleaning; brooms for wheel cleaning and concrete pad where wheels will be cleaned.					
			The dumpers carrying the muck/dry soil has to be covered while plying on the roads on the way to disposal location.					
			Contractor shall take due care that muck generated during piling works does not get contaminated with any contaminant.					
			The onsite muck shall be monitored quarterly at random location during piling works in progress. In case any polluted muck is produced; the muck shall be handled and disposed as per provisions of Hazardous and Other Wastes (Management and Trans boundary Movement) Rules, 2016 and its amendments.					
			Construction and Demolition Waste shall be disposed in accordance with the provisions of C & D waste Handling Rules 2016 and its amendments.					
			The Contractor at his own cost shall resolve any claim, arising out of waste disposal management.					
			Muck Disposal Site Management:					
			• Disposal sites shall be cleaned and then treated so that leached water does not contaminate the Ground Water.					
			• Material will be stock-piled with suitable slopes					
			• Material will be stabilised each day by watering or other accepted dust suppression techniques. The muck shall be filled in the dumping site in layers and compacted mechanically.					
			• Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top and covered with vegetation.					

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
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			Guidelines on muck and debris disposal and site management are provided in **Annexure 10.7** and **Annexure 10.8** respectively. Reporting format on muck and debris disposal and site selection and management are provided in **Annexure 10.22** and **Annexure 10.23**. Guidelines for storage, handling, use and emergency response for Hazardous substance are provided in **Annexure 10.12**.					
C.1.6	Stripping, stocking and preservation of top soil	At all construction material storage areas	The preservation of Top soil shall be in accordance with EPA 1986 and ESS 1 & 6 of World Bank and EIB ESS 1 & 3.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			The topsoil from all areas of cutting and all areas to be permanently covered shall be stripped off to a specified depth of 150 mm and stored in stockpiles. A portion of the temporarily acquired area and/or Right of Way shall be earmarked for storing topsoil. The locations for stock piling shall be pre-identified in consultation and with approval of Environmental Specialist of GC. The following precautionary measures shall be taken to preserve them till they are used:					
			Stockpile shall be designed such that the slope does not exceed 1:2 (Vertical to horizontal), and height of the pile is restricted to 2 m. To retain soil and to allow percolation of water, silt fencing shall protect the edges of the pile.					
			Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum to ensure that no compaction shall occur. The stockpiles shall be covered with gunny bags or vegetation.					
			It shall be ensured by the Contractor that the topsoil shall not be unnecessarily trafficked either before stripping or when in stockpiles.					
			Such stockpiled topsoil shall be utilized for –					
			(a) Covering all disturbed areas including borrow areas, only in case where they are to be rehabilitated.					
			(b) Dressing of slopes of embankment/agricultural fields of farmers acquired temporarily land.					

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			Guidelines on topsoil conservation and reuse and slope stabilization measures are presented in **Annexure 10.1** and **Annexure 10.3** respectively.					
C.1.7	Accessibility	Throughout the project corridor especially at intersections and settlements and schools	The Contractor shall provide safe and convenient passage for vehicles, pedestrians and livestock to and from roadsides and property access, providing temporary connecting roads in compliance with WB ESS 1 & 4 and EIB ESS 1 & 9.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			The Contractor shall also ensure that the existing accesses shall not be undertaken without providing adequate provisions.					
C.1.8	Traffic Management Planning for traffic diversions and detours	Throughout the project corridor especially at intersections and settlements and schools	Detailed Traffic Management Plans shall be prepared by the Contractor incorporating details of temporary diversions, traffic safety arrangements for construction under traffic, details of traffic arrangement after cessation of work each day, safety measures for night time traffic and precaution for transportation of hazardous materials and arrangement of flagmen. The TMP shall be submitted to the Environmental Specialist of GC for approval before 10 days of commencement of works at concerned sites. After review, this TMP shall be approved by Environmental Specialist and Resident Engineer of GC from seven days prior to commencement of works on minor sections of road. If required, the TMP shall be passed on to the PIA to obtain approval and support from the concerned official of the Competent authority such as Regional Transport Office, in Traffic Management at major work sites.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			The contractor shall ensure that the diversion/detour is always maintained in running condition, particularly during the monsoon to avoid disruption to traffic flow.					
			The Contractor shall also inform local community of changes to traffic routes, conditions and pedestrian access arrangements with assistance from GC and K RIDE. The temporary traffic detours shall be kept free of dust by sprinkling of water three times a day and as required under specific conditions (depending on weather conditions, construction in the settlement areas and volume of traffic). This will comply with WB ESS 4 & EIB ESS 9.					

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			Guidelines for Preparation of Traffic Management Plan are provided as **Annexure 10.10**.					
C.2	Procurement of Construction Materials							
C.2.1	Earth from Borrow Areas for Construction	All borrow areas	Procurement of Borrow Earth for construction shall be in compliance with EPA, 1986, IRC 10: 1961, MoEFCC Notifications and WB ESS 1, 3 & 6 and EIB's 1, 3, & 4. No borrow area shall be opened without permission of the Environmental Specialist of GC. The location, shape and size of the designated borrow areas shall be as approved by the Environmental Specialist of GC and in accordance to the IRC recommended practice for borrow pits for road embankments (IRC: 10: 1961). The borrowing operations shall be carried out as specified in the guidelines for siting and operation of borrow areas.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			The unpaved surfaces used for the haulage of borrow materials, if passing through the settlement areas or habitations; shall be maintained dust free by the Contractor. Sprinkling of water shall be carried out twice a day to control dust along such roads during their period of use. During dry seasons (winter and summer) frequency of water sprinkling shall be increased in the settlement areas and Environmental Specialist of GC shall decide the sprinkling time depending on the local requirements.					
			Contractor shall rehabilitate the borrow areas as soon as borrowing of soil is over from a particular borrow area in accordance with the approved Borrow Area Redevelopment Plan. Guidelines on siting, operation, and redevelopment of borrow area is presented in **Annexure 10.4**. Reporting format for borrow area management plan is provided in **10.19**.					
C.2.2	Transporting Construction Materials and Haul Road Management	All roads used for haulage of construction materials	Transportation of Construction Materials and Haul Road Management shall be in line with WB ESS 1, 3 & 6 and EIB's 1, 3, & 4.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			Contractor shall maintain all existing roads, which are used for transporting construction materials, equipment and machineries as précised. All vehicles delivering fine materials to the site shall be covered to avoid spillage of materials.					

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			All existing roads used by vehicles of the Contractor or any of his subcontractor or suppliers of materials and similarly roads, which are part of the works, shall be kept clear of all dust/mud or other extraneous materials dropped by such vehicles.					
			Contractor shall arrange for regular water sprinkling as necessary for dust suppression of all such roads and surfaces.					
C.2.3	Construction Material Management and House Keeping	Construction Camp, Plant Sites and Work Sites	Implementation of the proposed mitigation measures in compliance with Indian Standards and WB ESF guidelines ESS 1, 3 & 6 and EIB's 1, 3, & 4.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			Full height fence, barriers, barricades etc. shall be erected around the site					
			All stairways, passageways and gangways shall be maintained without any blockages or obstructions					
			All surplus earth and debris shall be removed/disposed-off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials, etc. shall be covered while moving.					
			Unused/surplus cables, steel items and steel scrap within the working areas shall be removed to pre-identified locations.					
			All wooden scrap, empty wooden cable drums and other combustible packing materials shall be removed from workplace to identified locations.					
			Empty cement bags and other packaging materials shall be properly stacked and removed.					
			Proper and safe stacking of material is of paramount importance at yards, stores and such locations for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.					
C.2.4	Construction Water	Throughout the project corridor	Procurement of Construction Water shall be carried out by the Contractor in compliance with Environmental Protection Act, 1986, The Water (Prevention and Control of Pollution) Act, 1974 and WB ESS 1, 3 & 4 and EIB's ESS 1, 3, & 9. The quantity required for construction with other details shall be planned properly, linked to the contractor's work plan and the same shall be submitted to the CSC.				Contractor	Environmental Specialist of GC, & PIA, K RIDE

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			Contractor need to implement the finally approved contractors Construction Water Management Plan in accordance with Environmental Protection Act 1986. This is linked to the contractor's work plan.					
			Contractor shall arrange adequate supply and storage of water for the whole construction period at his own cost. The contractor shall submit a list of source/s from where water shall be used for the project to GC and K RIDE.					
			The Contractor shall source the requirement of water preferentially by conjunctive use of Surface water and groundwater but with prior permission from the Groundwater Authority. A copy of the permission shall be submitted to GC and K RIDE prior to initiation of construction. The Contractor shall take all precaution to minimize the wastage of water in the construction process/operation.					
C.3	Measures during Construction Activities							
C.3.1	Drainage and flood control	Construction sites of cross drainage structures	Contractor shall ensure that no construction materials like earth, stone, or appendage disposed-off in a manner that block the flow of water of any water course and cross drainage channels in compliance with WB ESS 1 & 3 and EIB ESS 1 &3.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			Contractor shall take all necessary measures to prevent any blockage to the water flow. In addition to the design requirements, the Contractor shall take all required measures as directed by the Environmental Specialist of GC to prevent temporary or permanent flooding of the site or any adjacent area.					
C.3.2	Control of Siltation of water bodies and degradation of water quality	Construction sites of cross drainage structures	The Contractor shall not excavate beds of any stream/canals/any other water body for borrowing earth for embankment construction in compliance with WB ESS 1& 3 and EIB's ESS 1 &3.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			Contractor shall construct silt fencing at the base of the embankment construction for the entire perimeter of any water body (including springs and wells) adjacent to the project corridor and around the stockpiles at the construction sites including ancillary sites close to water bodies. The fencing shall be provided prior to commencement of					

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			earthwork and continue till the stabilization of the embankment slopes, on the particular section of the project corridor. Typical cross section of Silt trap is presented in **Annexure 10.31**.					
			Contractor shall ensure that construction materials containing fine particles are stored in an enclosure such that sediment-laden water does not drain into nearby watercourse. Guidelines on sediment control measures are provided in **Annexure 10.6.**					
C.3.3	Slope protection and control of soil erosion	At bridge approaches; high embankment sections (Low lying areas) and borrow pits	All temporary sedimentation control works and maintenance thereof shall be deemed as incidental to the earth work or other items of work and as such no separate payment shall be made for them in compliance with WB ESS 1 & 3 and EIB's 1 &3.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			Contractor shall ensure the following aspects:					
			i) After construction of railway embankment, the side slopes shall be covered with grass and shrubs (refer **Annexure 10.3** and **Annexure 10.25**) as per design specifications.					
			ii) Turfing works shall be taken up as soon as possible provided the season is favorable for the establishment of grass sods. Other measures of slope stabilization shall include mulching netting and seeding of batters and drains immediately on completion of earthworks.					
			iii) In borrow pits, the depth shall be so regulated that the sides of the excavation shall have a slope no steeper than 1 vertical to 2 horizontal, from the edge of the final section of the bank.					
			iv) Along sections abutting water bodies, pitching as per design specification shall protect slopes.					
			Guidelines on slope stabilization, sediment control and Embankment/slope protection measures are presented in **Annexure 10.3, Annexure 10.6** and **Annexure 10.25** respectively**.** Typical cross section of Silt trap is presented in **Annexure 10.31**.					
C.4	Environmental Pollution	Monitoring Locations as given in Table	The periodic monitoring of the ambient air quality, noise level, vibration level, water (both ground and surface water) quality, soil quality shall be carried out at the selected locations as suggested in pollution monitoring plan of EMP and shall be in compliance				Contractor	Environmental Specialist

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		10.3 of EIA Report.	with Environmental Protection Act, 1986, The Air (Prevention and Control) Act, 1981, The Water (Prevention and Control) Act, 1976 and The noise pollution (regulation and control) rules, 2000; and with all with Amendments and in compliance with WB ESS 1& 3 and EIB's 1 & 3. Reporting format for pollution monitoring is presented in **Annexure 10.34**.					of GC, & PIA, K RIDE
			Construction Phase Environmental Monitoring cost = ₹ 93.36 Lakhs	Construction Phase Environmental Monitoring cost = ₹ 88.86 Lakhs	Construction Phase Environmental Monitoring cost = ₹ 82.5 Lakhs	Construction Phase Environmental Monitoring cost = ₹ 95.04 Lakh	Contractor	Environmental Specialist of GC, & PIA, K RIDE
C.4.1	Water Pollution Control							
C.4.1.1	Water Pollution from Construction Wastes	At all surface water bodies intercepting with the project corridor (as given in Table 5.10 under Section 5.6.3.1 – Surface Water Quality in EIA Report).	The proposed measures shall be implemented in compliance with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 1& 3 of World Bank and EIB's ESS 1& 3.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			The Contractor shall take all precautionary measures to prevent entering of wastewater into streams, water bodies or the irrigation system during construction.					
			Contractor shall avoid construction works close to the streams or water bodies during monsoon.					
			Contractor shall not wash his vehicles in water body and shall not enter the water body for that purpose.					
			Measures such as sedimentation tanks on site for batching plants shall be implemented.					
			Contractor shall try and reduce the water consumption through use of energy efficient water fixtures at sites and project offices.					
			Leakage of water should not be allowed through pipes and valves.					
			Reuse of water used for curing and for other uses shall be planned.					
			Proper sanitation facilities will be provided at the construction site to prevent health related problems due water contamination					

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			An effective traffic management plan is to be implemented to avoid any accidental spillage of hazardous materials.					
			All the construction and preparatory activities including construction of CD structures will be carried out during dry seasons only.					
			The CD structures should not be drained to the agricultural and horticultural farms or to the immediate vicinity of houses of the locales.					
			The unlined roadside drains in rural stretches carrying storm water will be connected to the nearest natural drainage channel, water bodies with silt traps.					
			The Contractor shall take all precautionary measures to prevent entering of wastewater into streams, water bodies or the irrigation system during construction.					
			Contractor shall avoid construction works close to the streams or water bodies during monsoon. All measures related to water pollution control as mentioned under C. 4.1.2. Water Pollution from Fuel and Lubricants of EMAP table, shall be strictly followed.					
			<u>Rainwater Harvesting Measures :</u> Measures including treatment and reuse of waste water and rain water harvesting to augment ground water shall be implemented. Rainwater harvesting structure shall be constructed at 500m interval along the alignment and at stations and Depot. Typical cross section for rain water harvesting/ground water recharge pit is given as **Annexure 10.32.**					
C.4.1.2	Water Pollution from Fuel and Lubricants	At all surface water bodies intercepting with the project corridor; refueling	The Contractor shall ensure that all construction vehicle parking locations, fuel/lubricants storage sites, vehicle, machinery and equipment maintenance and refueling sites shall be located at least 500 m away from rivers and irrigation canal/ponds. All required measures as presented below shall be undertaken in accordance with 1 & 3 and EIB ESS 1 &3.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			The Contractor shall submit all locations and layout plans of such sites prior to their establishment and shall be approved by the Environmental Specialist of GC.					

