

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,

SOUTHERN ZONE, CHENNAI

O.A. NO. 236 of 2024 (SZ)

BETWEEN:

Suo moto proceedings initiated
Based on news item titled "Over
2000 citizens oppose felling of
33000 trees for Bengaluru Suburban
Railway Project Report" appearing
in the Hindustan Times
dated 11.06.2024

PETITIONER

AND:

Bruhat Bengaluru Mahanagara Palike
And others

RESPONDENTS

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CHENNAI

DATE: 25/10/24



ADVOCATE FOR RESPONDENT NO.2

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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



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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

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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

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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

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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

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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
SO ₂	:	Sulphur dioxide

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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
tCO ₂ e	:	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

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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
km ²	:	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	Baiyyappanahalli 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

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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.

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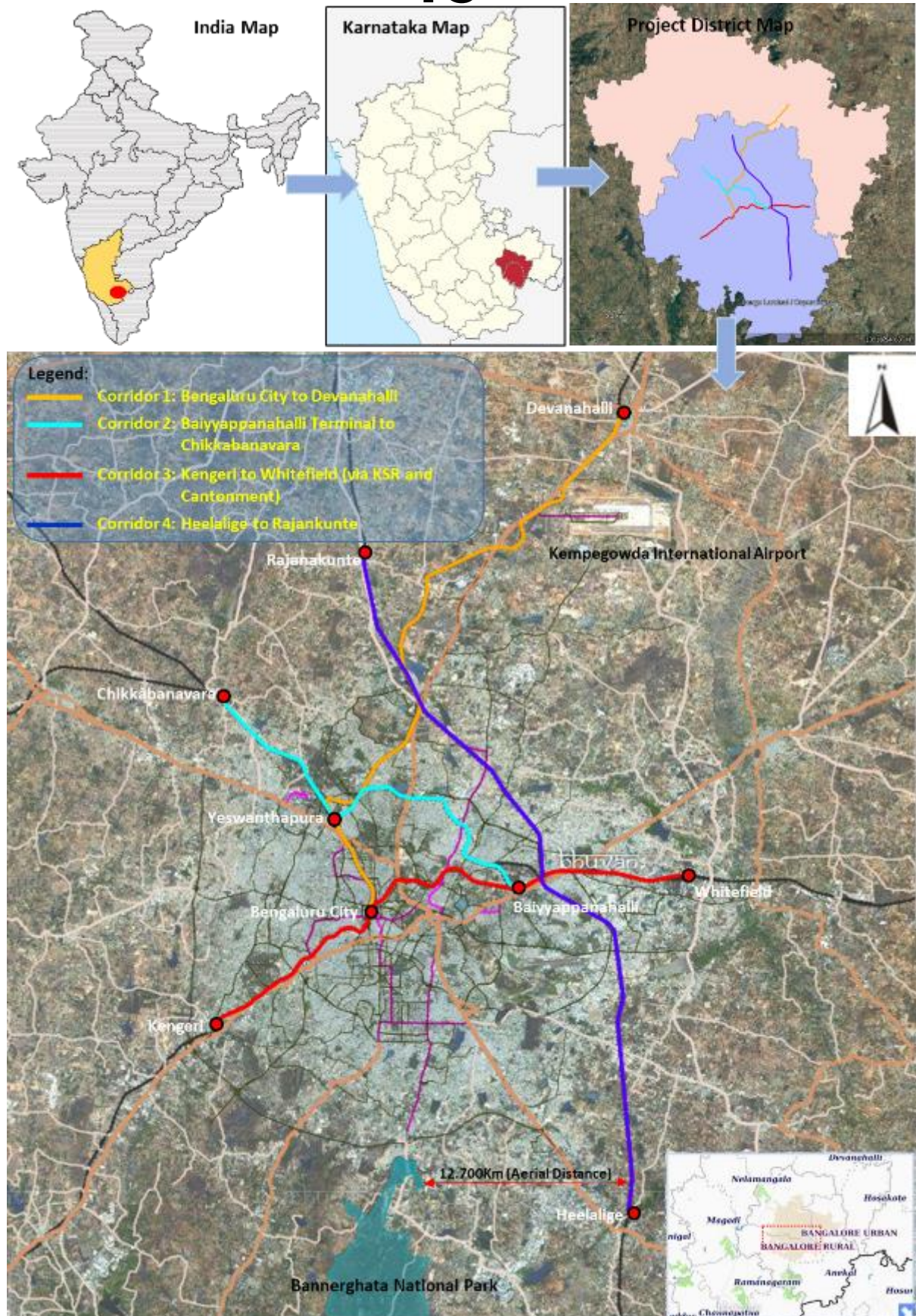


Figure 1.1. Key Map of the Bengaluru Suburban Railway Project Corridors

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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

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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, BESCO, 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

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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)

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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

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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 construction 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

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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 Geddalhalli (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

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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 (PM_{2.5}), Respirable Particulate Matter (PM₁₀), Sulphur dioxide (SO₂), Nitrogen oxides (NO_x), 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 PM₁₀, PM_{2.5}, SO₂, NO_x, 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.

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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.

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In Corridor 4, the ambient noise level exceeds the permissible level of CPCB standards in Bangalore 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.

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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 variety 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 in Natural and Critical Habitats. However, project alignment passes through modified forest (agricultural land and plantation 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*

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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

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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.