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		stations and construction camps (as given in Table 5.10 under Section 5.6.3.1 – Surface Water Quality).	Contractor shall ensure that all vehicle/machinery and equipment operation, maintenance and refuelling shall be carried out in such a manner that spillage of fuels and lubricants does not contaminate the ground.					
			Provision for oil interceptors shall be made at all the construction camps / workshop areas to separate the oil and grease waste generated from servicing of equipment and vehicles used in the construction. Wastewater from vehicle parking, fuel storage areas, workshops, wash down and refuelling areas shall be treated in an oil interceptor before discharging it on land or into surface water bodies or into other treatment system.					
			Overall fuel storage and refuelling areas, if located on agricultural land or areas supporting vegetation, the topsoil shall be stripped, stockpiled and returned after cessation of such storage.					
			Contractor shall arrange for collection, storing and disposal of oily wastes to the pre-identified disposal sites (list to be submitted to GC and K RIDE) and approved by the Environmental Specialist of GC. All spills and collected petroleum wastes shall be disposed-off in accordance with Petroleum Rules and PCB guidelines.					
			Streams at RHS Km 2/610 and 11/850; Gantigunahalli Lake at LHS Km 4/200 and Nellukunte Lake at Km 6/300 and at RHS Km 1/350 Yelahanka Lake and Open Well at Km LHS 12/000. Proper care and measures shall be undertaken as mentioned above	No Lakes or Streams. Open Wells at 4 locations - RHS at km 216/830, Km 217/450, Km 217/600 & Km 218/100 and at LHS Km 217/550 and Borewell with Pump at RHS Km 216/625. Proper care and measures shall be undertaken as	No Lakes or Streams. Bore well at RHS Km 6/820 and Open Well at RHS Km 349/860. Proper care and measures shall be undertaken as mentioned above and in line with Water (Prevention and Control of Pollution) Act,	Lakes along the existing corridor - Huskur Lake at LHS Km 188/600, Panathur Lake at LHS Km 185/800 and Doddanekundi Lake at LHS Km 202/050; Jakkur Lake at RHS Km 12/880 and Yalahanka Lake at RHS Km 17/600.	Contractor	Environmental Specialist of GC, & PIA, K RIDE

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			and in line with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank.	mentioned above and in line with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank.	1974 & its amendments and ESS 3 of World Bank.	Proper care and measures shall be undertaken as mentioned above and in line with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 3 of World Bank.		
			Reporting format for pollution monitoring is presented in **Annexure 10.34**. Typical cross section of silt traps and oil interceptors to control water pollution are presented in **Annexure 10.31** and **Annexure 10.33**.					
			Water Pollution Monitoring :				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			Monitoring locations : Baseline Water Quality monitoring locations, labour camp & other sensitive water bodies as suggested by Envi. Specialist of GC and cost = ₹ 6.72 Lakhs	Monitoring locations : Baseline Water Quality monitoring locations, labour camp & other sensitive water bodies as suggested by Envi. Specialist of GC and cost = ₹ 7.56 Lakhs	Monitoring locations : Baseline Water Quality monitoring locations, labour camp & other sensitive water bodies as suggested by Envi. Specialist of GC	Monitoring locations : Baseline Water Quality monitoring locations, labour camp & other sensitive water bodies as suggested by Envi. Specialist of GC and cost = ₹ 8.4 Lakhs		

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					and cost = ₹ 6.72 Lakhs			
			Rainwater Harvesting Measures :					
			Measures including treatment and reuse of waste water and rain water harvesting to augment ground water shall be implemented. Rainwater harvesting structure shall be constructed at 500m interval along the alignment and at stations and Depot. Typical cross section for rain water harvesting/ground water recharge pit is given as **Annexure 10.32.**					
			No. of RWH Locations = 100	No. of RWH Locations = 65	No. of RWH Locations = 51	No. of RWH Locations = 114		
			Cost = ₹ 94.7 Lakhs (@ ₹ 0.947 lakh/Unit)	Cost = ₹ 61.56 Lakhs (@ ₹ ₹ 0.947 lakh/Unit)	Cost = ₹ 48.30 Lakhs (@ ₹ 0.947 lakh/Unit)	Cost = ₹ 108.4 Lakhs (@ ₹ 0.947 lakh/Unit)		
			Oil Interceptor with Silt trap at Workshop - washing area - Capacity 50L (24” X 16” X 12”), 18 Gauge					
			One unit at each construction camp Cost = ₹ 0.15 Lakhs	One unit at each construction camp Cost = ₹ 0.15 Lakhs	One unit at each construction camp Cost = ₹ 0.15 Lakhs	One unit at each construction camp Cost = ₹ 0.15 Lakhs		
C.4.2	Air Pollution Control							
C.4.2.1	Dust Pollution	Construction sites and construction establishment such as batching plants, Stone crushers as given in Table	The proposed measures shall be implemented in compliance with The Air (Prevention and Control of Pollution) Act, 1981 & its amendments and ESS 1 & 3 of World Bank and EIB’s ESS 1 & 3.				Contractor	Environmental Specialist of GC, & PIA, K RIDE through Engineer
			The Contractor shall take every precaution to reduce the level of dust from construction plants, construction sites involving earthwork by sprinkling of water, encapsulation of dust source.					
			The Contractor shall take all mandatory precautions to minimise fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste					

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		10.3 of EIA Report.	and from processes such as pneumatic filling of silos, transportation by road, drilling and blasting, crushing, screening, bulk/bag unloading, etc.					
			The Contractor shall not allow emissions of fugitive dust from any transport during handling of materials, construction or storage activity. The emission should not remain visible in atmosphere beyond the property line of emission source for any prolonged period of time.					
			The Contractor shall use cover for materials of dust generating like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free-board to reduce spills and avoid fugitive dust.					
			Contractor shall install barriers around the open construction sites before commencing the work.					
			The temporary dumping areas shall be maintained by the Contractor at all times until excavated materials are reutilized for backfilling wherever necessary or as directed by Employer. Dust control activities shall continue even during any work stoppage.					
			The Contractor shall place material in a manner that will minimize dust production. Material shall be wetted each day, to minimize dust production. During dry weather, dust control measures must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.					
			The Contractor shall sprinkle water at construction sites to suppress dust, during handling of excavation soil or debris or during demolition.					
			The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use.					
			Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.					
			In case of water scarcity in certain areas or periods, Contractor may limit water sprinkling once in the early morning hours and should erect warning boards on dust nuisance to the road users and limit the dust emanating activities.					

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			The concentration of suspended particulate matter at a distance of 40m from a construction plant located in a cluster of industries should be less than 500 µg. The environmental monitoring is to be conducted as per the monitoring plan.					
			Alternatively, only crushers licensed by the KSPCB shall be used. The Environmental Specialist, EO and K RIDE through the Engineer shall submit required certificates and consents.					
C.4.2.2	Emission from Construction Vehicles, Equipment and Machineries	Construction sites and construction establishment such as batching plants, Stone crushers as given in Table 10.3 of EIA Report.	Contractor shall ensure that all vehicles, equipment and machinery used for construction are regularly maintained and confirm that pollution emission standards and comply with the relevant statutory requirements of CPCB such as The Air (prevention and control of pollution) Act, 1981 and EPA, 1986 and/Motor Vehicles Rules 2000 with amendments and WB ESS 1 & 3 and EIB's ESS 1 & 3.				Contractor	Environmental Specialist of GC, & PIA, K RIDE
			The Contractor shall procure the Standard construction plants, equipment and machinery, which shall conform to the pollution control norms specified by MoEFCC/CPCB/KSPCB.					
			He shall maintain evidence of design and equipment to make these available for inspection by Employer.					
			Contractor shall ensure that all vehicles, equipment and machinery procured for construction are regularly maintained and confirm that pollution emission standards and comply with the relevant statutory requirements of CPCB such as The Air (prevention and control of pollution) Act, 1981 and EPA, 1986 and/Motor Vehicles Rules 2000 with amendments and WB ESS 1 & 3 and EIB's ESS 1 & 3.					
			The Contractor shall properly maintain and periodically check all construction / haulage vehicles, machinery and Equipment so as to comply emission in accordance with National Ambient Air Quality Standards stipulated by Statutory Agencies of Government of India or the State Government from time to time.					
			Stack height of equipment/ Plants and D. G. sets at plant site should conform to KSPCB Standards.					

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.					
			The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction Depot and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.					
			The Contractor shall submit PUC certificates for all vehicles/equipment/machinery used for the Project.					
			Air Pollution Monitoring:					
			Monitoring locations at baseline Air Quality monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 28.8 Lakhs	Monitoring locations at baseline Air Quality monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 25.2 Lakhs	Monitoring locations at baseline Air Quality monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 21.6 Lakhs	Monitoring locations at baseline Air Quality monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 28.8 Lakhs	Contractor	Environmental Specialist of GC, & PIA, K RIDE
			Reporting format for pollution monitoring is presented in **Annexure 10.34**. Reporting format for details of Batching plant is given in **Annexure 10.15**.					
C.4.3	Noise Pollution Control							

<table>
<tr><th rowspan="2">Sl. No</th><th rowspan="2">Implementation Activity and Environmental Impact Issue</th><th rowspan="2">Location</th><th colspan="4">Mitigation Measures with Applicable Laws/Acts/Guidelines</th><th rowspan="2">Planning and Executing Organization</th><th rowspan="2">Supervising Authority /Project Proponent</th></tr>
<tr><th>Corridor 1: KSR Bengaluru City – Devanahalli</th><th>Corridor 2 : (Baiyappanahalli - Chikkabanawar)</th><th>Corridor 3: Kengeri - White Field</th><th>Corridor 4: Heelalige - Rajankunte</th></tr>
<tr><td rowspan="12">C.4.3.1</td><td rowspan="12">Noise Pollution: Noise from Vehicles, Plants and Equipment</td><td rowspan="12">Throughout the project corridor and other construction establishments as given in Table 10.3 of EIA Report.</td><td colspan="4">All construction activities will have to comply with Noise Pollution (Regulation and Control) Rules, 2000 & amendments and ESS 1& 3 of World Bank and EIB's ESS 1 & 3. Night time work could require a variance for local noise regulations.</td><td rowspan="12">Contractor</td><td rowspan="12">Environmental Specialist of GC, & PIA, K RIDE</td></tr>
<tr><td colspan="4"><u>Source Control</u> : Each internal combustion engine used for any purpose on the project or related to the project will be equipped with a muffler of a type recommended by the manufacturer. No internal combustion engine will be operated without a muffler.</td></tr>
<tr><td colspan="4">All Construction plants and equipment used in construction shall strictly conform to the MoEFCC/CPCB noise standards.</td></tr>
<tr><td colspan="4">All Vehicles and equipment used in construction shall be fitted with exhaust silencers.</td></tr>
<tr><td colspan="4">Construction of permanent and temporary noise barriers; and natural and artificial barriers could be considered for use as shielding against construction noise. Strategic placement of stationary equipment, such as compressors and generators, could reduce effects at sensitive receivers.</td></tr>
<tr><td colspan="4">A main source of noise shall be controlled by Re-routing and regulating the traffic,</td></tr>
<tr><td colspan="4">Electric equipment shall be used instead of diesel powered equipment,</td></tr>
<tr><td colspan="4">Hydraulic tools shall be used instead of pneumatic tools,</td></tr>
<tr><td colspan="4"><u>Provision of acoustic enclosures</u> : Acoustic enclosures shall be provided for individual noise generating construction equipment. Special acoustic enclosures should be provided for individual noise generating equipment, wherever possible. Workers in those sections where periodic adjustment of equipment/machinery is necessary, shall be provided with sound proof control rooms so that exposure to higher noise level is reduced.</td></tr>
<tr><td colspan="4">Scheduling of truck loading, unloading and hauling operation,</td></tr>
<tr><td colspan="4">In Loading and un-loading areas with machinery noise muffles, etc. and personal protective gear shall be provided to workers.</td></tr>
</table>

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			Maintenance of vehicles, equipment and machinery shall be regular and up to the satisfaction of the Environmental Specialist of GC to keep noise levels at the minimum. Proper operation and maintenance of the construction vehicles and equipment would keep them within noise limit,					
			Servicing of all construction vehicles and machinery shall be done regularly and during routine servicing operations, the effectiveness of exhaust silencers shall be checked and if found defective shall be replaced,					
			Job rotation - Shifting of workers to the extent possible from high noise level area to low noise level areas and vice-versa from time to time avoid the workers to get impacted due to continuous exposure to high level noise,					
			Scheduling work to avoid simultaneous activities,					
			Automation of equipment and machineries - Wherever possible the Automation of equipment and machineries shall be applied to avoid continuous exposure of workers to noise. If automation of machineries is not possible or feasible, then the workers exposed to noise shall be provided with protective devices.					
			Related Noise Control Measures – The following noise control measures shall be undertaken:					
			• Use of Anti-drumming floor and noise absorption material,					
			• Use of Low speed compressor, blower and air conditioner,					
			• Mounting of under frame equipment on anti-vibration pad,					
			• Provision of Smooth and gradual control of door,					
			• Provision of GRP baffle on the via-duct for elimination of noise transmission,					
			• Provision of sound absorbing material in the supply duct and return grill of air conditioner,					

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			• Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes,					
			Noise reduction from various sources - The noise reduction from various sources is possible with the following effective measures during the construction period:					
			The noise from air compressor can be reduced by fitting exhaust and intake mufflers.					
			Noise proof barriers will be provided on the construction boundary near the residential area.					
			Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds.					
			Alternate Construction Methods – During pile driving activity increase in noise levels is anticipated even when noise mitigation measures are implemented, however, noise levels will be within acceptable limits. During these activities, alternate methods of construction may be applied to reduce noise Risks and Impacts. Vibratory or hydraulic insertion may be used for pile driving, depending on a variety of factors. Drilling holes for cast-in-place piles is an alternative construction method that may produce significantly lower level noise.					
			Management of Time Schedule and Activity Constraints - Noisier activities involving large machinery will be limited to daytime hours as practical, when most people normally get affected are either not present or engaged in less noise-sensitive activities. Night time construction will require a variance. Compliance with local noise ordinances would mitigate effects associated with construction noise. To comply with these ordinances, all construction activities adjacent to residential uses will be limited to day time hours (7:00 A.M. to 6:00 P.M.) from Monday to Saturday.					

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			The contractor shall comply with standard specifications and all local sound control and noise level rules, regulations, and ordinances that apply to any work performed pursuant to the contract.					
			At the construction sites within 150 m of the nearest habitation, noisy construction work such as crushing, operation of DG sets, use of high noise generation equipment shall be stopped during the night time between 10.00 pm to 6.00 am. Working hours of the construction activities shall be restricted around educational institutions/Health Centers (silent zones) up to a distance of 100 m from the sensitive receptors i.e., School, Health Centers and Hospitals etc.					
			Contractor shall provide noise barriers to the suggested locations of educational Institutions & health centers. List of locations for noise barriers is given in Table 8.43 of Section 8.6.1.1 of EIA Report. Guidelines for provision of Noise Barrier are provided as **Annexure 10. 14.**					
			Noise Barrier proposed for a length of - 545-- m (₹ 0.2 Lakh/meter) and the cost will be ₹ 109 Lakhs.	Noise Barrier proposed for a length of --1161-- m (₹ 0.2 Lakh/meter) and the cost will be ₹ 232.2 Lakhs.	Noise Barrier proposed for a length of --937-- m (₹ 0.2 Lakh/meter) and the cost will be ₹ 187.4 Lakhs.	Noise Barrier proposed for a length of --415-- m (₹ 0.2 Lakh/meter) and the cost will be ₹ 83.00 Lakhs.		
			Noise monitoring shall be carried out at the locations specified in monitoring plan by the K RIDE and the Engineer through the approved monitoring agency. Reporting format for pollution monitoring is presented in **Annexure 10.34**.					
			Monitoring locations at baseline Noise level monitoring locations, labour	Monitoring locations at baseline Noise level monitoring locations, labour	Monitoring locations at baseline Noise level monitoring	Monitoring locations at baseline Noise level monitoring	Contractor	Environmental Specialist

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
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			camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 9 Lakhs	camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 6.3 Lakhs	locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 6.3 Lakhs	locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 9 Lakhs		of GC and PIA, K RIDE
C.4.4	Vibration Control	Work sites near Sensitive Receptors (Table 8.43 under Section 8.6.1.2 Noise Impact on Sensitive Receptors).	Vibration monitoring and building condition surveys at sensitive structures shall be carried out as per regulations and Guidelines; and in line with WB ESS 1& 3 and EIB's ESS 1& 3.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			Preparation and implementation of a Vibration mitigation plan will be prepared by the contractor incorporating all required mitigation measures mentioned under Vibration Mitigation Measures and Scheme for Vibration Mitigation Plan in the section 8.5.12.2 of Chapter 8 of EIA Report and as per codes of practice during construction phase of the project. Following measures shall be incorporated in the mitigation Plan and implemented during construction :					
			Routing heavily-loaded trucks away from residential and sensitive areas,					
			Operation of earth-moving equipment on the construction site as far away from vibration - sensitive sites as possible,					
			Phase demolition, earth-moving and ground-impacting operations so as not to occur in the same time period. The total vibration level produced could be significantly less when each vibration source operates separately,					
			Avoidance of night time construction activities near residential and sensitive areas,					
			Avoidance of impact pile-driving where possible in vibration-sensitive areas,					

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			Avoidance of vibratory rollers near sensitive areas.					
			Vibration Monitoring shall be carried out at the locations specified in monitoring plan by the K RIDE and the Engineer through the approved monitoring agency. Reporting format for vibration monitoring presented as **Annexure 10.35.**					
			Monitoring locations: Baseline Vibration monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 43.2 Lakhs	Monitoring locations: Baseline Vibration monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 43.2 Lakhs	Monitoring locations: Baseline Vibration monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 43.2 Lakhs	Monitoring locations: Baseline Vibration monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 43.2 Lakhs		
C.4.5	Soil pollution Control	Work sites, Plant sites and Construction Camps	The measures proposed to prevent ingress of toxic / heavy metals shall be implemented. Measures to mitigate the Soil Erosion and dust generation include careful planning, timing of cut and fill operations and re-vegetation in accordance with Water (Prevention and Control of Pollution) Act, 1974 & its amendments and ESS 1, 3 and 6 of World Bank and EIB Standards 1 & 3. In general, construction works shall be stopped during monsoon season.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			Top soil preservation : As far as practicable, top soil removed from the construction sites will be used for construction of embankment to enhance growth of vegetation on the embankment surface and its consolidation. Besides, adequate temporary or					

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			permanent drainages are planned to be provided before slope construction begins with lagoons to allow silt to settle out. As for the borrow areas, appropriate measures for the management of borrow areas will be taken. Top soils of the borrow pit sites will be conserved and restored after excavation is over.					
			Suitable storage area for such materials shall be prepared and equipment shall be made available for handling of these materials.					
			Contractor shall take all necessary precautions such that construction material, diesel, grease, waste oil, chemicals etc. does not spill on ground.					
			The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures. It is suggested to utilize Ready Mix Concrete (RMC) at site directly from batching plant to avoid spillage. The Construction materials such as steel, bricks, etc. will be stored in a fenced stored yard. The unwanted or unused balance materials will be removed for use, if required; if not will be disposed after the completion of works. The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of temporary berms, temporary mulches, seeding or other methods as necessary to control erosion shall be implemented. The pre-identified disposal location shall be part of Comprehensive Solid Waste Disposal Plan which may be revised by the Contractor in consultation and with approval of Environmental Specialist of GC, if any variation is observed at identified disposal sites. Guidelines shall be followed as per Comprehensive Solid Waste Management Plan are provided in **Annexure 10.9**. Guidelines on topsoil conservation and reuse and slope stabilization measures are provided in **Annexure 10.1** and **Annexure 10.3**.					