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- 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 – ██████████	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: ██████████	Discussed on forest spread along project corridors

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SI 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/hazard 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 presence 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/hazard 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 advised to undertake

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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 explained that necessary permission required to obtain from this Authority prior to initiating 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 conducted at cultural heritage sites i.e., 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 anticipate 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;

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- 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

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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.

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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.

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Environmental Issue/Attributes	Mitigation Measures
	<p>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.</p> <p>After compacting, water will be sprayed on the earthwork regularly to prevent dust.</p> <p>Material transportation will be carried out in covered vehicles</p> <p>Vehicles and machinery will be regularly checked to conform to the CPCB Standards for emission</p> <p>Concrete mixing, batch mix plant, will be well sealed. equipped with dust suppression system</p> <p>Workers at mixing sites will wear nasal masks to reduce the chances of exposure to fine dusts (PM₁₀& PM_{2.5})</p> <p>Regular monitoring of PM₁₀, PM_{2.5}, SO₂, NO₂, CO and /HC will be carried out as mentioned in the Environmental Monitoring Plan</p>
Noise Pollution from Construction vehicles and Machinery	<p>The plants and equipment used for construction will strictly conform to CPCB noise standards.</p> <p>Vehicles and equipment used will be fitted with silencer and maintain accordingly.</p> <p>Noise standards of industrial enterprises will be strictly enforced to protect construction workers from severe noise impacts.</p> <p>Noise levels to be monitored (for 24 hrs.) as per monitoring plan</p>
Loss or Damage to Vegetation	<p>Apart from trees earmarked for felling, no additional tree clearing within the RoW will be carried out.</p> <p>Area of tree plantation cleared will be replaced according to compensatory Afforestation Policy under Forest Conservation Act-1980.</p>
Compaction of Vegetation	<p>Construction vehicles, machinery and equipment will move or be stationed in the designated area only to prevent compaction of vegetation outside the RoW.</p> <p>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.</p>
Occupational Health & Safety	<p>The Contractor will comply with the requirements of the Environmental, Health, and Safety (EHS), Guidelines of the World Bank Group, April 2007¹ and the statutory norms of safety during Construction. The relevant ones are general guidelines available on the internet.</p> <p>Adequate drainage, sanitation and waste disposal will be provided at workplaces.</p> <p>Proper drainage will be maintained around sites to avoid water logging leading to various diseases.</p> <p>Adequate sanitation and waste disposal facilities will be provided at construction camps by means of septic tanks, soakage pits etc.</p> <p>A health care system will be maintained at construction camp for routine check-up of workers and avoidance of spread of any communicable disease</p>

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Environmental Issue/Attributes	Mitigation Measures
	<p>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.</p> <p>The electrical equipment will be checked regularly</p> <p>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.</p> <p>Strict enforcement of labour laws to discourage child labour and forced labour</p> <p>The Contractor will organize awareness program on HIV aids and sexually transmitted diseases (STDs) for workers on periodic basis.</p>
Infection of Covid Virus	<p>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.</p> <p>The Contractor will periodically organise awareness camps on prevention and control of COVID-19 spread.</p> <p>The Contractor will strictly follow the government instructions on COVID-19</p> <p>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.</p>
Community Health and Safety	<p>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</p> <p>To ensure safe construction in the temporary accesses during Construction, lighting devices and safety signal devices will be install.</p> <p>Traffic rules and regulations will be strictly adhered to.</p> <p>Railway & road safety education will be imparted to drivers running construction vehicles.</p> <p>Adequate signage, barriers and persons with flags during construction to control the traffic will be provided.</p> <p>Temporary makeshift pathways and wooden planks will be provided for public and nearby property owners to access their property.</p> <p>Proper barricading will be provided at all the work sites, near habitation areas and camp sites will be</p> <p>At all-time safe access for public movement near habitation area will be ensured</p>
Archaeology and religious and cultural hearitage	<p>Interpretation panels/signage must be provided for the monument.</p> <p>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.</p> <p>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</p>

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Environmental Issue/Attributes	Mitigation Measures
	<p>Prior permission must be obtained from the Competent Authority for any construction or increase in height.</p> <p>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.</p> <p>Affected religious/ cultural structures shall be suitably relocated in consultation with local community and urban local bodies.</p>
Clean-up Operations, Restoration and Rehabilitation	<p>Contractor will prepare site restoration plans, which will be approved by the Engineer.</p> <p>The clean-up and restoration operations are to be implemented by the Contractor prior to demobilization.</p> <p>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).</p> <p>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.</p> <p>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).</p>
Operation Phase	
Monitoring of Operation Performance	<p>The K RIDE will monitor the operational performance of the various mitigation/enhancement measures carried out as a part of the project.</p> <p>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.</p>
Maintenance of Drainage	<p>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..</p>
Pollution Monitoring	<p>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.</p> <p>K RIDE will appoint MOEFCC/NABL/ approved pollution monitoring agency/Laboratory for this purpose.</p>
Noise Pollution	<p>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.</p>

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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, NO_x – 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,

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- 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

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- 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.