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			Regular monitoring of groundwater and soil leachate shall be conducted at muck disposal areas where possibility of ground water contamination is anticipated. Reporting format for pollution monitoring is presented in **Annexure 10.34**.					
			Monitoring locations at baseline Soil Quality monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 3.84 Lakhs	Monitoring locations at baseline Soil Quality monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 4.8 Lakhs	Monitoring locations at baseline Soil Quality monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 2.88 Lakhs	Monitoring locations at baseline Soil Quality monitoring locations, labour camp, construction site & other sensitive locations as suggested by Envi. Specialist of GC and cost = ₹ 3.84 Lakhs	Contractor	Environmental Specialist of GC, & PIA, K RIDE
C.5	Solid waste disposal from construction activities	Work sites, Plant sites and Construction Camps	The contractor shall prepare the comprehensive waste management plan in line with the provisions of Hazardous and other wastes (management and trans boundary movement) rules 2016 and its amendments and ESS 1&3 of World Bank, EIB's ESS 1&3 and submit to the Project Authority for concurrence.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			Contractor shall ensure that hazardous wastes are labeled, recorded, stored in impermeable containment and for periods not exceeding mandated periods and in a manner suitable for handling storage and transport.					
			The contractor shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection.					

<table>
<tr><th rowspan="2">Sl. No</th><th rowspan="2">Implementation Activity and Environmental Impact Issue</th><th rowspan="2">Location</th><th colspan="4">Mitigation Measures with Applicable Laws/Acts/Guidelines</th><th rowspan="2">Planning and Executing Organization</th><th rowspan="2">Supervising Authority /Project Proponent</th></tr>
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<tr><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td><td colspan="4">Contractor shall dispose-off nonhazardous solid wastes, non-hazardous liquid wastes, and biomedical wastes as per the provisions of Hazardous and other wastes (management and trans boundary movement) rules 2016 and its amendments, EHS guidelines and WB ESS 1& 3 and EIB's ESS 1 & 3.</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td colspan="4">The contractor shall approach only Authorized Recyclers for treatment and disposal of Hazardous Waste, under intimation to the Project Authority.</td></tr>
<tr><td colspan="4">If required, the treatment and disposal sites will be identified by the K RIDE in consultation with KSPCB such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. Applicable EHS guidelines shall be followed during Hazardous Material Management.</td></tr>
<tr><td colspan="4">Guidelines for preparation muck disposal & site management, debris disposal & site management and comprehensive waste management plan are presented in Annexure 10.7, Annexure 10.8 and Annexure 10.9. Reporting format for identification, site selection and management of Muck and Debris disposal sites are presented in Annexure 10.21, Annexure 10.22 and Annexure 10.23.</td></tr>
<tr><td>C.6</td><td>Occupational Safety</td><td></td><td colspan="4"></td><td></td><td></td></tr>
<tr><td rowspan="5">C.6.1</td><td rowspan="5">Personal Safety Measures for Workers</td><td rowspan="5">Throughout the project corridor and construction phase of the project</td><td colspan="4">Contractor shall provide safety to working personnel complying with EIA report, WB ESS 1& 4 and EIB's ESS 1 & 9. The Contractor Shall confirm the following personnel safety during construction:</td><td rowspan="5">Contractor</td><td rowspan="5">Environmental Specialist of GC and PIA, K RIDE</td></tr>
<tr><td colspan="4">i) Protective footwear, protective goggles and nose masks to the workers employed in asphalt works, concrete works, crusher etc.</td></tr>
<tr><td colspan="4">ii) Welder's protective eye-shields to workers who are engaged in welding works</td></tr>
<tr><td colspan="4">iii) Earplugs to workers exposed to loud noise, and workers working in crushing or compaction</td></tr>
<tr><td colspan="4">iv) The Contractor shall comply with all regulations regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress.</td></tr>
</table>

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
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			v) Contractor shall provide the adequate personal protection equipment for the workers working with height, heavy electric equipment and working along existing Indian Railway alignment.					
			The Contractor shall comply with all the precautions as required for ensuring the safety of the workmen as per the International Labour Organization (ILO) Convention No. 62 as far as those are applicable to this contract.					
			The Contractor shall make sure that during the construction work all relevant provisions of Building and other Construction Workers (regulation of Employment and Conditions of Services) Act, 1996 are adhered to.					
			The Contractor shall not employ any person below the age of 18 years (as per ILO's stipulations for hazardous work) for any work and no woman shall be employed on the work of painting with products containing lead in any form.					
			The Contractor shall also ensure that paint containing lead or lead products is used except in the form of paste or readymade paint.					
			Periodical (Monthly/Quarterly) Safety Audits shall be carried out by the Contractor and the Audit report shall be submitted to GC.					
			The Contractor shall follow the Guidelines to ensure worker safety during construction as presented in **Annexure 10.11.** Periodically contractor should report the workers safety to GC Environmental Specialist using Reporting format for Safety checklist and project safety measure are presented in **Annexure 10.26** and **Annexure 10.27.**					
C.7	Community Health and Workers Safety	Throughout the project corridor especially at work sites, intersections and settlements	Contractor shall provide community safety which shall be included in Traffic and Safety Management Plan prepared in compliance with EHS guidelines and WB ESS 1 & 4 and EIB ESS 1 & 9. Periodical (Monthly/Quarterly) Safety Audits shall be carried out by the Contractor and the Audit report shall be submitted to GC.				Contractor	Environmental Specialist of GC and PIA, K RIDE

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C.7.1	Traffic Management and Pedestrian / Road Users' Safety	Construction sites, intersections and settlements	Traffic Management and Engineering measures like traffic segregation, one-way movements, traffic diversions, acquisition of service lanes, etc. shall be implemented in compliance with the Traffic Management Plan and Indian Standards and WB ESS 4 and EIB's ESS 9 guidelines for the safety of pedestrians and other road users. The Contractor shall take all necessary measures for the safety of traffic during construction and provide erect and maintain such barricades, including safety signage - warning/Caution signage, information signage in advance of the work sites; markings, flags, lights and flagmen as proposed in the Traffic Management Plan with Drawings and as required by the Environmental Specialist of GC for the information and protection on traffic approaching or passing through the section of any existing cross roads. The Contractor shall ensure that all signs, retro-reflectors, barricades, pavement markings are provided as per the guidelines. Before taking up of construction on any section of the existing lanes of the intersection roads, a Traffic Management Plan shall be devised and implemented to the satisfaction of the Environmental Specialist of GC. Guidelines for preparation of Traffic Management Plan are provided as **Annexure 10.10.**				Contractor	Environmental Specialist of GC and PIA, K RIDE
C.7.2	Access to adjacent public properties	Construction sites	Temporary ramps, makeshift pathways, temporary mobile foot over bridges, etc., should be provided to facilitate easy access to adjacent buildings and shops. Special consideration shall be given in the local traffic management to the safety of pedestrians. The temporary traffic arrangement should be kept free of encroachments / commercial activities. This should be undertaken in compliance with WB's ESS 4. Contractor shall at all times during construction, make available, at least pedestrian access to adjacent properties so as not to obstruct the ingress and egress from the neighbouring houses and commercial and other buildings. This will be a part of Traffic Management Plan. This should be undertaken in compliance with WB's ESS 4 and EIB ESS 9.				Contractor	Environmental Specialist of GC and K RIDE
C.7.3	Electrical Safety	Construction sites, Plant	The Contractor shall take all required precautions to prevent danger from electrical equipment in line with WB's ESS 4 and EIB's ESS 9, and ensure that –				Contractor	Environmental

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		sites, Labour camp and storage areas	a) No material shall be so stacked or placed as to cause danger or inconvenience to any person or the public.					Specialist of GC and PIA, K RIDE
			b) All necessary fencing and lights shall be provided to protect the public in construction zones.					
			c) All machines to be used in the construction shall conform to the relevant Indian Standards (IS) codes, shall be free from patent defect, shall be kept in good working order, shall be regularly inspected and properly maintained as per IS provision and to the satisfaction of the Environmental Specialist of GC.					
			d) Contractor shall provide the adequate personal protection equipment for the workers working with height and heavy electric equipment					
C.7.4	Fire Safety	Construction sites, Plant sites and Labour camp	The Contractor shall implement required preventive measures for Fire safety as per The Karnataka Fire Force Act, 1964 and Indian Fire Safety Requirements, complying with WB ESS 4 and EIB's ESS 9.				Contractor	Environmental Specialist of GC and K RIDE
			The Contractor shall provide Fire Extinguishers at Plant sites and Construction Camps. The Contractor shall organize Training and Mock Drill for Workers, Technical and Non-technical persons involved in the project. Guidelines to ensure workers safety is presented in **Annexure 10.11.**					
C.7.5	Risk force measure	Throughout the construction phase	Contractor shall take all reasonable precautions to prevent danger to the workers and public from fire, flood, etc. resulting due to construction activities in line with WB's ESS 2 & 4 and EIB's ESS 8 & 9.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			Contractor shall make required arrangements so that in case of any mishap all necessary steps can be taken for prompt first aid treatment. Construction Safety Plan prepared by the Contractor shall identify necessary actions in the event of an emergency. Guidelines to ensure worker's safety during construction are provided as **Annexure 10.11.** Contractor shall prepare reports on workers safety, project safety measures, accident report, workers health check-up and workshop/awareness programme on Workers					

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			health/AIDS/COVID using reporting formats presented as **Annexure 10.26, Annexure 10.27, Annexure 10.28, Annexure 10.29** and **Annexure 10.30** respectively**.**					
C.7.6	Informatory Signs and Hoardings	Construction sites and construction establishments	The Contractor shall provide, erect and maintain informatory/safety signs, hoardings written in English and local language (Kannada), wherever required or as suggested by the Environmental Specialist of GC and in compliance with WB ESS 2 & 4 and EIB ESS 8 & 9.				Contractor	Environmental Specialist of GC and PIA, K RIDE
C.7.7	Incident/Accident/Risk/ Disaster Management	Risk/Accident areas	Disaster Management Plan and Emergency Response Plan shall be revised as per requirement and reported as per reporting formats. Preventive measures shall be adopted to avoid reoccurrence of the incident. In addition the Contractor shall report the Accident occurred referring to Reporting format presented in **Annexure 10.28**. This is in line with WB ESS 2 & 4 and EIB ESS 8 & 9.				Contractor	Environmental Specialist of GC and PIA, K RIDE
	Emergency Response - First Aid Facilities and Transport to Hospital	Construction sites; labour camps and construction establishments	Emergency Response Plan shall be revised as required and implemented. The Contractor shall arrange immediately for –					
			• Readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules.					
			• Suitable transport at all times to take injured to the nearest hospital.					
			• Equipment and trained nursing staff to attend the injured person.					
			The Contractor shall prepare the Accident report referring to Reporting format presented in **Annexure 10.28.** Periodical (Monthly/Quarterly) Safety Audits shall be carried out by the Contractor and the Audit report shall be submitted to GC.					
C.8	Construction/Labour Camp Management							
C.8.1	Accommodation	Labour camps	Contractor shall follow all relevant provisions of the Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act, 1996 and Factories Act, 1948 and amended in 1987, International Labour Standards (ILO), as per IFC's				Contractor	Environmental Specialist

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			Workers accommodation procedures (**as given Annexure 10.20.)** and WB ESS 2 & 4 and EIB's ESS 8 & 9 for construction and maintenance of labour camp.					of GC and PIA, K RIDE
			The location, layout and basic facility provision of each labour camp shall be submitted to GC and K RIDE prior to their construction.					
			The Construction shall commence only upon the written approval of the Environmental Specialist of GC.					
			Shelter at Workplace: At every workplace, shelter shall be provided free of cost, separately for use of men and women labourers. The height of shelter shall not be less than 3m from floor level to lowest part of the roof. Shelters shall be with adequate illumination and ventilation and the space provided shall be on the basis of at least 0.5m2 per head. Sufficient number of mosquito nets shall be provided. Housekeeping and hygiene are monitored by the Contractor.					
			Canteen Facilities : A cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered necessary. Usage of Fire Wood for cooking or any other purpose shall be totally avoided to prevent CO_2 emission.					
			Conveyance : Free and adequate transport facilities shall be provided for all workers employed by the Contractor and residing at base camp to construction sites and Back.					
			The Contractor shall maintain necessary living accommodation and ancillary facilities in functional and hygienic manner and as approved by the Sr. Environmental Specialist, GC.					
C.8.2	Provision for Potable Water	Construction site and Labour camp	The Contractor shall construct and maintain all labour accommodation in such a fashion that potable water is available for drinking, cooking and washing.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			The Contractor shall also provide potable water facilities within the premises of every camp at an accessible place, as per standards set by the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and as per IFC's workers accommodation procedures (**as given Annexure 10.20.)** also in line with WB ESS 3 and EIB ESS 3.					

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			The Contractor shall also guarantee the following:					
			a) Supply of sufficient quantity of Potable Water (as per IS) in every workplace/labour camp (Site at suitable and easily accessible places and regular maintenance of such facilities.					
			b) If any water storage tank is provided that shall be kept such that the bottom of the tank at least 1 m above the surrounding ground level.					
			c) If water is drawn from any existing well, which is within 30 m proximity of any toilet, drain or other source of pollution, the well shall be disinfected before water is used for drinking.					
			d) All such wells shall be entirely covered and provided with a trap door, which shall be dust proof and water proof.					
			e) A reliable pump shall be fitted to each covered well. The trap door shall be kept locked and opened only for cleaning or inspection, which shall be done at least once in a month.					
			f) Analysis of water shall be done every month as per parameters prescribed in IS 10500-1991. Water quality testing shall be carried out as per the guidelines provided in Environmental Monitoring plan is presented in section 10.10 of EIA Report and reporting format for recording results is given in **Annexure 10.39.**					
			Environmental Specialist of GC shall be required to inspect the labour camp once in a week to ensure the compliance of the EMP.					
C.8.3	Sanitation and Sewage System	Labour camps	The Contractor shall implement proper sanitation and sewage system in accordance with the Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act, 1996 and Factories Act, 1948 and amended in 1987, also in line with WB ESS 1 & 3 and EIB ESS 1 & 3.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			a) The Sewage system for the camp shall be designed, built and operated in such a manner that no health hazards occurs and no pollution to the air, ground water or adjacent water courses take place.					

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			b) Separate and adequate toilets/urinals and wash room Facilities shall be provided at Base Camp for Workers, separate for men and women (marked in vernacular). Cleaning/washing and bathing places shall be provided. Separate and adequate toilets and bathrooms, wherever required, shall be provided for men and women.					
			c) Adequate water supply shall be provided in all toilets and urinals; and wash rooms/bath rooms.					
			d) Drains for waste water shall be provided for the flow of used water outside the camp. Drains and ditches shall be treated on a regular basis.					
			e) Wastewater shall be discharged to the existing sewage network or will be disposed-off in septic tank and soak pit.					
			f) Night soil can be disposed of with the help of local municipal extractor or disposed of by putting layer of it at the bottom of a permanent tank prepared for the purpose and covered with 15 cm layer of waste or refuse and then covered with a layer of earth for fortnight.					
			g) Hygienic condition shall be maintained till the closure of labour camp. All septic tank/soak pits shall be regularly serviced and emptied to reduce the risk of surface or groundwater pollution.					
			h) The contractor shall conform generally to sanitary requirements of local medical, health and municipal authorities and at all times adopt such precautions as may be necessary to prevent soil pollution of the site.					
C.8.4	Solid Waste Disposal	Labour camps and Construction Sites	The pre-identified disposal site shall be a part of Comprehensive Waste Disposal Plan. Solid Waste Management Plan to be prepared by the Contractor in consultation and with approval of Environmental Specialist of CSC. In case of non-availability of disposal site, Solid Wastes shall be handed over to BBMP authority regularly, as per the Solid Waste Management Rules, 2016, amended in 2018 and Regulations of PCB; and in line with WB ESS 3 and EIB's ESS 3.				Contractor	Environmental Specialist of GC and K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			The Contractor shall provide colour coded garbage bins for wet and dry wastes 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 Specialist of GC.					
			Solid waste generated from labour camps shall be segregated and collected in separate Garbage bins for non-biodegradable and biodegradable waste and regularly emptied and the garbage shall be disposed-off in a hygienic manner. Biodegradable Municipal solid waste shall be collected by local BBMP and transported to local municipal bins for onward disposal to disposal site. Non-biodegradable waste shall be disposed by selling to scrap dealers (recyclable) and to existing authorized agency (inert and non-recyclables). Guidelines for preparation of Comprehensive Waste Management Plan are provided as **Annexure 10.9.**					
C.8.5	Occupational Health Measures and Medical Facilities for Workers	Construction Sites and Labour camps	Measures shall be as follows in compliance with WHO, the Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act, 1996 and Factories Act, 1948 and amended in 1987 and WB ESS 4 and EIB's ESS 9.				Contractor	Environmental Specialist of GC and K RIDE
C.8.5.1	Occupational Health Measures - Health Check-up & First Aid Facilities	Construction Sites and Labour camps	Medical Facilities on site: Occupational Health Centre, Ambulance van and clinical room to test HIV/ AIDS/COVID prevention and control with all requirements. The Contractor shall arrange for the following –				Contractor	Environmental Specialist of GC and PIA, K RIDE
			i) A readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone and Labour Camp.					
			ii) Availability of suitable transport at all times to take injured or sick person(s) to the nearest hospital.					
			iii) Equipment and trained nursing staff at construction camp.					
			iv) Periodical health check-up for construction workers and their family and for the sick persons.					