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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	<p>Transplantation of trees shall be carried out by the BBMP Forest Wing and Forest Authority in consultation with K RIDE.</p> <p>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.</p> <p>Compensatory afforestation and its maintenance for loss of trees will be undertaken by Bengaluru Rural Forest division as per these above Acts/guidelines.</p>	Design Consultant/GC & K RIDE

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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 available 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

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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

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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

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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

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Sl. No.	Implementation Activity and Environmental Impact Issue	Mitigation Measures with Applicable Laws/Acts/Guidelines	Executing /Supervision
C9	Air Pollution Control	<p>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.</p> <p>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.</p>	Contractor/GC & K RIDE
C10	Noise Pollution Control	<p>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.</p>	Contractor/GC & K RIDE
C11	Vibration Control	<p>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.</p>	Contractor/GC & K RIDE

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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

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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 0.5m ² 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

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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

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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

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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

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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 evaluate the implementation of EMP during construction and operation phase. Following figure indicate the institutional organisation for EMP implementation.

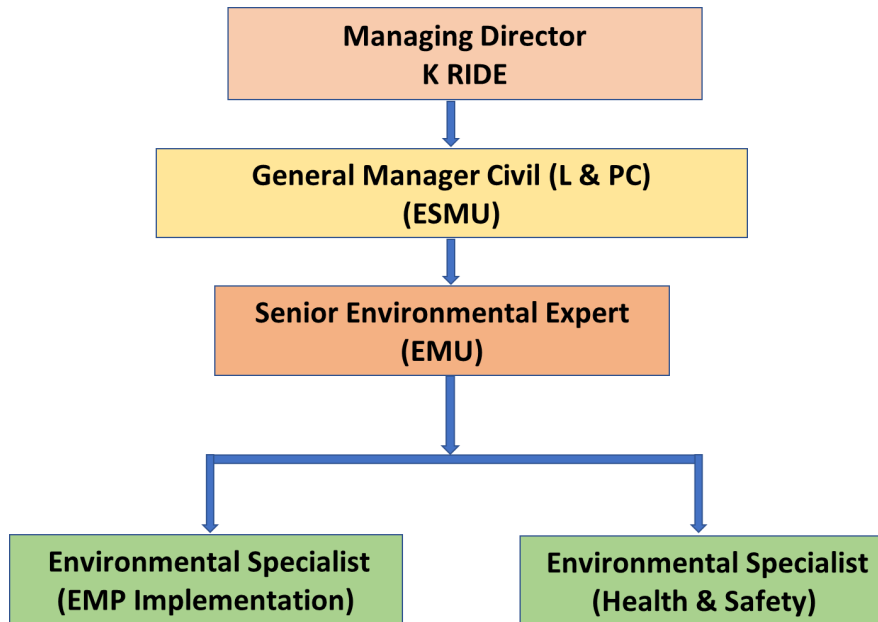


Figure.1.2. Organization Structure of PIA’s Environmental Management Unit

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

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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.

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- 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

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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 length 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: Baiyappanahalli 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

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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**.

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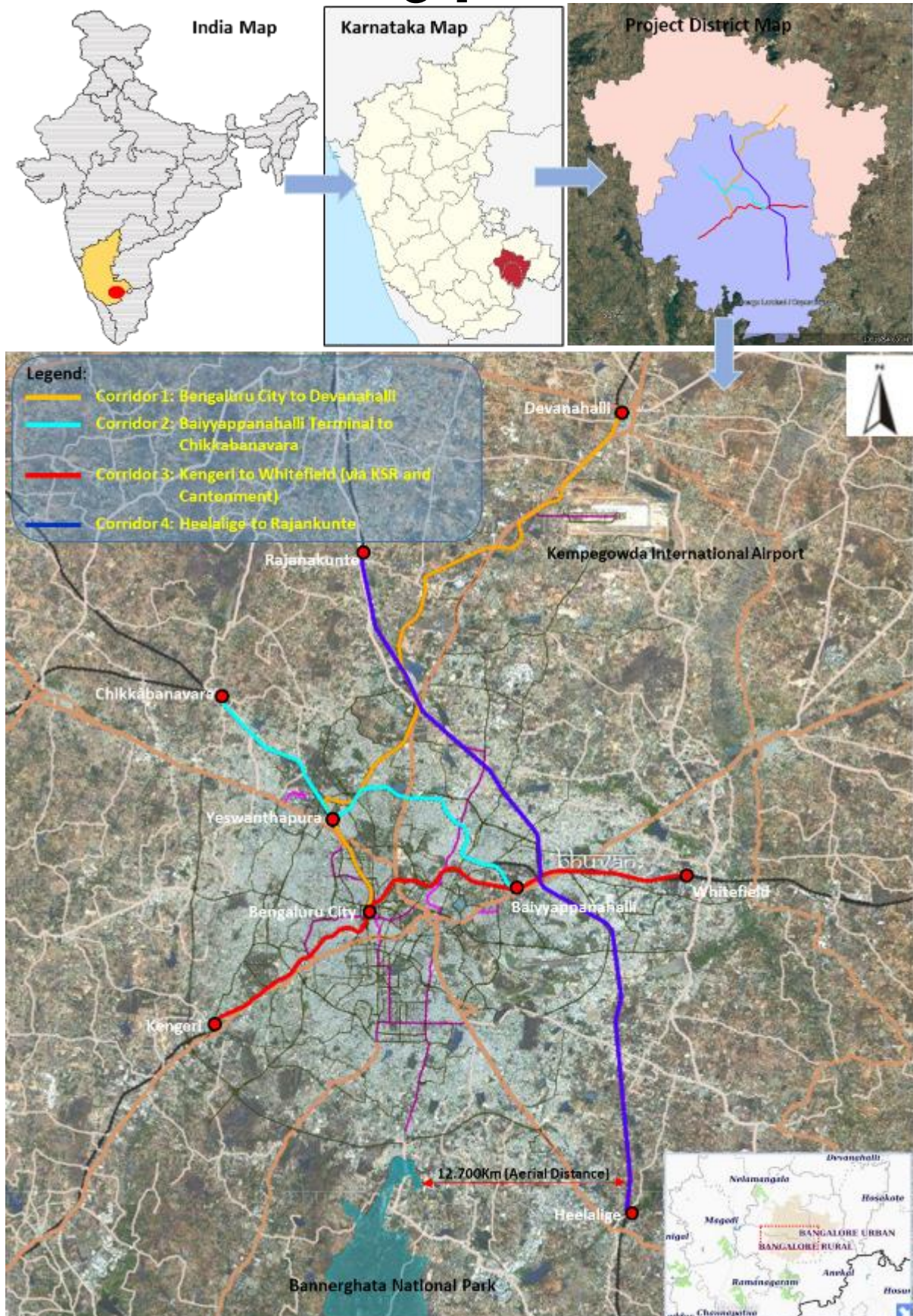


Figure 2.1. Key Map of the Bengaluru Suburban Railway Project Corridors

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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.

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- 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.

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- 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 devices 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.

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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.

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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 through 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

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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 km 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**.

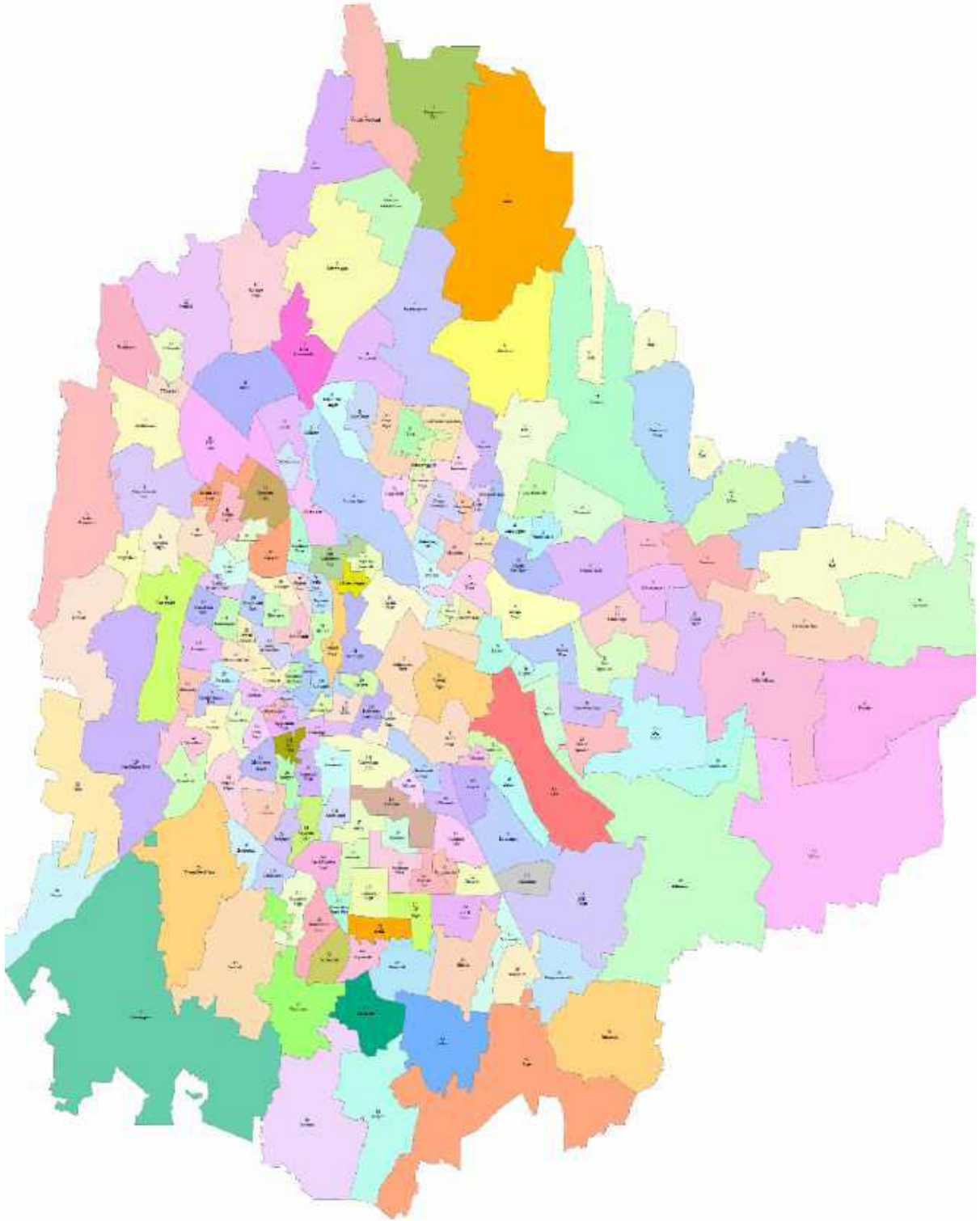


Figure 3.1. Traffic Zone System

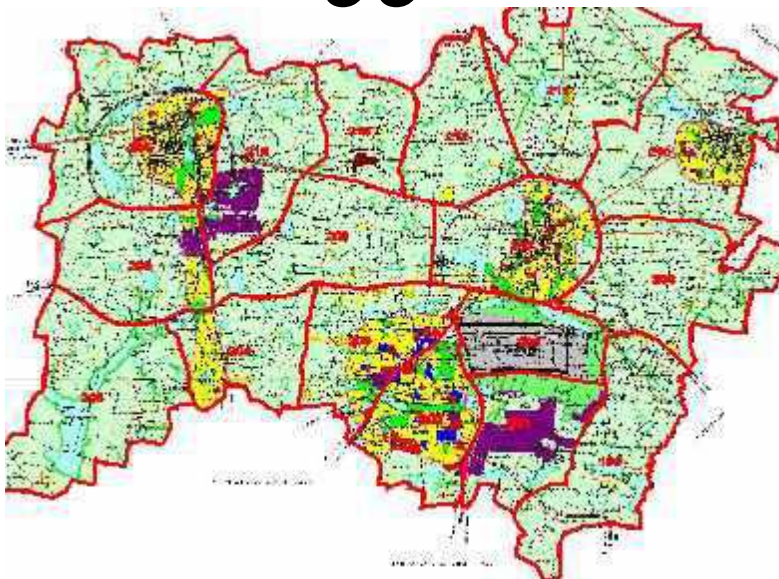