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			Control of Occupational Health Hazards : Housekeeping and hygienic (cleanliness) conditions shall be well maintained at labour camps and construction sites to avoid any epidemics such as COVID, etc. among workers. Mosquito breeding shall be prevented by avoiding any stagnant water at base camps or at work sites. Mosquito control fogging shall be carried out in all sites as well as in labor camps for Malaria and Dengue control. Rest sheds shall be provided to workers working on sites to avoid humidity effects and rest during lunch hours. Provision of conditions in contract and good construction practices will take care of any occupational health hazard issues and provide environmentally safe work areas.					
			Prevention of Infectious diseases:					
			• One-one interactions – helps to build confidence,					
			• Counselling- addressing the myths and misconceptions,					
			• Community events-street theatre, puppetry, cultural programs are proven communication tools to the illiterate community to message dissemination,					
			• STD clinic - early identification through testing,					
			• Condom promotion- encouraging condom usage, an accessible place, made available at all times and free distribution.					
			• Advertisement board at appropriate location will be put to make aware about the infectious diseases.					
			Reporting format for workers health check-up is presented as **Annexure 10.29.**					
C.8.5.2	Awareness Programme on HIV/AIDS/COVID, etc.	Labour camps	Periodical Awareness or Orientation Training Programme on HIV/AIDS/COVID, etc. shall be organized for the welfare of Labourers and their family in line with WB ESS 2 & 4 and EIB ESS 8 & 9. The Contractor should undertake workshop/awareness program on health/AIDS/COVID using reporting format presented in **Annexure 10.30**.				Contractor	Environmental Specialist

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			First Aid Training shall be organized by the Contractor for the welfare of Labourers and all the personnel involved in the project.					of GC and K RIDE
C.9	Community Health	In the vicinity of Construction Sites	Community health measures shall be implemented by the Contractor in line with ESS 4 of World Bank Guidelines and EIB's ESS 9. The measures include the following : ○ establishing workers camps separated from local communities (500ms away from the settlements) with strict protocols for interaction with local communities in order to avoid project impacts from labor influx; ○ implementing sensitization and specific mitigation measures for social impacts from labor influx during construction or service provision of the project; ○ adopting all required mitigation measures to avoid air, water, soil and noise pollution & vibration as mentioned under Mitigation Measures for air, water, soil and noise pollution & vibration Sections in this Chapter; ○ providing first aid facilities and establishing health clinics; ○ incorporating safe road crossings into project design; ○ implementing safety signage and traffic management during construction at work sites; ○ adopting all required safety protocols at work sites ○ strict following of protocols for temporary blasting during demolition at the reinstatement or restoration phase; Periodical Community Health Awareness programmes shall be conducted by the Contractor involving Community participation.				Contractor	Environmental Specialist of GC and PIA, K RIDE
C.10	Energy Management /Conservation	Construction sites, Plant sites and Labour camp	The contractor shall use and maintain lighting, tools and equipment of appropriate specifications so as to conserve energy as per EHS guidelines, complying with WB ESS 3& 6 and EIB's ESS 3 & 4.				Contractor	Environmental Specialist of GC and PIA, K RIDE

<table>
<tr><th rowspan="2">Sl. No</th><th rowspan="2">Implementation Activity and Environmental Impact Issue</th><th rowspan="2">Location</th><th colspan="4">Mitigation Measures with Applicable Laws/Acts/Guidelines</th><th rowspan="2">Planning and Executing Organization</th><th rowspan="2">Supervising Authority /Project Proponent</th></tr>
<tr><th>Corridor 1: KSR Bengaluru City – Devanahalli</th><th>Corridor 2 : (Baiyappanahalli - Chikkabanawar)</th><th>Corridor 3: Kengeri - White Field</th><th>Corridor 4: Heelalige - Rajankunte</th></tr>
<tr><td>C.11</td><td>Ban on Plastics</td><td>Construction sites, Plant sites and Labour camp</td><td colspan="4">There shall be total ban on usage of plastics and one time use plastic in accordance with the Plastic Waste Management Amendment Rules, 2021. The usage of Paper or cotton bags shall be encouraged and shall be in practice, complying with WB ESS 1, 3 & 4 and EIB's ESS 1, 3, & 9.</td><td>Contractor</td><td>Environmental Specialist of GC and PIA, K RIDE</td></tr>
<tr><td rowspan="7">C.12</td><td rowspan="7">Provision for Liquid Waste Management (Sewage and Effluent) during Operation</td><td rowspan="7">Stations & Depot</td><td colspan="4">Contractor shall make provisions for proper collection of liquid waste – Sewage and Effluent which will be generated from Stations and Depot during operation. Sewage water generated from station will be treated using Bio-digesters with in the vicinity and reused for flushing and gardening purposes. Typical cross section for Bio-digesters is given in Figure 8.6.
Sewage and Effluents from depot sites shall be collected and treated using Effluent Treatment Plant in the premises.</td><td rowspan="7">Contractor</td><td rowspan="7">Environmental Specialist of GC and PIA, K RIDE</td></tr>
<tr><td colspan="4">Provision of Bio-digesters for Stations:</td></tr>
<tr><td>No. of Bio-digester Locations = 16</td><td>No. of Bio-digester Locations = 14</td><td>No. of Bio-digester Locations = 14</td><td>No. of Bio-digester Locations = 20</td></tr>
<tr><td>Cost = ₹ 26.1 Lakhs</td><td>Cost = ₹ 16.8 Lakhs</td><td>Cost = ₹ 13.33 Lakhs</td><td>Cost = ₹ 23.56 Lakhs</td></tr>
<tr><td colspan="4">Effluent Treatment Plant (ETP) for Depot:</td></tr>
<tr><td>No. of ETP = 1</td><td>No. of ETP = 1</td><td>No. of ETP = 1</td><td>No. of ETP = 1</td></tr>
<tr><td>Cost = ₹ 1.75 Lakhs</td><td>Cost = ₹ 1.75 Lakhs</td><td>Cost = ₹ 1.5 Lakhs</td><td>Cost = ₹ 1.5 Lakhs</td></tr>
<tr><td>C.13</td><td>Institutional capacity & Strengthening</td><td>Project Site</td><td colspan="4">Environmental Engineer for implementation of EMP and Health & Safety Officer shall be employed by the Contractor for every project corridor. Project Manager of the Contractor shall monitor Environment Engineer and Health & Safety officer.
EMP trainings/Workshops on implementation of EMP, Health, Safety and Closure Activities as per EMP of EIA Report and EHS guidelines shall be undertaken periodically by the Contractor and will be conducted by the Environmental Specialist of GC.</td><td>Contractor & Environmental Specialist of GC</td><td>PIA, K RIDE</td></tr>
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Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			Environment Monitoring Unit (EMU) established at PIA (K RIDE) shall be the approval authority.					
C.14	Continuous Community Participation	Along the project corridor	The Environmental Specialist of GC in Coordination with EMU shall have continuous interactions with local people around the project area to ensure that the construction activities are not causing undue inconvenience to the locals residing in the vicinity of project site under construction due to noise, dust or disposal of debris, etc. in compliance with WB ESS 10 & EIB ESS 2. The contractor shall use the reporting format given in **Annexure 10.37** to carry out the public consultation at work sites.				Environmental Specialist of GC & EMU, K RIDE	PIA, K RIDE
C.15	Flora and Fauna: Plantation/Preservation/ Conservation Measures							
C.15.1	Tree protection, Cutting/Removal and Disposal	Throughout project corridor	The tree protection/preservation, cutting and disposal shall be planned in line with The Karnataka Tree Preservation Act, 1976 & amendment Rule 2008, Forest Conservation Act 1980 and ESS 6 of World Bank and EIB's ESS 4.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			Other than Contractor, no one is allowed to cut the identified trees which are falling in the ROW.					
			Fugitive dust deposition on pubescent leaves of nearby vegetation shall be controlled to avoid impact on reduction of their photosynthesis.					
			Biomass shall not be stored at site for more than 15 days.					
			The Contractor shall do turfing on embankment slopes, plantation of shrubs as specified in the Contract.					
C.15.2	Impact on Flora and chance finds - wild Fauna	Throughout project corridor especially near forest stretches including	Vegetation shall be removed from the construction zone before commencement of construction. All works shall be carried out such that the damage or disruption of flora other than those identified for cutting is minimal. Only ground cover/shrubs that impinge directly on the permanent works or necessary temporary works shall be removed with prior approval from the Sr. Environmental Specialist of GC.				Contractor	Environmental Specialist of GC and PIA, K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
		surface water bodies	The Contractor, under any circumstances shall not cut or damage trees and forest reserves, if any. Trees identified under the project shall be cut only after receiving clearance from the BBMP Forest Wing/Forest Dept./DoEF/MoEFCC (as applicable) and after the receipt of K RIDE's written permission in this regard. This will be in line with ESS 1, 3 & 6 of World Bank and EIB Standards 1, 3 & 4. Vegetation only with girth size of over 30 cm shall be considered as trees and shall be compensated, in the event of K RIDE's instruction to undertake tree cutting. Translocation of trees less than 30cm and trees as suggested by BBMP Forest Wing/Forest Dept. shall be carried out adequately. Compensatory afforestation for the tree cut and translocated trees shall be carried out by BBMP forest Wing/ Forest Dept. as per the statutory guidelines of Forest Conservation Act, 1980 and Karnataka Preservation of Trees Act, 1976.					
			The Contractor shall take reasonable precaution in line with WB ESS 6 and EIB ESS 4 to prevent his workmen or any other persons from removing and damaging any flora (plant/vegetation) and fauna (animal) including fishing in any water body and hunting of any animal. If any wild animal is found in the vicinity of construction sites by chance, at any point of time, the contractor shall immediately upon discovery thereof acquaint in the Environmental Specialist of GC and carry out his instructions for dealing with the same.					
			Environmental Specialist of GC shall report to the nearby forest office (range office or divisional office) and shall take appropriate steps/measures, if required in consultation with the forest officials.					
C.15.3	Plantation in Surplus land available along Railway alignment and Compensatory Afforestation Strategy	Surplus land available along Railway alignment	The trees for compensatory plantation shall be as per the Tree Plantation Strategy.	Contractor shall prepare an action plan as per compensatory afforestation norms	Contractor shall prepare an action plan as per compensatory afforestation	Contractor shall prepare an action plan as per compensatory afforestation	Contractor	Environmental Specialist of GC & PIA K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
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			The proposed Afforestation measures shall comply with World Bank ESF guidelines. The Contractor shall prepare an action plan as per compensatory afforestation norms provided by BBMP Forest Wing/Forest Dept., for successful implementation of compensatory afforestation in line with WB ESS 6 and EIB ESS 4.	provided by BBMP Forest Wing/Forest Dept., for successful implementation of compensatory afforestation in line with WB ESS 6 and EIB ESS 4.	norms provided by BBMP Forest Wing/Forest Dept., for successful implementation of compensatory afforestation in line with WB ESS 6 and EIB ESS 4.	norms provided by BBMP Forest Wing/Forest Dept., for successful implementation of compensatory afforestation in line with WB ESS 6 and EIB ESS 4.		
			The compensatory plantation shall be carried out by the State Forest Department/BBMP forest wing.				Contractor	Environmental Specialist of GC and PIA, K RIDE
			Minimum 80 percent survival rate of the saplings shall be acceptable otherwise the Contractor/Forest Department shall replace dead plants at his own cost.					
			The Environmental Specialist of GC shall inspect regularly the survival rate of the trees planted by the Contractor to carryout by BBMP Forest Wing/Forest Dept.					
			About 24703 trees to be affected and trees proposed to be	About 3491 trees to be affected and trees proposed to be	About 2072 trees to be affected and trees proposed to	About 2306 trees to be affected and trees proposed to	Contractor	Environmental Specialist

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			planted are about 247030 saplings.	planted are about 34910 saplings.	be planted are about 20720 saplings.	be planted are about 23060 saplings.		of GC and PIA, K RIDE
			Number of Trees along the alignment is 24703. About 17323 trees comes under forest Dept. in proposed Akkupete depot	Number of Trees along the alignment is 3491.	Number of Trees along the alignment is 2072.	Number of Trees along the alignment is 2306.		
			Compensatory Afforestation cost is ₹ 4026.6 Lakhs.	Compensatory Afforestation cost is ₹ 565.4 Lakhs.	Compensatory Afforestation cost is ₹ 337.7 Lakhs.	Compensatory Afforestation cost is ₹ 375.9 Lakhs.		
			Ecological monitoring during tree felling & translocation and compensatory afforestation is ₹ 1.8 Lakhs.	Ecological monitoring during tree felling & translocation and compensatory afforestation is ₹ 1.8 Lakhs.	Ecological monitoring during tree felling & translocation and compensatory afforestation is ₹ 1.8 Lakhs.	Ecological monitoring during tree felling & translocation and compensatory afforestation is ₹ 1.8 Lakhs.		
C.16	Preservation of fossils, archaeological remains, etc.							
C.16.1	Impact on Archaeological sites, monuments, fossils,	Throughout project corridor	• Interpretation panels/signage must be provided for the monument. • In case of cultural/religious structures, water sprinkling, barricading, flagman and signboard should be provided.				Contractor	Environmental Specialist

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
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	historical and cultural heritage, etc. and Chance findings,		• Drainage system should be checked so that the corridor level should not be higher than the monument and water should not enter inside the monument complex. • Prior intimation should be given to ASI authority to monitor the site and also to check the impact on monument during /post digging (excavation) process. • Prior permission must be obtained from the Competent Authority for any construction or increase in height. • A certificate should be furnished to the Competent Authority on completion of proposed construction to effect that it has complied with all conditions of the permission. • The compliance must be with the heritage bye-laws of the protected monument concerned as and when the bye-laws are approved.					of GC and PIA, K RIDE
			All fossils, coins, articles of value of antiquity, structures and other remains of archaeological interest and historical/cultural heritages discovered on the site shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation and WB ESS 8 and EIB's ESS 10. The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He shall, immediately upon discovery thereof and before removal acquaint the Environmental Specialist of GC of such discovery and carry out the GC's instructions for dealing with the same, waiting which all work shall be stopped. The GC shall seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work in the site. The Archaeological structures identified along the project corridors, if any, shall be protected/ preserved or enhanced as per the law. The details regarding Chance Find procedure is given in **Annexure 10.5.**					
C.17	Contractor's Closure Activities before Demobilization							

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
C.17.1	Clean-up Operations, Restoration and Rehabilitation	Throughout the project corridor	Clean-up Operations, Restoration and Rehabilitation activities shall be implemented during project closure by the Contractor in line with WB ESS 3, 4 & 6 and EIB ESS 3, 9 & 4				Contractor	Environmental Specialist of GC and K RIDE
			Contractor shall prepare site restoration plans, which shall be approved by the Environmental Specialist of GC. The clean-up and restoration operations are to be implemented by the Contractor prior to demobilization. The Contractor shall clear all temporary structures; dispose all garbage, night soils and POL (Petroleum, Oil and Lubricants) wastes as per Comprehensive Waste Management Plan and as approved by GC. Guidelines for preparation of Comprehensive Waste Management Plan are provided presented in **Annexure 10.9.**					
			All disposal pits or trenches shall be filled in and effectively sealed off. Residual topsoil, if any shall be distributed on adjoining/proximate barren land or areas identified by the Contractor and approved by the Environmental Specialist of GC in a layer of thickness of 75 mm – 150 mm. All construction zones and facilities including culverts, project corridor side areas, camps, Crushers, batching plant sites and any other area used/affected due to the project operations shall be left clean and tidy, at the Contractor's expense, to the entire satisfaction to the Environmental Specialist of GC. The contractor shall carryout the restoration of construction sites using reporting format given in **Annexure 10.36.**					
C.18	Construction Activities by K RIDE							
C.18.1	Environmental Quality Measures (Third Party Testing)	Representative locations as directed by Sr. Environmental Specialist, GC.	Contractors will carry out environmental monitoring during construction, whereas Third Party will be hired by K RIDE. Third Party will carry out monitoring on behalf of K RIDE. The K RIDE through third party shall undertake seasonal monitoring of air, water and noise and soil quality through an approved monitoring agency in compliance with Environmental Protection Act, 1986, complying with WB ESS 3 & 6 and EIB's ESS 3 & 4. The parameters to be monitored, frequency and duration of monitoring as well as the				PIA, K RIDE	Environmental Specialist of GC and K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			locations to be monitored shall be as per the Monitoring Plan **Table 10.3** of EIA Report. There may minor variations while selecting monitoring locations during construction based on the activities going on during the period of pollution monitoring. National Standard of Air, Noise and Water given in **Annexure 10.34**. In addition Reporting format for recording environmental monitoring and mitigation measures shall be reported in the reporting format given in **Annexure 10.3** and **Annexure 10.40** respectively. Rectification Action shall be taken up by the Contractor for the improvement of Environmental Quality during Construction.					
C.18.2	Environmental Enhancement Measures - Tree Plantation	Throughout the project corridor	Environmental Enhancement activity will be undertaken by the K RIDE in the form of additional plantation under Compensatory Afforestation as Social forestry based on availability of land. The plantation at the following locations shall be implemented by BBMP forest wing/Forest dept. as per statutory guidelines of Karnataka Tree Preservation Act, 1976 and in line with Traffic Management Plan, WB ESS 6 and EIB's ESS 4.				State Forest Department/BBMP	PIA, K RIDE
		Nearby locations with available land	Compensatory Afforestation - Community Plantation shall be carried out by Forest Authority/BBMP in consultation with K RIDE. Local Trees shall be selected for plantation. This will comply with WB ESS 6 and EIB's ESS 4. In the long term, compensatory afforestation and Green belt development will enhance environment of the project area.					
Operation Phase								
O.1	Monitoring of Operation Performance Indicators	Throughout the project corridor	The K RIDE shall monitor the operational performance of the various mitigation/enhancement measures carried out as a part of the project in line with WB ESS 3, 4 & 6 and EIB ESS 3, 4 & 9.				PIA, K RIDE	PIA, K RIDE
			The indicators selected for monitoring include the survival rate of trees; utility of enhancement provision made under the project; status of rehabilitation of borrow areas; and effectiveness of noise barriers. This will comply with WB ESS 3, 4 & 6 and EIB ESS 3, 4 & 9.					