Figure 3.2. Traffic Zone System of BIAAPA

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-matriculantes or have completed matriculation or intermediate (12th 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.

100

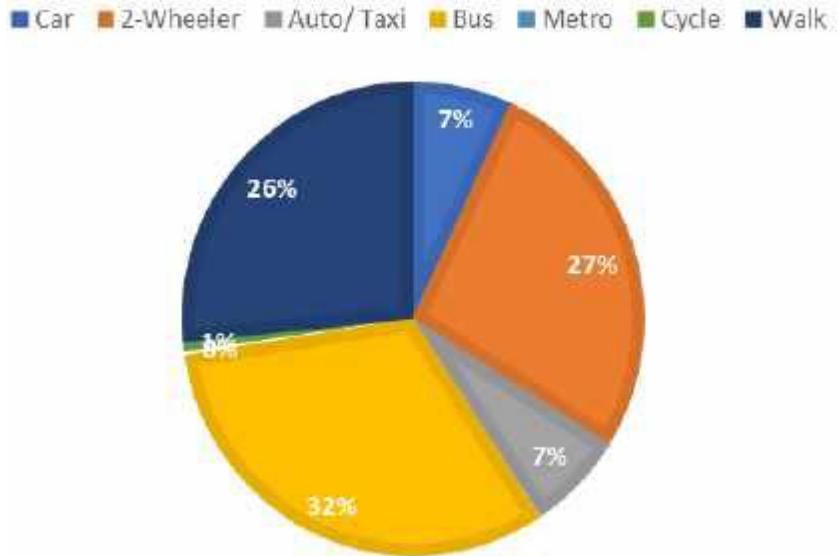


Figure 3.3. Modal Split - 2015 (Including Walk Trips)

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

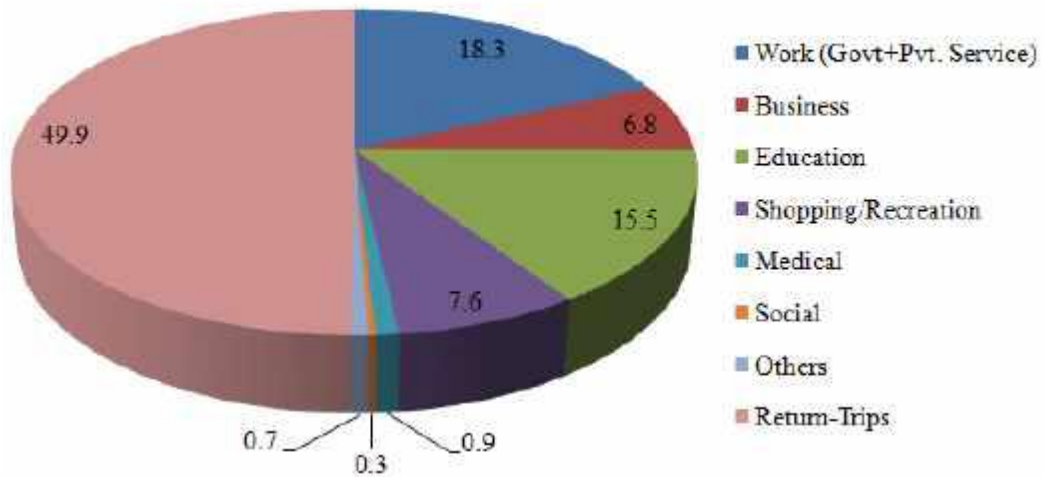


Figure 3.4. Purpose-wise Distribution of Total Trips

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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

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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

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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:

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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

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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**.