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
O.2	Maintenance of Drainage	Throughout the project corridor	K RIDE shall ensure that all drains (side drains, median drain and all cross drainages) are periodically cleared especially before monsoon season to facilitate the quick passage of rainwater and avoid flooding in low lying areas, as per the Contract Document and WB ESS 1 and EIB's ESS 1.				PIA, K RIDE	PIA, K RIDE
O.3	Water supply	All Stations and Depot	The source of water supply at Depot is municipal water supply. This will be supplemented by re-use of treated water of effluent treatment plant. The fresh water demand at stations & depot for the project year 2025, would be about 2,88,249 KLD required to be used for different purposes such as for train washing – 720 KLD, floor washing/cleaning – 2,80,000 KLD, for drinking purpose – 6494 KLD for passengers and official staffs at Stations and Depot and for sanitation purpose – 1012 KLD. Guidelines under WB ESS 3 and EIB ESS 3 shall be followed.				PIA, K RIDE	PIA, K RIDE
O.4	Pollution Monitoring	At representative Baseline monitoring locations + Additional, as required.	Baseline monitoring location is treated as the reference and comparison point. In addition wherever required, additional monitoring may be carried out as and when required and decision taken by the EMU, PIA, K RIDE. The periodic monitoring of the ambient air quality, noise level, water (both ground and surface water) quality, soil quality in the selected locations as suggested in pollution monitoring plan through the KSPCB or its approved monitoring agency and shall be in compliance with Environmental Protection Act, 1986, The Air (Prevention and Control) Act, 1981, The Water (Prevention and Control) Act, 1976 and The noise pollution (regulation and control) rules, 2000; and with all with Amendments and WB ESS 3 and EIB's ESS 3.				Pollution Monitoring Agency	PIA, K RIDE
			Environmental management cost during operation	Environmental management cost during operation	Environmental management cost during operation	Environmental management cost during operation		

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			phase will be ₹ 67.04 Lakhs	phase will be ₹ 63.62 Lakhs	phase will be ₹ 68.96 Lakhs	phase will be ₹ 79.8 Lakhs		
O.4.1	Air Pollution due to inter modal operational vehicles	At representative baseline monitoring locations and Depots	There are operational inter modal vehicles such as autorickshaws, taxis, two-wheelers or four wheelers to transport BSR commuters to reach nearby Suburban Railway Stations from source and Suburban Railway Stations to their destinations such as work place, residence, etc. Air Pollution monitoring shall be carried out in accordance with Air (Prevention and Control) Act, 1981 and CPCB regulations and WB ESS 3 and EIB's ESS 3.				PIA, K RIDE	PIA, K RIDE
			Air Quality Monitoring cost during Operation Phase (Stations and Depot) will be ₹ 8.64 Lakhs.	Air Quality Monitoring cost during Operation Phase (Stations only) will be ₹ 6.48 Lakhs.	Air Quality Monitoring cost during Operation Phase (Stations and Depot) will be ₹ 8.64 Lakhs.	Air Quality Monitoring cost during Operation Phase (Stations only) will be ₹ 10.8 Lakhs.		
O.4.2	Noise Pollution	All Stations and Depot	Mitigations measures for Noise Management shall be carried out in accordance with Noise Pollution (Regulation and Control) Rules, 2000 and its amendment and ESS 3 of World Bank and EIB's ESS 3.				PIA, K RIDE	PIA, K RIDE
			• Wherever required Noise barriers shall be erected and noise barriers on viaduct shall be maintained. • The use of green belt with vegetation of thick foliage at Depots and stations act as noise screeners and helps to reduce noise; • Wherever site layout permits, barrier blocks of less-vulnerable buildings may be used. • Screening of noise shall be ensured by providing parabolic noise barriers on each side of the track along the curved portion of the viaduct and at sensitive receptors during operation. Polycarbonate noise barriers 15mm to 25 mm thick are known to reduce noise level by 30dB.					

<table>
<tr><th rowspan="2">Sl. No</th><th rowspan="2">Implementation Activity and Environmental Impact Issue</th><th rowspan="2">Location</th><th colspan="4">Mitigation Measures with Applicable Laws/Acts/Guidelines</th><th rowspan="2">Planning and Executing Organization</th><th rowspan="2">Supervising Authority /Project Proponent</th></tr>
<tr><th>Corridor 1: KSR Bengaluru City – Devanahalli</th><th>Corridor 2 : (Baiyappanahalli - Chikkabanawar)</th><th>Corridor 3: Kengeri - White Field</th><th>Corridor 4: Heelalige - Rajankunte</th></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td><td colspan="4">Alternatively solid noise barrier walls shall be built (Manual on norms and standards for environment clearance of large construction projects, MoEFCC, 2007). Required solid Noise barriers shall be erected and shall be maintained at locations such as sharp curved portions, structures falling within 20m distance from the alignment and at sensitive receptors like educational institutions and hospitals where noise impact criteria is severe.
If compound walls are already present, the height of the wall shall be raised so that the height of the solid noise barrier shall be 3m. If not, based on the availability of land solid noise barriers shall be provided at sensitive receptors such as educational institutions and health centres.
Noise measures shall be undertaken in due consultation with Indian railway officials and land owners during pre-construction stage. Details of solid concrete noise barriers proposed for each corridor is given in Table 8.43. EMU of K RIDE shall arrange to monitor the noise environment at these locations before erecting the solid noise barriers during operation.</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>Noise Level Monitoring cost will be ₹ 3.6 Lakhs.</td><td>Noise Level Monitoring cost will be ₹ 2.34 Lakhs.</td><td>Noise Level Monitoring cost will be ₹ 4.32 Lakhs.</td><td>Noise Level Monitoring cost will be ₹ 4.32 Lakhs.</td></tr>
<tr><td>Noise Barrier proposed for a length of - 545-- m (₹ 0.2 Lakh/meter) and the cost will be ₹ 109 Lakhs.</td><td>Noise Barrier proposed for a length of --1161-- m (₹ 0.2 Lakh/meter) and the cost will be ₹ 232.2 Lakhs.</td><td>Noise Barrier proposed for a length of --937-- m (₹ 0.2 Lakh/meter) and the cost will be ₹ 187.4 Lakhs.</td><td>Noise Barrier proposed for a length of --415-- m (₹ 0.2 Lakh/meter) and the cost will be ₹ 83.00 Lakhs.</td></tr>
<tr><td>O.4.3</td><td>Vibration</td><td></td><td colspan="4">Vibration monitoring and building condition surveys at sensitive structures shall be implemented, as per requirement in line with WB's ESS 3 and EIB ESS 3.</td><td>PIA, K RIDE</td><td>PIA, K RIDE</td></tr>
</table>

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
		Stations and running corridors	• The proper maintenance of track and rolling stock during operation helps in controlling vibration. The vibration level can be significantly reduced by incorporating the following standard measures/factors: • Vehicles with no stiff primary suspension • No Worn or Wheel with flats • No Worn/Corrugated Track • With Floor-to-Floor Attenuation in receptor buildings • In case of ballast less track, the following are some measures for vibration damping : • Use of Resilient soft base plates between rail and track slab; • Use of Resilient rubber between the base plate and track slab; • Application of Soft elastic fastening system and • Deep and narrow trenches in the ground shall be tested at vibration-sensitive structures.					
			Vibration Monitoring cost will be ₹ 32.4 Lakhs.	Vibration Monitoring cost will be ₹ 32.4 Lakhs.	Vibration Monitoring cost will be ₹ 32.4 Lakhs.	Vibration Monitoring cost will be ₹ 32.4 Lakhs.		
O.4.4	Soil Monitoring	All Stations and Depot	Visual Monitoring and inspection of borrow areas in case operated (if closed and rehabilitated), embankments and other places expected to be affected, shall be carried out once in every three months as per monitoring plan, to check soil erosion if any. Measures shall be necessitated to avoid residual impacts such as soil erosion and mosquito breeding at stagnated water.				PIA, K RIDE	PIA, K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			Soil Quality Monitoring shall be carried out in accordance with EPA, 1986 and ESS 3 of World Bank and WB ESS 3 & EIB's ESS 3.					
			Soil Quality Monitoring cost will be ₹ 2.88 Lakhs.	Soil Quality Monitoring cost will be ₹ 2.88 Lakhs.	Soil Quality Monitoring cost will be ₹ 2.88 Lakhs.	Soil Quality Monitoring cost will be ₹ 3.6 Lakhs.		
O.4.5	Water Pollution due to Liquid waste - sewage & Effluent	All Stations and Depot; and nearby water bodies, if any.	Water Quality Management at Stations and Depot will be in accordance with Water and Waste Water Management Plan in compliance with Indian Standards, in accordance with Water Pollution (Prevention and Control) Act, 1976 and its amendment, and ESS 3 of World Bank and EIB ESS 3. If required, additional locations may be provided by EMU, PIA, K RIDE.				PIA, K RIDE	PIA, K RIDE
			Required number of Latrines or urinals shall be provided as per specifications and guidelines mentioned in the Railways Works Manual, 2000 and CPCB/KSPCB regulations. Other Measures include treatment and reuse of waste water by installing Bio-digesters at Stations and Effluent treatment plant for Depots. Measures including treatment and reuse of waste water by installing Bio-digesters at Stations and Effluent treatment plant for Depot. Treated water shall be reused for flushing and washing purpose.					
			No. of Bio-digester at Stations = 16	No. of Bio-digester at Stations = 14	No. of Bio-digester at Stations = 14	No. of Bio-digester at Stations = 20		
			Water Quality Monitoring cost will be ₹ 7.68 Lakhs (for	Water Quality Monitoring cost will be ₹ 7.68 Lakhs (for	Water Quality Monitoring cost will be ₹ 10.24 Lakhs (for monitoring of	Water Quality Monitoring cost will be ₹ 13.44 Lakhs (for monitoring of		

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			monitoring of water and waste water).	monitoring of water and waste water).	water and waste water).	water and waste water).		
			No. of ETP at Depot = 1	No. of ETP at Depot = 1	No. of ETP = 1	No. of ETP = 1		
O.5	Water supply	All Stations and Depot	The source of water supply at Depot is municipal water supply. This will be supplemented by re-use of treated water of effluent treatment plant. The fresh water demand at stations & depot for the project year 2025, would be about 2,88,249 KLD required to be used for different purposes such as for train washing – 720 KLD, floor washing/cleaning – 2,80,000 KLD, for drinking purpose – 6494 KLD for passengers and official staffs at Stations and Depot and for sanitation purpose – 1012 KLD.				PIA, K RIDE	PIA, K RIDE
O.6	Solid waste disposal at stations and Depot	All Stations and Depot	Solid Waste Management at Stations and Depot will be in accordance with Solid Waste Management Plan and in compliance with Indian Standards and ESS 3 of World Bank and EIB ESS 3. EMU, PIA, K RIDE may redevelop or modify the Solid Waste Management Plan.				PIA, K RIDE	PIA, K RIDE
			Organic waste shall be segregated and treated by in-site bio composter technique.					
			Based on the situations, the municipal solid waste shall be handed over to the BBMP Authority for proper treatment and disposal.					
O.7	Soil Erosion and Monitoring of Borrow Areas	Borrow areas and embankment slopes	Visual Monitoring and inspection of operated and closed borrow areas, embankments and other places shall be carried out once in every three months as per monitoring plan, to check soil erosion if any. Measures shall be necessitated to avoid residual impacts such as soil erosion and mosquito breeding at stagnated water. This will comply with WB ESS 3 and EIB Standards 3.				PIA, K RIDE	PIA, K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
O.8	Ecological Monitoring – Flora & Fauna and Water Bodies	Plantation and Water Body sites	Assessment for Change in Bio-diversity and Water body quality - Once in a season, four seasons in a year in line with WB ESS 6 and EIB ESS 4.				BBMP Forest wing/ Forest Dept. in consultation with K RIDE	PIA, K RIDE
O.9	Operational Safety	Stations. Corridors and Depots	• Implementation of rail operational safety procedures aimed at reducing the likelihood of train collisions such as a positive train control (PTC) system. If a full PTC system is not practical, automatic rail switches should be installed or, where manual switches remain, documenting when a manually operated switch in non-signalled territory is changed from the main track to a siding, and returned back to the normal position for main track movements. This information should be communicated to all crew members and the train dispatcher. • Regular inspection and maintenance of the rail lines and facilities to ensure track stability and integrity in accordance with national and international track safety standards; Implementation of an overall safety management program that is equivalent to internationally recognized railway safety programs. PPE shall be provided to workers involved in maintenance of cars. Security personnel shall also be employed.				PIA, K RIDE	PIA, K RIDE

Sl. No	Implementation Activity and Environmental Impact Issue	Location	Mitigation Measures with Applicable Laws/Acts/Guidelines				Planning and Executing Organization	Supervising Authority /Project Proponent
			Corridor 1: KSR Bengaluru City – Devanahalli	Corridor 2 : (Baiyappanahalli - Chikkabanawar)	Corridor 3: Kengeri - White Field	Corridor 4: Heelalige - Rajankunte		
			Periodical Safety Audit procedures shall be followed. Above measures will be in line with Guidelines under WB ESS 4 and EIB ESS 9.					
O.10	Incident/Disaster/Accident Management	All Stations and Depot	Guidelines under WB ESS 4 and EIB ESS 9 shall be followed. Incident Management Plan shall be in accordance with EHS guidelines, Risk/ Disaster Management plan and Emergency Response Plan.				PIA, K RIDE	PIA, K RIDE
			Proper maintenance of Incident Records shall be taken care.					
			Required preventive measures shall be under taken to avoid repetition of risks/hazards.					
O.11	Community Health and Safety	Throughout the project corridor	Emergency-response planning and monitoring for prevention and control of pollution or other risk incidents during operation shall be established in compliance with Guidelines under WB ESS 4 and EIB ESS 9.				PIA, K RIDE	PIA, K RIDE
			Sufficient number of Security personnel shall be employed to secure commuters' safety at stations.					
			Corporate Social Responsibility: Public shall be advised to construct the noise barriers such as walls, double glazed windows and tree plantation between the roads and their property.					
			The Public awareness on Safety, Noise levels and Health Impacts is necessary through the newspapers and public consultations and distribution of pamphlets during the operation stage - Once in 3 months and 4 times in a year as per EHS/EMS.				PIA, K RIDE	PIA, K RIDE
O.12	Monitoring and Grievances	Throughout the project corridor, wherever required	Grievance mechanism shall be in line to monitor progress of implementation of the EMP/EMoP measures and results achieved. Guidelines under WB ESS 10 & 4 and EIB ESS 2 & 9 shall be followed by GRC during operation.				PIA, K RIDE	PIA, K RIDE
			Project-level grievance redressal Mechanism shall be implemented.					

10.9.1. Reporting System

The monitoring report of environmental parameters (Air, Noise, Vibration, Water and soil) will be prepared by the environmental engineer of the Contractor and submitted to the Project Management Consultant.

- The contractor will report to General Consultant (GC) and GC will report to K RIDE on compliance. K RIDE may disseminate the information to all allied / interested parties.
- Non-compliance of the monitoring will be seen by the K RIDE.
- Photographic monitoring record will be maintained by the contractor. All material source points, disposal locations, plant locations, camp locations, etc. should be photographed.
- A full record of construction activities will be kept as a part of normal contract monitoring system under the various stages of construction.

The Reporting Formats and Checklists for various activities during construction are enclosed as **Annexure 10.15** to **Annexure 10.31**.

10.9.2. Record Keeping

Project specific Monitoring forms will need to be devised for use, focusing attention on environmental issues and providing feedback for future improvement. Mitigation and enhancement measures adopted in the final design will be explicitly under the bill of quantities (BOQ), so that performance and completion is readily documented. Project diaries would record environmental problems (soil erosion, air quality, water quality, noise level etc.), as well as safety incidents and will be retained as part of the accepted environmental management.

10.10. Environmental Monitoring Plan (EMoP)

The Environmental Monitoring Programme/Plan (EMoP) plays a significant role during project implementation. The project specific Environmental Monitoring Programme aides in identification and rectification of potential environmental problems arise due to activities during project implementation. Project specific Environmental Monitoring Plan is prepared to monitor environmental pollution parameters or factors during Pre-construction, Construction and Operation phases of the project and to control risks, if any, with appropriate mitigation measures. Also it includes worker’s health and safety aspects during project implementation. The same is discussed below.