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Bengaluru Suburban Rail Project (BSRP) (Total sanctioned length-148.17 km)

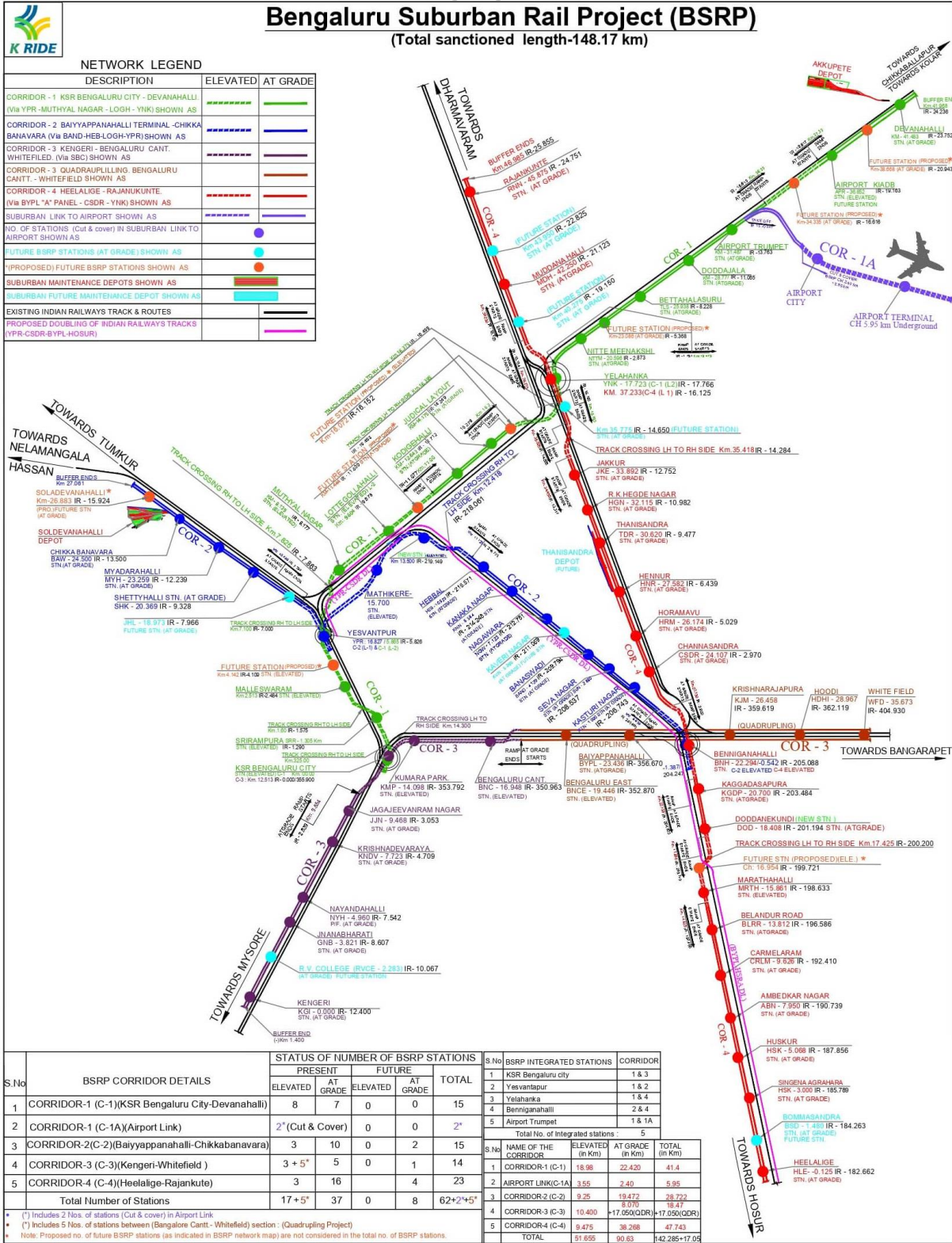


Figure 3.5. System Map of the Bengaluru Suburban Railway Project Corridors

3.3.5. Design Modification in BSRP Corridors

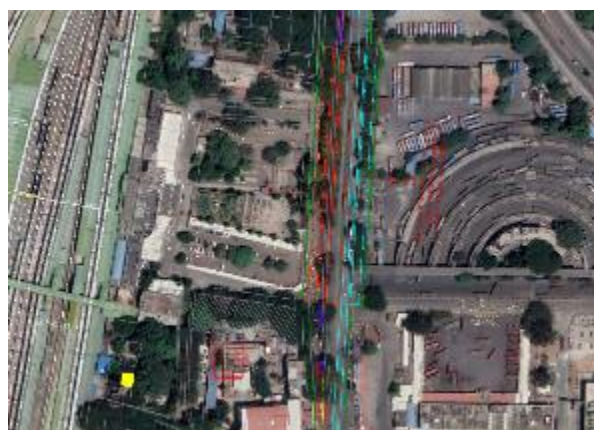
Due to some design change, there are a few changes made in the Stations locations, levels, included new stations and depot. Details of design modification are incorporated in the project are given in the following table.

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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 shifted 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

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Corridor 1 - Srirampura Station



Corridor 1 - Yeswantpur Station



Corridor 1 - Yelahanka Station

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Corridor 1 - Nitte Meenakshi & Doddajala



Corridor 1 - Airport KIADB



Corridor 1 - New Future Station

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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.