10.10.1. Pre-Construction Phase

Pre-construction phase monitoring has been done for the proposed project for air, noise, vibration, and water and soil quality as part of this report. The results of base line environmental monitoring are reported in **Chapter 5.**

10.10.2. Construction Phase

Construction Phase Monitoring Plan for the entire period of construction (3 Years) is summarized in **Table 10.3.** The number of locations could be modified based on need when the construction commences. Monitoring should be carried out by NABL Accredited/MoEFCC recognized private or Government agency. The contractor will be responsible for carrying out monitoring during construction under the supervision of GC/PIA. The results of air quality, water quality, waste water, vibration monitoring will be submitted by the Contractors to management /executing agency quarterly during construction phase. The environmental auditing shall be carried out bi-annually for 3 years.

Table 10.3. Environmental Monitoring Plan (EMoP) for Construction Stage

Key Performance Indicators	Parameters	Locations and Frequency	Reference/ Standards	Implementing Agency	Approval Authority
Ambient Air Quality	PM_{10}, $PM_{2.5}$, SO_2, NO_x, CO and HC	One day monitoring once a month at construction sites or Ambient air quality monitoring locations (as suggested by Envi. Specialist of GC) and 1 location each at Base camp and Plant site for each corridor for entire construction period.	Guidelines for Ambient Air Quality Monitoring , CPCB, 2003 National Ambient Air Quality Standards 2009	Contractor	GC/K RIDE
Noise	Leq, L90, L50, L10, Lday, Lnight, Lday-night	One day monitoring once in a month at construction sites or Ambient noise level monitoring locations (as suggested by Envi. Specialist of GC) and 1 location each at Base camp and Plant site for each corridor for entire construction period.	Protocol for Ambient Level Noise Monitoring, CPCB, May 2015 ISO/ TC 108 (vibration)	Contractor	GC/K RIDE
Vibration	Peak Particle velocity in mm/sec	Once in a season, for four seasons at construction site or Ambient vibration quality monitoring locations (as suggested by Envi. Specialist of GC).			
Water (surface and ground water)	pH, Biochemical Oxygen Demand (BOD 3 days 27°c), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS),Total Dissolved Solids (TDS), Chlorides,	Once in a season, four seasons in a year at baseline monitoring locations.	Guide Manual – Water and waste water analysis, CPCB Drinking water – Specifications	Contractor	GC/K RIDE

Key Performance Indicators	Parameters	Locations and Frequency	Reference/ Standards	Implementing Agency	Approval Authority
	Nitrates, Sulphates, Iron, Calcium, Total Nitrogen, Lead, Total Phosphates, oils and grease and Heavy metals (optional)		IS 10500: 2012 and CPHEEO Manual		
Waste Water	pH, Biochemical Oxygen Demand (BOD 3 days 27°c), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS),Total Dissolved Solids (TDS), Chlorides, Nitrates, Sulphates, Iron, Calcium, Total Nitrogen, Lead, Total Phosphates, oils and grease; and Heavy metals	Inlet & Outlet of Sedimentation tank at stations and Depot.	Guide Manual– Water and Waste water analysis, CPCB	Contractor	GC/K RIDE
Soil	pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorous, Organic Matter, Heavy Metal, oil and Grease	Once in a season, four seasons in a year at baseline monitoring locations	USEPA test protocols	Contractor	GC/K RIDE
Ecology	• Seasonal Assessment of Water body • Biodiversity - Flora	Afforestation sites	As per BBMP Forest wing /Forest authorities	BBMP/ Forest Department	BBMP/ Forest Department
Workers' Health and Safety	• Provision of PPE • Safety Audit • Periodical Health Check up • Awareness & Training	Throughput the Construction Period at Construction sites and Worker's camp sites.	As per EHS/EMS	Contractor	GC/K RIDE
Community ' Health and Safety	• Provision of Safety caution boards and proper traffic diversions with boards • Traffic Safety management • Periodical Health Check up • Safety Audit	Throughput the Construction Period at Construction sites.	As per EHS/EMS	Contractor	GC/K RIDE

Key Performance Indicators	Parameters	Locations and Frequency	Reference/ Standards	Implementing Agency	Approval Authority
	• Awareness & Training				

Ecological Monitoring: The ecological monitoring includes visual monitoring of water body and biodiversity – flora /afforestation of trees will be solely carried out by the BBMP Forest wing/Forest Authority but in consultation with K RIDE, as per requirement.

Community and Workers Health and Safety:

Contractor will be responsible to take care of health and safety of workers and Community during construction and K RIDE is responsible to review/audit the health and safety measures/plans with the assistance of Sr. Environmental Specialist of GC. Following are the main measures to be taken up during construction by the Contractor :

- Provision of required PPE to workers at operational plant sites, borrow area operation sites, work sites and base camp.
- Regular inspection shall be carried out to workers health and safety monitoring.
- Conducting Periodical Safety Audit
- Epidemiological studies at construction sites will be performed to monitor the potential spread of diseases.
- Any recurrence of health incidents shall be recorded and appropriate mitigation measures shall be taken.
- Conducting Periodical Medical/Health Check up for workers (and local community people if required)
- Awareness & Training for workers and community regarding Health and Safety

10.10.3. Operation Phase

The environmental monitoring schedule during operation phase for 2 years is presented in **Table 10.4**. The results of air quality, water quality, waste water, noise and vibration, soil, solid and liquid waste will be submitted to management bi-annually during operation phase. The environmental auditing shall be carried out bi-annually for 2 years.

Table 10.4. Environmental Monitoring Plan (EMoP) for Operation Stage

Key Performance Indicators	Parameter	Frequency	Reference/Standard	Implementation /Approval by
Air Quality	PM10, PM2.5, SO2, NOx,CO and HC	24 hours in a week for each season, three seasons in a year at baseline monitoring locations	Guidelines for Ambient Air Quality Monitoring , CPCB, 2003 National Ambient Air Quality Standards 2009	K RIDE

Key Performance Indicators	Parameter	Frequency	Reference/Standard	Implementation /Approval by
Noise Quality	Leq, Lday, Lnight, Lday-night	24 hours in a week for each season, three seasons in a year at baseline monitoring locations	Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015	K RIDE
Vibration	Peak Particle velocity in mm/sec	24 hours, once a month at baseline monitoring locations of all corridors.		
Water Quality (Surface and Ground water)	pH, Biochemical Oxygen Demand (BOD 3 days 27°c), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS),Total Dissolved Solids (TDS), Chlorides, Nitrates, Sulphates, Iron, Calcium, Total Nitrogen, Lead, Total Phosphates, oils and grease and Heavy metals (optional)	Once in a season, four seasons in a year at baseline monitoring locations	Drinking water – Specifications IS 10500:2012 and CPHEEO Manual 2012 Guide Manual –Water and waste water analysis, CPCB	K RIDE
Waste Water Quality	pH, Biochemical Oxygen Demand (BOD 3 days 27°c), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS),Total Dissolved Solids (TDS), Chlorides, Nitrates, Sulphates, Iron, Calcium, Total Nitrogen, Lead, Total Phosphates, oils and grease; and Heavy metals	Once in a season, four seasons in a year at baseline monitoring locations		
Assessment of Solid Waste Management	Monitorng for proper collection, segregation, reeuse and disposal of solid wastes	Once in a season, Four seasons in a year at Depot	Solid Waste Management Rules, 2016	K RIDE

Key Performance Indicators	Parameter	Frequency	Reference/Standard	Implementation /Approval by
Soil	pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorous, Organic Matter, Heavy Metal, oil and Grease	Once in a season, four seasons in a year at baseline monitoring locations	USEPA test protocols	K RIDE
Ecology – Flora	• Seasonal Assessment of Water body and • Biodiversity - Flora	Once in a season, four seasons in a year at Afforestation Sites	As per BBMP Forest wing /Forest authorities	BBMP Forest wing/Forest Dept. in consultation with K RIDE
Community Health and Safety	• Periodical Health Check up • Safety Audit • Awareness & Training	Once in 3 months and 4 times in a year	As per EHS/EMS	K RIDE

10.11. Management/Monitoring of Contractors' Environmental and Social Performance

The PIA supported by the Sr. Environmental Specialist and Sr. Social Specialist of General Consultant will monitor the performance of contractors concerning implementation of Environmental and Social impact Management including contracted workers also and focusing on compliance by contractors and their contractual agreements and this LMP. This will include the following:

- • Review of Contractor's monthly reports
- • Review of Contractor's incident/accident reports
- • Periodic monitoring visits to sub-project sites involving spot checks and interaction with workers and community people
- • Inspection of on-site records maintained by Contractor

The performance requirements by the Contractor will be overseen and managed by the Sr. Environmental Specialist and Sr. Social Specialist of General Consultant under the overall guidance and direction of the Chief Project Director, K RIDE.

In the context of COVID, additionally, the Contractor with respect to health of workers, will be required to include:

- Provision of medical insurance covering treatment for COVID-19, sick pay for workers who either contract the virus or are required to self-isolate due to close contact with infected workers, and compensation payment in the event of death

- Designating/appointing a COVID-19 focal point officer responsible for monitoring and reporting COVID-19 issues and liaising with competent authorities designated by district administration or the State Government.

Non-compliance by the Contractor will result in remedial actions as per the provisions of the contractual agreement.

Managing Environmental and Social Performance, a reference document is enclosed as **Annexure 10.42** to assess the Contractor.

10.11.1. EHS Non-conformity Management Process

Non-conformity management process is to fix the error carried out by the Contractor during his performance towards Environmental and Social issues. The Corrective and Preventive Actions (CAPA) will be taken up by the Contractor in time and he should submit the evidences for his action taken for non-conformity through audio-visuals such as videos, photographs, documents, recordings, etc. and to follow in compliance with the applicable laws to the needy non-conformities during construction as well as project completion/closure stage to meet the quality standards. Non-conformity Procedure and management shall be in line with the procedure and actions given in **Annexure 10.13**. Once the report is conformity Report is submitted in compliance with applicable laws/Rules and WB's ESS Guidelines, then reviewed and assessed by the monitoring authority GC/K RIDE and the non-conformity will be closed by the authority – K RIDE.

10.11.2. Management of Change (MOC)

Management of Change (MOC) is a systematic approach to dealing with change in project improvements with respect to location, construction methodology, materials used, etc. during different phase of the project, which will have significate impacts of environmental and social aspects of the project. These changes may also have long term impacts too. The goal of this approach is to safeguard the environment and social concerns from potential harm during the change in the project or specific activity.

In order to capture the severity of the impacts on environmental and social aspects due to proposed changes, a supplementary study shall be conducted inline with National standards & Environmental and Social Framework of KfW, EIB and WB. Decision on requirement of the supplementary study shall be taken by Senior Environmental & Social Experts of ESMU. Based on the severity, it shall decide whether the study can be conducted though engaging external consultant firm or a team comprising of environmental & social experts of ESMU, GC and Contractor. In case of major change in the location, construction methodology, etc., consultation with concerned stakeholders including affected parties shall be conducted to achieve the information dissemination and collection of their grievances. The supplementary report, shall be submitted to PIA for further submission to funding agencies for approval. The approved report should be disclosed in K RIDE's website.

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Chapter 11. Environmental Budget for Implementation of EMP

11.1. Environmental Monitoring Cost during Construction

The environmental monitoring cost includes the total cost of environmental pollution monitoring and ecological monitoring cost during construction and operation phases of the project.

The environmental pollution monitoring cost during construction phase is estimated as ₹ 93.36 Lakhs for Corridor 1, ₹ 88.86 Lakhs for Corridor 2, ₹ 84.3 Lakhs for Corridor 3 and ₹ 95.04 Lakhs for Corridor 4. The estimated cost ₹ 361.56 Lakhs towards environmental monitoring during construction will be part of civil contract and details are given in **Table 11.1**.

Table 11.1 Environmental Monitoring Cost during Construction Phase

Sl. No.	Item	Quantity	Total Cost (₹ in Lakhs)
Corridor – 1: KSR Bengaluru City to Devanahalli			
i.	Air Quality Monitoring at ₹10000/sample	8 Samples X 12 times in a year X 3 Years	28.8
ii.	Noise Quality Monitoring at ₹2500/sample	10 Samples X 12 times in a year X 3 Years	9
iii.	Soil Quality Monitoring at ₹8000/sample	4 Samples X 4 times in a year X 3 Years	3.84
iv.	Water Quality Monitoring at ₹7000/sample	8 Samples X 4 times in a year X 3 Years	6.72
v.	Vibration Monitoring at ₹120000/sample	3 Samples X 4 times in a year X 3 Year	43.2
vi.	Ecological Monitoring at ₹20000/assessment	3 times in a year X 3 Years	1.8
vii.	Worker's Health and Safety monitoring	4 times in a year X 3 Years	-
vii.	Workers and Community Health and Safety Orientation Program	4 times in a year X 3 Years	-
Envi. Monitoring Cost for Corridor 1:			**93.36**
Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara			
i.	Air Quality Monitoring at ₹10000/sample	7 Samples X 12 times in a year X 3 Years	25.2
ii.	Noise Quality Monitoring at ₹2500/sample	7 Samples X 12 times in a year X 3 Years	6.3
iii.	Soil Quality Monitoring at ₹8000/sample	5 Samples X 4 times in a year X 3 Years	4.8
iv.	Water Quality Monitoring at ₹7000/sample	9 Samples X 4 times in a year X 3 Years	7.56
v.	Vibration Monitoring at ₹120000/sample	3 Samples X 4 times in a year X 3 Year	43.2

Sl. No.	Item	Quantity	Total Cost (₹ in Lakhs)
vi.	Ecological Monitoring at ₹20000/assessment	3 times in a year X 3 Years	1.8
vii.	*Worker's Health and Safety monitoring	4 times in a year X 3 Years	-
viii.	*Workers and Community Health and Safety Orientation Program	4 times in a year X 3 Years	-
Envi. Monitoring Cost for Corridor 2:			**88.86**
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)			
i.	Air Quality Monitoring at ₹10000/sample	6 Samples X 12 times in a year X 3 Years	21.6
ii.	Noise Quality Monitoring at ₹2500/sample	7 Samples X 12 times in a year X 3 Years	6.3
iii.	Soil Quality Monitoring at ₹8000/sample	3 Samples X 4 times in a year X 3 Years	2.88
iv.	Water Quality Monitoring at ₹7000/sample	8 Samples X 4 times in a year X 3 Years	6.72
v.	Vibration Monitoring at ₹120000/sample	3 Samples X 4 times in a year X 3 Year	43.2
vi.	Ecological Monitoring at ₹20000/assessment	3 times in a year X 3 Years	1.8
vii.	*Worker's Health and Safety monitoring	4 times in a year X 3 Years	-
viii.	*Workers and Community Health and Safety Orientation Program	4 times in a year X 3 Years	-
Envi. Monitoring Cost for Corridor 3:			**82.5**
Corridor – 4: Heelalige to Rajanukunte			
i.	Air Quality Monitoring at ₹10000/sample	8 Samples X 12 times in a year X 3 Years	28.8
ii.	Noise Quality Monitoring at ₹2500/sample	10 Samples X 12 times in a year X 3 Years	9
iii.	Soil Quality Monitoring at ₹8000/sample	4 Samples X 4 times in a year X 3 Years	3.84
iv.	Water Quality Monitoring at ₹7000/sample	10 Samples X 4 times in a year X 3 Years	8.4
v.	Vibration Monitoring at ₹120000/sample	3 Samples X 4 times in a year X 3 Year	43.2
vi.	Ecological Monitoring at ₹20000/assessment	3 times in a year X 3 Years	1.8
vii.	*Worker's Health and Safety monitoring	4 times in a year X 3 Years	
viii.	*Workers and Community Health and Safety Orientation Program	4 times in a year X 3 Years	
Envi. Monitoring Cost for Corridor 4:			**95.04**

Included in the Contracts under EHS clause. Hence, no separate cost is estimated for the same.