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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 onelstand 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**.

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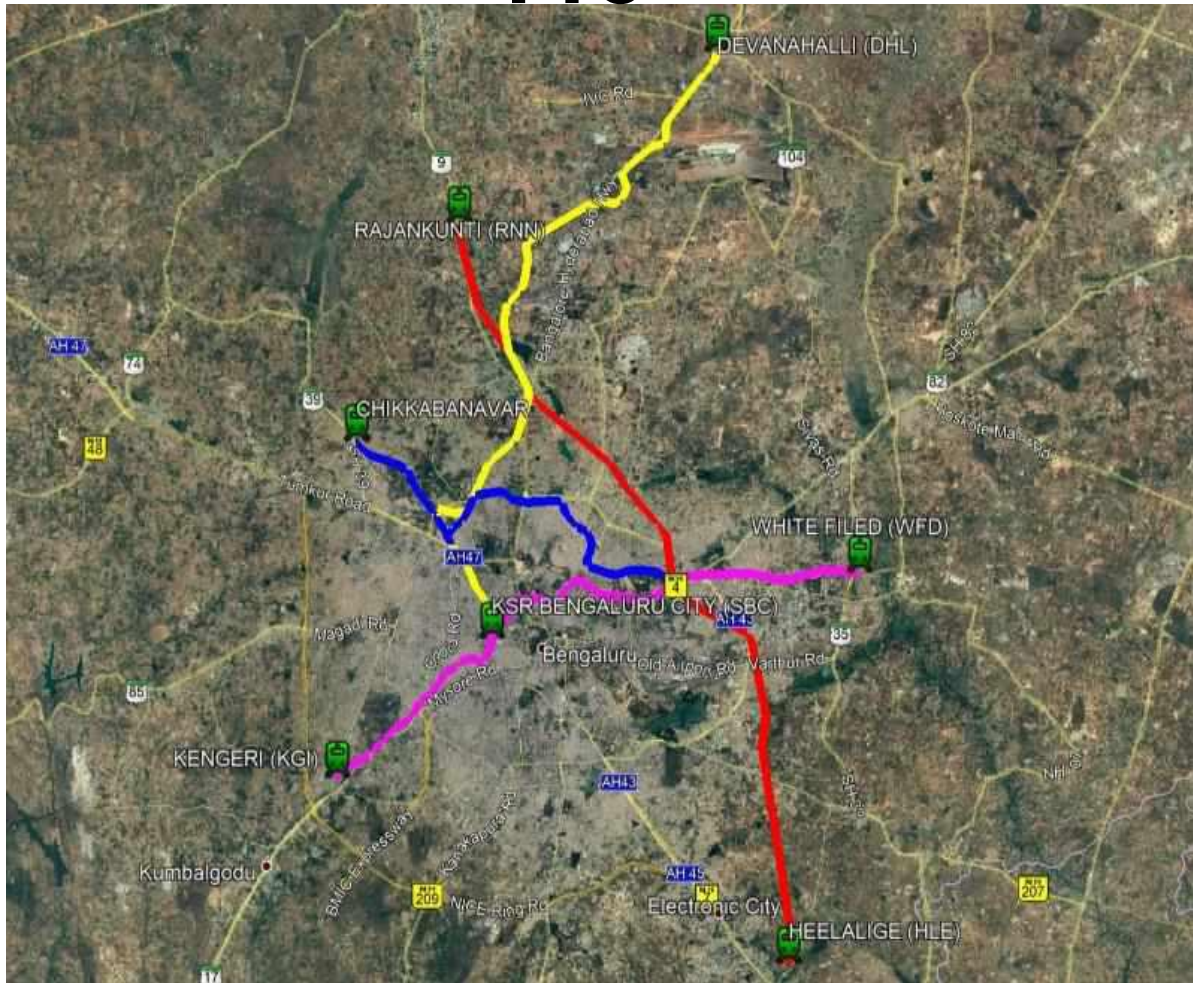


Figure 3.7. Proposed Suburban Rail Corridors in Bengaluru

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.

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- 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).

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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.