11.1.1. Bio-digester Implementation Cost at Stations and Depot

The total quantity of Waste water generation and requirement of DRDO approved Bio-digesters with capacity and cost estimate for all stations at each corridor of the Suburban Rail Project are given below in **Table 11.2.**

Table 11.2. Provision of Bio-digesters at Suburban Railway Stations

Sl. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Cost of Bio Digester in ₹ Lakh	Cost of Bio Digester in ₹
Corridor 1 (KSR Bengaluru City - Devanahalli)					
1	KSR Bengaluru City	27.537	5	2.50	2,50,336
2	Srirampura	10.672	2	0.97	97,018
3	Malleswaram	21.889	4	1.99	1,98,991
4	Yeshwantpur	22.654	4	2.06	2,05,945
5	Muthyalanagar	18.649	3	1.70	1,69,536
6	Lottegolahalli	35.008	6	3.18	3,18,255
7	Kodigehalli	23.088	4	2.10	2,09,891
8	Judicial Layout	32.58	6	2.96	2,96,182
9	Yelahanka	29.099	5	2.65	2,64,536
10	Nitte Meenakshi	9.199	2	0.84	83,627
11	Betahalasuru	1.571	0	0.14	14,282
12	Doddajala	13.889	3	1.26	1,26,264
13	Airport Trumpet	4.788	1	0.44	43,527
14	Airport KIADB	12.984	2	1.18	1,18,036
15	Future Station @ Km 38/800	12.181	2	1.11	1,11,000
	Devanahalli	11.378	2	1.03	1,03,436
Total		**287.166**	**52**	**26.110**	**26,10,862**
Corridor 2 (Baiyappanahalli - Chikkabanawar)					
1	Baiyyappanahalli Terminal	8.626	2	0.78	78,418
2	Kasturi Nagar	9.218	2	0.84	83,800
3	Sevanagar	10.99	2	1.00	99,909
4	Banaswadi	7.753	1	0.70	70,482
5	Kaveri Nagar	15.199	3	1.38	1,38,173
6	Nagawara	22.266	4	2.02	2,02,418
7	Kanakanagara	10.075	2	0.92	91,591
8	Hebbal	7.719	1	0.70	70,173
9	Lottegolahalli	12.176	2	1.11	1,10,691
10	Yeshwantpur	22.886	4	2.08	2,08,055
11	Jalahalli	15.57	3	1.42	1,41,545
12	Shettihalli	20.532	4	1.87	1,86,655
13	Mydarahalli	11.146	2	1.01	1,01,327
14	Chikkabanavar	9.56	2	0.87	86,909
Total		**183.717**	**33**	**17**	**16,70,145**

Sl. No.	Station Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Cost of Bio Digester in ₹ Lakh	Cost of Bio Digester in ₹
Corridor 3 (Kengeri - White Field)					
1	Kengeri	25.321275	5	2.30	2,30,193
2	RV College	11.88	2	1.08	1,08,000
3	Jnanabharati	15.645825	3	1.42	1,42,235
4	Nayandahalli	6.124275	1	0.56	55,675
5	Krishnadevaraya	6.1749	1	0.56	56,135
6	Jagajeevanram Nagar	7.32375	1	0.67	66,580
7	KSR Bengaluru City	18.965475	3	1.72	1,72,413
8	Kumarapark (BDA)	10.32885	2	0.94	93,899
9	Bengaluru Cantt.	13.1004	2	1.19	1,19,095
10	Bengaluru East	10.01025	2	0.91	91,002
11	Baiyyappanahalli	6.506325	1	0.59	59,148
12	Krishanrajapuram	8.5455	2	0.78	77,686
13	Hoodi	5.977125	1	0.54	54,338
14	White Field	0.7047	0	0.06	6,406
Total		**146.608**	**27**	**13**	**13,32,806**
Corridor 4 (Heelalige - Rajankunte)					
1	Heelalige	3.116	1	0.28	28,327
2	Bommasandra	2.941	1	0.27	26,736
3	Singena Agrahara	2.415	0	0.22	21,955
4	Huskur	9.047	2	0.82	82,245
5	Ambedkar Nagar	6.219	1	0.57	56,536
6	Karmelram	24.324	4	2.21	2,21,127
7	Belandur Road	10.14	2	0.92	92,182
8	Marathahalli	12.72	2	1.16	1,15,636
9	Future Station @ Km 199/700	14.05	3	1.28	1,28,000
10	Kagadaspura	15.38	3	1.40	1,39,818
11	Benniganahalli	8.191	1	0.74	74,464
12	Channasandra	14.343	3	1.30	1,30,391
13	Horamavu	19.314	4	1.76	1,75,582
14	Hennur	30.011	5	2.73	2,72,827
15	Tannisandra	36.636	7	3.33	3,33,055
16	RK Hegde Nagar	20.971	4	1.91	1,90,645
17	Jakkur	8.596	2	0.78	78,145
18	Yelahanka	10.356	2	0.94	94,145
19	Muddenahalli	5.656	1	0.51	51,418
20	Rajanukunte	4.725	1	0.43	42,955
Total		**259.151**	**49**	**23.56**	**23,56,189**

11.1.1.1. Cost Estimate of Bio-digesters at BSRP Stations

The cost estimate of Bio-digesters at all stations in all the 4 corridors is given in **Table 11.3.**

Table 11.3. Provision of Bio-digesters at Suburban Rail Stations

Sl. No.	Corridor Name	Waste Water in KLD	Capacity of Bio Digester System in KLD	Cost of Bio Digester in ₹ Lakh
1	Corridor 1 (KSR Bengaluru City - Devanahalli)	287.166	52	26.106
2	Corridor 2 (Baiyappanahalli - Chikkabanawar)	183.717	33	16.701
3	Corridor 3 (Kengeri - White Field)	146.608	27	13.328
4	Corridor 4 (Heelalige - Rajankunte)	259.151	49	23.559
Total		**876.642**	**159**	**79.69**

11.1.1.2. Bio-Digester & Effluent Treatment Plant at Depot

Implementation Bio-digester with Reed bed system approved by DRDO will help to handle human waste as well as waste water at each Depot. In addition to this a ETP is proposed in Depot for treatment of effluent generated. The details of waste water generated and estimated cost of depot is given in **Table 11.4.** The treated waste water may be reused for rail car washing, floor cleaning and flushing purpose in the depot area. Total estimated cost for waste water treatment is ₹ 7.18 Lakhs for depot.

Table 11.4. Capacity and Estimated Cost of Bio-Digester & ETP at Depot

Sl. No.	Corridor No.	Depot Name	Domestic Waste Water in KLD	Waste Water from Car/Train Washing in KLD	Capacity of Bio Digester System in KLD	Estimated cost of Bio-Digester in ₹ Lakh	Estimated cost of ETP ₹ Lakh
Major Depots							
1	Corridor 1	Akkupete Depot	2.04	3.5	0.371	0.19	1.75
2	Corridor 2	Soladevanahalli Depot	2.04	3.5	0.371	0.19	1.75
Micro Depots							
1	Corridor 3	Kengeri Station	1.7	3	0.309	0.15	1.5
2	Corridor 4	Heelalige Station	1.7	3	0.309	0.15	1.5
Total = 4			**7.48**	**13**	**1.36**	**0.68**	**6.5**

11.1.2. Rain Water Harvesting Cost

In view of augmentation of storage of ground water, it is proposed to construct roof top rain water harvesting structure of suitable capacity in the Depot. Ground water shall be recharged through Rainwater harvesting at each depot. One Rainwater harvesting unit for each depot is proposed. The cost estimated is ₹ 91700.00 + ₹ 3000 surcharge for installation of rainwater harvest units during construction phase. Total cost is estimated to be ₹ -312.9 Lakhs.

Table 11.5. Cost Estimate for Provision of Rain Water Harvesting

Sl. No.	Particulars	Amount in ₹. Lakhs					
		Quantity	Corridor 1	Corridor 2	Corridor 3	Corridor 4	Total
1	Rainwater Harvesting @ ₹ 0.917 lakh/Unit + ₹ 3000 Surcharges (LS)*	Quantity	100 x ₹ 94700	65 x ₹94700	51 x ₹ 94700	114x ₹ 94700	330
		Cost ₹ in Lakhs	₹ 94.7	₹ 61.56	₹ 48.30	₹ 108.4	₹ 312.9

11.1.3. Environmental Monitoring/Management Unit Cost

The estimated cost for each corridor for 3 years of Construction is ₹ 29.55 Lakhs and total estimated cost for all corridors is ₹ 118.20 Lakhs. The division will be setup at one location for all the four corridors and capital & recurring costs are distributed equally amongst four corridors. The estimated cost for Environmental Monitoring / Management Unit is as given below (**Table 11.6**) :

Table 11.6. Environmental Monitoring/Management Unit Cost

Sl. No.	Item	Annual Cost (₹)				
		Corridor 1	Corridor 2	Corridor 3	Corridor 4	Total Cost for all Corridors
A. Capital Cost	**Office Establishment - ₹ 50,000/month LS	6,00,000	6,00,000	6,00,000	6,00,000	24,00,000
B Recurring Cost	Man Power Cost					
a.	Environmental Engineer/Officer @ ₹ 60,000/month	7,20,000	7,20,000	7,20,000	7,20,000	28,80,000
b.	Assistant Environmental Engineer @40000/month	4,80,000	4,80,000	4,80,000	4,80,000	19,20,000
c.	Office Assistant @ ₹ 15,000/month	1,80,000	1,80,000	1,80,000	1,80,000	7,20,000
d.	Office Maintenance and consumables @ ₹ 20,000/month	2,40,000	2,40,000	2,40,000	2,40,000	9,60,000
	B. Sub Total=	**16,20,000**	**16,20,000**	**16,20,000**	**16,20,000**	**64,80,000**
C	**Sub Total (A+B)**	**22,20,000**	**22,20,000**	**22,20,000**	**22,20,000**	**88,80,000**
D. Miscellaneous	Miscellaneous - Consumables and unforeseen expenses, LS (10 % of C)	2,22,000	2,22,000	2,22,000	2,22,000	8,88,000

Sl. No.	Item	Annual Cost (₹)				
		Corridor 1	Corridor 2	Corridor 3	Corridor 4	Total Cost for all Corridors
Total cost for establishment of cell for 1 Year		**24,42,000**	**24,42,000**	**24,42,000**	**24,42,000**	**97,68,000**
Total cost for EMU for 3 Years of Construction Period with 10% annual increase		**29.55**	**29.55**	**29.55**	**29.55**	**118.20**
Total cost for EMU for additional 2 Years of Operation Period with 10% annual increase		**35.75**	**35.75**	**35.75**	**35.75**	**143.00**
Total cost for 5 years (Const. 3 Years + Operation 2 Years) with 10% annual increase		**35.75**	**35.75**	**35.75**	**35.75**	**143.00**

***Office Establishment includes Rent, water & electricity consumption, Computer, furniture, communication & Internet facilities, security, etc.*

11.2. Environmental monitoring cost during Operation

The environmental monitoring cost includes the total cost of environmental pollution monitoring and ecological monitoring cost during construction and operation phases of the project.

The details of estimated cost towards environmental Pollution monitoring during operation stage are given in **Table 11.7**.

Table 11.7. Environmental Monitoring Cost during Operation

Sl. No.	Item	Quantity	Total Cost (₹ in Lakhs)
Corridor 1 - KSR Bengaluru City – Devanahalli			
i.	Air Quality Monitoring at ₹12000/sample	12 Samples X 3 times in a year X 2 Years	8.64
ii.	Noise Quality Monitoring at ₹3000/sample	20 Samples X 3 times in a year X 2 Years	3.6
iii.	Soil Quality Monitoring at ₹ 9000/sample	4 Samples X 4 times in a year X 2 Years	2.88
iv.	Water Quality Monitoring at ₹8000/sample	12 Samples X 4 times in a year X 2 Years	7.68
v.	Vibration Monitoring at ₹135000/sample	3 Samples X 4 times in a year X 2 Years	32.4
vi.	Quality of Waste Water at Stations & Depot at ₹ 8500/sample	16 Samples X 4 times in a year X 2 Years	10.88
vii.	Solid Waste Characteristics at Depot at ₹ 12000/sample	1 Sample X 4 times in a year X 2 Years	0.96
Envi. Monitoring Cost for Corridor 1:			**67.04**
Corridor 2 - Baiyappanahalli - Chikkabanawar			
i.	Air Quality Monitoring at ₹ 12000/sample	9 Samples X 3 times in a year X 2 Years	5.76

Sl. No.	Item	Quantity	Total Cost (₹ in Lakhs)
ii.	Noise Quality Monitoring at ₹ 3000/sample	13 Samples X 3 times in a year X 2 Years	2.16
iii.	Soil Quality Monitoring at ₹ 9000/sample	4 Samples X 4 times in a year X 2 Years	2.16
iv.	Water Quality Monitoring at ₹ 8000/sample	12 Samples X 4 times in a year X 2 Years	7.04
v.	Vibration Monitoring at ₹ 135000/sample	3 Samples X 4 times in a year X 2 Years	32.4
vi.	Quality of Waste Water at Stations & Depot at ₹ 8500/sample	16 Samples X 4 times in a year X 2 Years	10.2
vii.	Solid Waste Characteristics at Depot at ₹ 12000/sample	1 Sample X 4 times in a year X 2 Years	0.96
Envi. Monitoring Cost for Corridor 2:			**63.62**
Corridor 3 - Kengeri - White Field			
i.	Air Quality Monitoring at ₹12000/sample	12 Samples X 3 times in a year X 2 Years	8.64
ii.	Noise Quality Monitoring at ₹3000/sample	24 Samples X 3 times in a year X 2 Years	4.32
iii.	Soil Quality Monitoring at ₹ 9000/sample	4 Samples X 4 times in a year X 2 Years	2.88
iv.	Water Quality Monitoring at ₹8000/sample	16 Samples X 4 times in a year X 2 Years	10.24
v.	Vibration Monitoring at ₹135000/sample	3 Samples X 4 times in a year X 2 Years	32.4
vi.	Quality of Waste Water at Stations & Depot at ₹ 8500/sample	14 Samples X 4 times in a year X 2 Years	9.52
vii.	Solid Waste Characteristics at Depot at ₹ 12000/sample	1 Sample X 4 times in a year X 2 Years	0.96
Envi. Monitoring Cost for Corridor 3:			**68.96**
Corridor 4 - Heelalige - Rajankunte			
i.	Air Quality Monitoring at ₹12000/sample	15 Samples X 3 times in a year X 2 Years	10.8
ii.	Noise Quality Monitoring at ₹3000/sample	24 Samples X 3 times in a year X 2 Years	4.32
iii.	Soil Quality Monitoring at ₹ 9000/sample	5 Samples X 4 times in a year X 2 Years	3.6
iv.	Water Quality Monitoring at ₹8000/sample	21 Samples X 4 times in a year X 2 Years	13.44
v.	Vibration Monitoring at ₹135000/sample	3 Samples X 4 times in a year X 2 Years	32.4
vi.	Quality of Waste Water at Stations & Depot at ₹ 8500/sample	21 Samples X 4 times in a year X 2 Years	14.28
vii.	Solid Waste Characteristics at Depot at ₹ 12000/sample	1 Sample X 4 times in a year X 2 Years	0.96

Sl. No.	Item	Quantity	Total Cost (₹ in Lakhs)
Envi. Monitoring Cost for Corridor 4:			**79.8**

The environmental monitoring cost during operation phase is ₹ 67.04 Lakhs for Corridor 1 (KSR Bengaluru City – Devanahalli), ₹ 63.62 Lakhs for Corridor 2 (Baiyappanahalli - Chikkabanawar), ₹ 68.96 Lakhs for Corridor 3 (Kengeri - White Field) and ₹ 79.8 Lakhs for Corridor 4 (Heelalige - Rajankunte). The total estimated cost towards environmental monitoring during operation will be ₹ 279.42 Lakhs and the responsibility of monitoring lies with EMU.

11.2.1. Capacity Building Training Cost

During operation stage of the project, the periodical EMP training (for 6 sessions of 3 days each) will be imparted by Environmental Engineer/Officer from EMU, PIA, K RIDE (one for each corridor – totally 4 Officers are required for EMU, PIA, K RIDE for one year duration) for K RIDE engineers, Managers and all the workers. The training modules will cover implementation of EMP, occupational safety and Health, Community safety and Health, Risk Assessment, Disaster Management and Emergency Response Actions. The task modules for all the corridors will remain same. In addition to the Training he will also assist the EMU, PIA in site inspections as and when required; and he will be responsible to (a) monitor implementation of approved EMP (b) monitor environmental status (c) monitor risks and disaster probabilities and (d) preparation of Training and Site Inspection Reports. The Assistant Environmental Engineer will support the Environmental Engineer/Officer in EMP training and overall implementation activities (one for each corridor – totally 4 Assistants are required for EMU, PIA, K RIDE for one year duration).

The cost is estimated to be ₹ 12.20 Lakhs for each corridor as given in **Table 11.8.** The curriculum for all the corridors will be same. One Assistant Environmental Engineer for each corridor (is considered and cost is distributed equally among the each corridor.

Table 11.8. Cost Estimate for Training Program

Sl. No.	Particulars	Cost (₹)
1	Module Development and Material preparation - 1 month ₹ 50,000 LS	50,000
2	Environmental Engineer/Officer for 1 year (₹ 60,000/month)	7,20,000
3	Assistant Environmental Engineer (₹25,000/month)	3,00,000
4	Presentation Aids (LS)	1,00,000
5	Miscellaneous (LS)	50,000
Total		**12,20,000**

11.3. Summary of EMP Implementation Cost

The total estimated environmental management and monitoring cost for the proposed project is **₹ 7227.54 Lakhs** including Compensatory Afforestation and Transplantation charges and the same is detailed corridor wise in **Table 11.9** & **11.10**. The cost towards environmental monitoring and rain water harvesting during construction phase will be the part of Civil Contract and remaining cost will be the part of Project Implementation Authority (PIA). The Compensatory afforestation cost including Transplantation cost, if any, will be decided by the Forest Authority in consultation with K RIDE after the finalization of Tree enumeration by the Forest Department. Source for unit cost consider for preparation EMP implementation is presented as **Annexure 11.1.**

Table 11.9. Summary of Total Cost Estimation for Implementation of Environmental Management Plan for Corridor 1 & 2

Sl. No.	Particulars	Amount in ₹.			
		Quantity	Corridor 1	Quantity	Corridor 2
1	Compensatory Afforestation & Transplantation @ ₹ 1630 per Tree (Forest SR)	247030 x ₹ 1630	₹ 40,26,58,900.00	34690 x ₹1630	₹ 5,65,44,700.00
2	Solid Concrete Noise Barriers at sensitive receptors @ 0.20 Lakh/meter (KPWD SR)	545 x ₹ 20000	₹ 1,09,00,000.00	1161 x ₹ 20000	₹ 2,32,20,000.00
3	Rainwater Harvesting @ ₹ 0.917 lakh/Unit + ₹ 3000 Surcharges (KPWD SR)	100 x ₹ 94700	₹ 94,70,000.00	65 x ₹94700	₹ 61,55,500.00
4	Oil Interceptor with Silt Trap @ 0.15 lakh/Unit (as per agency price in India Mart)	1 x ₹ 15000 (Base Camp) + 1 x ₹ 15000 (Depot)	₹ 15,000.00	1 x ₹ 15000	₹ 15,000.00
5	A. Environmental Monitoring during Construction (Quotation Received)				
	Air Quality Monitoring @ ₹ 10000/sample	8 Samples X 12 times in a year X 3 Years x ₹ 10000/sample	₹ 28,80,000.00	7 Samples X 12 times in a year X 3 Years x ₹ 10000/sample	₹ 25,20,000.00
	Noise Quality Monitoring ₹ 2500/sample	10 Samples X 12 times in a year X 3 Years x ₹ 2500/sample	₹ 9,00,000.00	7 Samples X 12 times in a year X 3 Years x ₹ 2500/sample	₹ 6,30,000.00
	Soil Quality Monitoring ₹ 8000/sample	4 Samples X 4 times in a year X 3 Years x ₹ 8000/sample	₹ 3,84,000.00	5 Samples X 4 times in a year X 3 Years x ₹ 8000/sample	₹ 4,80,000.00
	Water Quality Monitoring ₹ 7000/sample	8 Samples X 4 times in a year X 3 Years x ₹7000/sample	₹ 6,72,000.00	9 Samples X 4 times in a year X 3 Years x ₹7000/sample	₹ 7,56,000.00
	Vibration Monitoring ₹ 120000/sample	3 Samples X 4 times in a year X 3 Year x ₹ 120000/sample	₹ 43,20,000.00	3 Samples X 4 times in a year X 3 Year x ₹ 120000/sample	₹ 43,20,000.00
	Ecological Monitoring (Seasonal Assessment of Water body and Biodiversity - Flora) ₹ 20000/- LS per assessment	3 times in a year X 3 Years x ₹ 20000/assessment	₹ 1,80,000.00	3 times in a year X 3 Years x ₹ 20000/assessment	₹ 1,80,000.00
	*Workers Health and Safety monitoring at ₹ 10000/Session	4 times in a year X 3 Years		4 times in a year X 3 Years	
	*Workers and Community Health and Safety Orientation Program at ₹ 5000/Session	4 times in a year X 3 Years		4 times in a year X 3 Years	
	A. Sub-Total		₹ 93,36,000.00		₹ 88,86,000.00

Sl. No.	Particulars	Amount in ₹.			
		Quantity	Corridor 1	Quantity	Corridor 2
	B. Environmental Monitoring during Operation (Quotation Received)				
	Air Quality Monitoring ₹ 10000/sample	12 Samples X 12 times in a year X 2 Years x ₹ 12000/sample	₹ 8,64,000.00	9 Samples X 12 times in a year X 2 Years x ₹ 12000/sample	₹ 6,48,000.00
	Noise Quality Monitoring ₹ 2500/sample	20 Samples X 12 times in a year X 2 Years x ₹ 3000/sample	₹ 3,60,000.00	13 Samples X 12 times in a year X 2 Years x ₹ 3000/sample	₹ 2,34,000.00
	Soil Quality Monitoring ₹ 8000/sample	4 Samples X 4 times in a year X 2 Years x ₹ 9000/sample	₹ 2,88,000.00	4 Samples X 4 times in a year X 2 Years x ₹ 9000/sample	₹ 2,88,000.00
	Water Quality Monitoring ₹ 7000/sample	12 Samples X 4 times in a year X 2 Years x ₹8000/sample	₹ 7,68,000.00	12 Samples X 4 times in a year X 2 Years x ₹8000/sample	₹ 7,68,000.00
	Vibration Monitoring ₹ 120000/sample	3 Samples X 4 times in a year X 2 Year x ₹ 135000/sample	₹ 32,40,000.00	3 Samples X 4 times in a year X 2 Year x ₹ 135000/sample	₹ 32,40,000.00
	Quality of Waste Water (LS)**	16 Samples X 4 times in a year X 2 Years x ₹8500/sample	₹ 10,88,000.00	16 Samples X 4 times in a year X 2 Years x ₹8500/sample	₹ 10,88,000.00
	Solid Waste Management at Depot (LS)**	1 Sample X 4 times in a year X 2 Years x ₹12000/sample	₹ 96,000.00	1 Sample X 4 times in a year X 2 Years x ₹12000/sample	₹ 96,000.00
	B. Sub-Total		₹ 67,04,000.00		₹ 67,04,000.00
6	EHS Training and Extension (as per the current expenses on Training aids, fees for preparation of Training modules and arrangement)	₹ 1220000/Training	₹ 12,20,000.00	₹ 1220000/Training	₹ 12,20,000.00
7	Environment Management Unit/Cell (LS) (3 construction & 2 years of operation)	₹ 35,75,000/5 years	₹ 35,75,000.00	₹ 35,75,000/5 years	₹ 35,75,000.00
8	Environmental Auditor (LS) (to monitoring and auditing the implementation of EMP measures during construction and operation phase)	₹ 20,00,000/5 years	₹ 20,00,000.00	₹ 20,00,000/5 years	₹ 20,00,000.00
9	Waste Water Treatment through Bio Digesters for Stations & Depot (DRDO) (as per agency price in India Mart)	₹ 26,10,000.00	₹ 27,80,000.00	₹ 13,00,000.00	₹ 16,70,000.00

Sl. No.	Particulars	Amount in ₹.			
		Quantity	Corridor 1	Quantity	Corridor 2
10	Effluent Treatment Plant for Depot for 100 KLD (as per agency price in India Mart)	₹ 1,75,000.00	₹ 1,75,000.00	₹ 1,75,000.00	₹ 1,75,000.00
Total Cost in ₹.			**₹ 44,86,63,900**		**₹ 10,98,23,200**
Total in ₹. Lakh			**₹ 4486.6390**		**₹ 1098.232**

Table 11.10. Summary of Total Cost Estimation for Implementation of Environmental Management Plan for Corridor 3 & 4

Sl. No.	Particulars	Amount in ₹.			
		Quantity	Corridor 3	Quantity	Corridor 4
1	Compensatory Afforestation & Transplantation : Compensatory Afforestation @ ₹ 1630 per Tree (Forest SR)	20720 x ₹ 1630	₹ 3,37,73,600.00	23060 x ₹ 1630	₹ 3,75,87,800.00
2	Soild Concrete Noise Barriers at sensitive receptors @ 0.20 Lakh/meter (KPWD SR)	937 x ₹ 20000	₹ 1,87,40,000.00	415 x ₹ 20000	₹ 83,00,000.00
3	Rainwater Harvesting @ ₹ 0.917 lakh/Unit + ₹ 3000 Surcharges (KPWD SR)	51 x ₹ 94700	₹ 48,29,700.00	113 x ₹ 94700	₹ 1,07,95,800.00
4	Oil Interceptor with Silt Trap @ 0.15 lakh/Unit (LS) (as per agency price in India Mart)	1 x ₹ 15000	₹ 15,000.00	1 x ₹ 15000	₹ 15,000.00
5	A. Environmental Monitoring during Construction (Quotation Received)				
	Air Quality Monitoring @ ₹ 10000/sample	6 Samples X 12 times in a year X 3 Years x ₹ 10000/sample	₹ 21,60,000.00	8 Samples X 12 times in a year X 3 Years x ₹ 10000/sample	₹ 28,80,000.00
	Noise Quality Monitoring ₹ 2500/sample	7 Samples X 12 times in a year X 3 Years x ₹ 2500/sample	₹ 6,30,000.00	10 Samples X 12 times in a year X 3 Years x ₹ 2500/sample	₹ 9,00,000.00
	Soil Quality Monitoring ₹ 8000/sample	3 Samples X 4 times in a year X 3 Years x ₹ 8000/sample	₹ 2,88,000.00	4 Samples X 4 times in a year X 3 Years x ₹ 8000/sample	₹ 3,84,000.00
	Water Quality Monitoring ₹ 7000/sample	8 Samples X 4 times in a year X 3 Years x ₹7000/sample	₹ 6,72,000.00	10 Samples X 4 times in a year X 3 Years x ₹7000/sample	₹ 8,40,000.00

Sl. No.	Particulars	Amount in ₹.			
		Quantity	Corridor 3	Quantity	Corridor 4
	Vibration Monitoring ₹ 120000/sample	3 Samples X 4 times in a year X 3 Year x ₹ 120000/sample	₹ 43,20,000.00	3 Samples X 4 times in a year X 3 Year x ₹ 120000/sample	₹ 43,20,000.00
	Ecological Monitoring (Seasonal Assessment of Water body and Biodiversity - Flora) ₹ 20000/-LS per assessment	3 times in a year X 3 Years x ₹ 20000/assessment	₹ 1,80,000.00	3 times in a year X 3 Years x ₹ 20000/assessment	₹ 1,80,000.00
	*Worker's Health and Safety monitoring at ₹ 10000/Session	4 times in a year X 3 Years		4 times in a year X 3 Years	
	*Workers and Community Health and Safety Orientation Program at ₹ 5000/Session	4 times in a year X 3 Years		4 times in a year X 3 Years	
	A. Sub-Total		₹ 82,50,000.00		₹ 95,04,000.00
	B. Environmental Monitoring during Operation (Quotation Received)				
	Air Quality Monitoring ₹ 10000/sample	12 Samples X 12 times in a year X 2 Years x ₹ 12000/sample	₹ 8,64,000.00	15 Samples X 12 times in a year X 2 Years x ₹ 12000/sample	₹ 10,80,000.00
	Noise Quality Monitoring ₹ 2500/sample	24 Samples X 12 times in a year X 2 Years x ₹ 3000/sample	₹ 4,32,000.00	24 Samples X 12 times in a year X 2 Years x ₹ 3000/sample	₹ 4,32,000.00
	Soil Quality Monitoring ₹ 8000/sample	4 Samples X 4 times in a year X 2 Years x ₹ 9000/sample	₹ 2,88,000.00	5 Samples X 4 times in a year X 2 Years x ₹ 9000/sample	₹ 3,60,000.00
	Water Quality Monitoring ₹ 7000/sample	16 Samples X 4 times in a year X 2 Years x ₹8000/sample	₹ 10,24,000.00	21 Samples X 4 times in a year X 2 Years x ₹8000/sample	₹ 13,44,000.00
	Vibration Monitoring ₹ 120000/sample	3 Samples X 4 times in a year X 2 Year x ₹ 135000/sample	₹ 32,40,000.00	3 Samples X 4 times in a year X 2 Year x ₹ 135000/sample	₹ 32,40,000.00
	Quality of Waste Water (LS)**	14 Samples X 4 times in a year X 2 Years x ₹8500/sample	₹ 9,52,000.00	21 Samples X 4 times in a year X 2 Years x ₹8500/sample	₹ 14,28,000.00
	Solid Waste Management at Depot (LS)**	1 Sample X 4 times in a year X 2 Years x ₹12000/sample	₹ 96,000.00	1 Sample X 4 times in a year X 2 Years x ₹12000/sample	₹ 96,000.00
	B. Sub-Total		₹ 68,96,000.00		₹ 78,84,000.00

Sl. No.	Particulars	Amount in ₹.			
		Quantity	Corridor 3	Quantity	Corridor 4
6	EHS Training and Extension (as per the current expenses on Training aids, fees for preparation of Training modules and arrangement)	₹ 1220000/Training	₹ 12,20,000.00	₹ 1220000/Training	₹ 12,20,000.00
7	Environment Management Unit/Cell (3 construction & 2 years of operation)	₹ 35,75,000/5 years	₹ 35,75,000.00	₹ 3575000/5 years	₹ 35,75,000.00
8	Environmental Auditor (LS) (to monitoring and auditing the implementation of EMP measures during construction and operation phase)	₹ 20,00,000/5 years	₹ 20,00,000.00	₹ 20,00,000/5 years	₹ 20,00,000.00
9	Waste Water Treatment through Bio Digesters for Stations & Depot (as per agency price in India Mart)	₹ 15,80,000.00	₹ 13,30,000.00	₹ 23,60,000.00	₹ 23,60,000.00
10	Effluent Treatment Plant for Depot for 100 KLD (as per agency price in India Mart)	₹ 1,50,000.00	₹ 1,50,000.00	₹ 1,50,000.00	₹ 1,50,000.00
Total Cost in ₹.			**₹ 8,07,79,300**		**₹ 8,34,87,600**
Total in Rs. Lakh			**₹ 807.793**		**₹ 834.876**

*Note: * Included in the Contracts under EHS clause. Hence, no separate cost is estimated for the same.*

Source Backup :

***Oil Interceptor with Silt Trap @ ₹ 0.12 lakh/Unit (as per agency price in India Mart) + Surcharges of ₹ 3,000/unit*	*Unit source enclosed*
***Training and Extension (LS)** (as per the current expenses on Training aids, fees for preparation of Training modules and arrangement)*	-
***Envi. Management Unit/Cell (LS) (as per the current price of Office & office items on rent basis and remuneration for Experts and Assistants)*	-
***Waste Water Treatment through Bio Digesters for Stations & Depot (DRDO) (Approx. Price of DRDO Bio-digester 500 lit – Rs. 25,000/- to 10 KLD 2 lakhs + Installation and other Surcharges ₹ 5,000)*	*Unit source enclosed*
***ETP for Depot ₹ 1,00,000 for 1to 5 KLD (₹ 1,00,000 /- per unit of 1 - 5 KLD + Surcharges & Implementation charges of approx. ₹ 50,000/- LS)*	*Unit source enclosed*
EHS Training and Extension (as per the current expenses on Training aids, fees for preparation of Training modules and arrangement)	*Estimated Cost*
Environment Management Unit/Cell (LS) (as per the current price of Office establishment & office items on rent basis and remuneration for Experts and Assistants; and other expenses) - (Cost estimate is for 3 Years of Construction and 2 Years of Operation Stage)	*Estimated Cost*
Ecological Monitoring (Seasonal Assessment of Water body and Biodiversity - Flora) ₹ 20000/- LS per assessment	*Estimated Cost*

Chapter 12. Conclusions

The Environmental Impact Assessment Report for the proposed BSRP Corridors ie., Corridor 1 - KSR Bengaluru City to Devanahalli, Corridor 2 - Baiyyappanahalli Terminal to Chikkabanavara, Corridor 3 - Kengeri to Whitefield and Corridor 4 - Heelalige to Rajanukunte provides the detailed information of baseline environmental condition, project improvement details and positive and negative environmental and social impacts of the project. After detailed assessment following conclusions are drawn for implementation of the project.

The proposed project will enhance rural-urban connectivity, ease traffic congestion, and provide a cleaner mobility solution to lakhs of daily commuters. It will play a key role to boost economic progress of the state. The project will enhance the air quality in Bengaluru city due to introduction of Suburban Railway as there will be drastic reduction in vehicular traffic resulting in the reduction in greenhouse gas emissions. It was also revealed in the public interactions that, the proposed project will help in resolving the traffic congestion of Bengaluru and enhance the overall environmental condition of the region.

To mitigate the risks & impacts during construction and operation stages of the project, a comprehensive environmental management and monitoring plan has been prepared using the ESS of WB, the EIB & the KfW, General EHS guidelines, Railway specific EHS Guidelines and other relevant Good International Industry Practices (GIIPs) and guidelines stipulated in Environmental Impact Assessment Notification for linear projects by MoEFCC. With this, the proposed project is unlikely to cause any significant adverse effects on the surrounding environment. To make the project environmentally sound and sustainable, the EMP will be made part of the contractual/bid document and will be ensured that, the implementation of EMP measures are contractors responsibility under the supervision and guidance of GC and K RIDE.

The Project will reduce the use of personal vehicles, increase the transit mode share and will contribute to community re-development through the stimulation of future concentrated and mixed land use, as well as a positive business environment. It will contribute to environmental sustainability initiatives by reducing regional car trips, enhance community livability and reducing greenhouse gas (GHG) emissions. Project operation is expected to have a positive effect on air quality since the Project will use an EMU train which is exhaust-free and quieter compared to diesel and locomotive-drawn multiple units. As such, the Project's contribution to the cumulative impacts particularly during the operation would be positive.

During project operations, due to existing high background noise levels along portions of the alignment caused by the existing volume of road traffic in the area and vicinities, receptors may experience a low to moderate noise impact close to the proposed stations and maintenance depots. This will be mitigated by an operating schedule of day time and erection of site specific noise attenuation panels at the stations such that the Project's contribution to cumulative impact on noise is considered not significant. Vibration levels associated with project operations (i.e., train passing by) will be largely imperceptible.

On the socio economic front the project has both positive and negative impact. As there is very minimum impacts of land acquisition, since BSRP alignments and stations are proposed within Indian Railway Land. There is insignificant impact on livelihood and economic activities of the project area.

On the other hand accessibility and connectivity increases. Thus, the time of travel between project localities shall reduce significantly. With the advent of the Suburban railway the vehicle operating and congestion of roads is expected to go down substantially.

Based on the foregoing, the Project along with related infrastructure development projects within the area will result in positive long-term benefits in air quality, public health, safety, and travel time savings and connectivity. No adverse residual effects to human health will occur as a result of project construction or operation. While exposure to elevated noise levels, fugitive dust and gaseous emissions will occur in proximity to project work sites during construction, due to their short-term, localized nature, these effects are expected to be minor. Project operations will benefit the general public by contributing to the long-term improvement of air quality in the area. By providing a viable alternative to the use of private vehicles, it will also reduce traffic volumes, relieve traffic congestion, and improve community liveability.

Chapter 13. Reference

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