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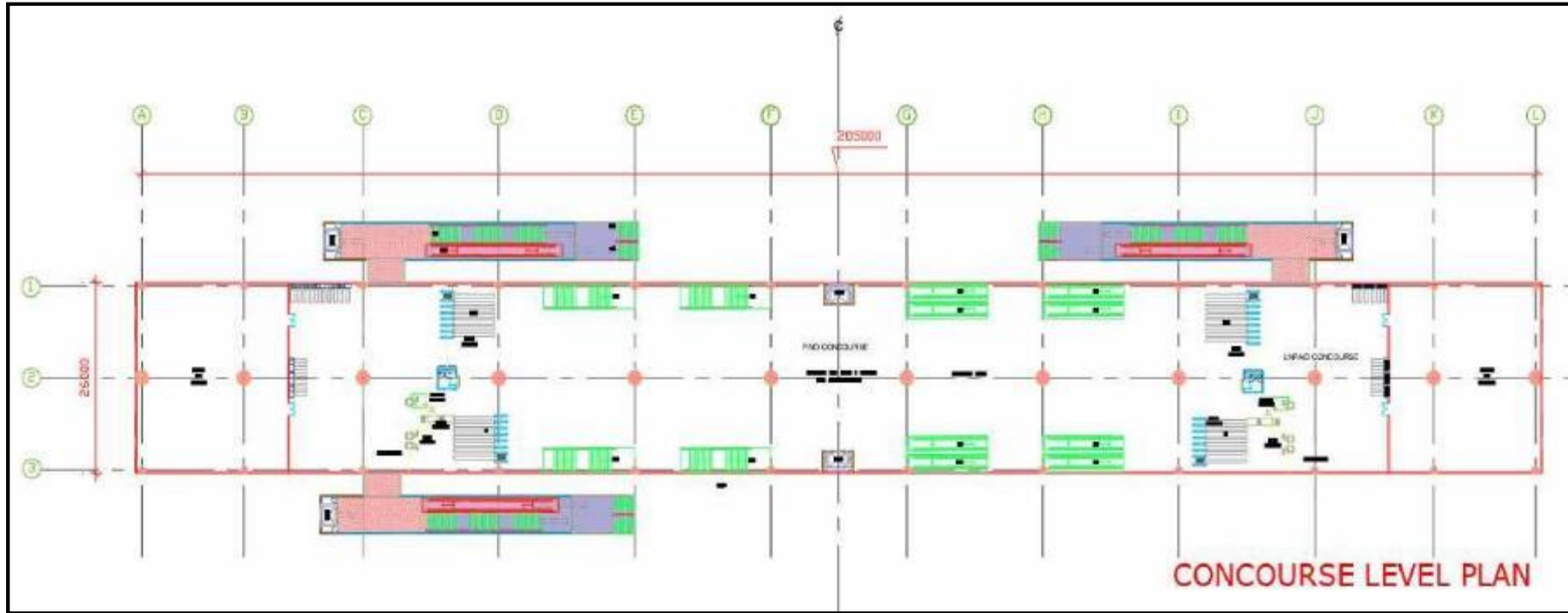


Figure 3.8. Kengeri Suburban Station (Concourse Level Plan)

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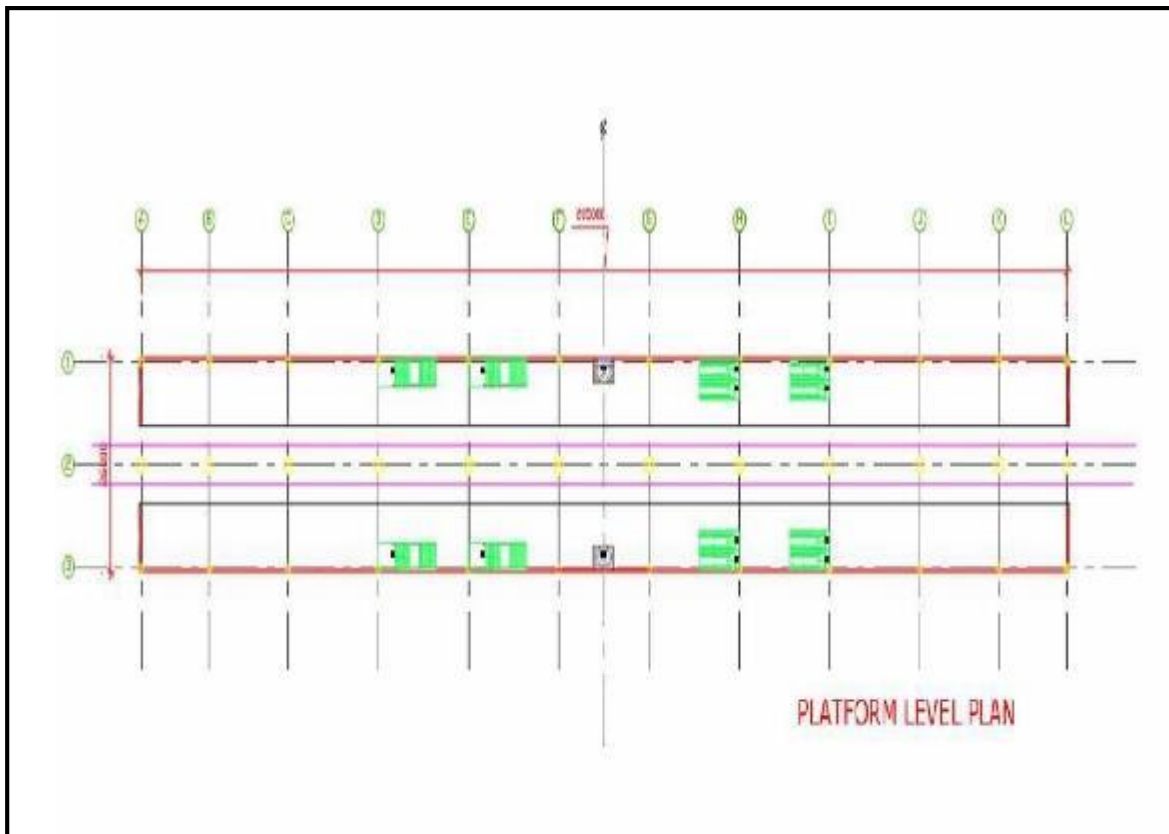


Figure 3.9. Kengeri sub station (Platform Level Plan)

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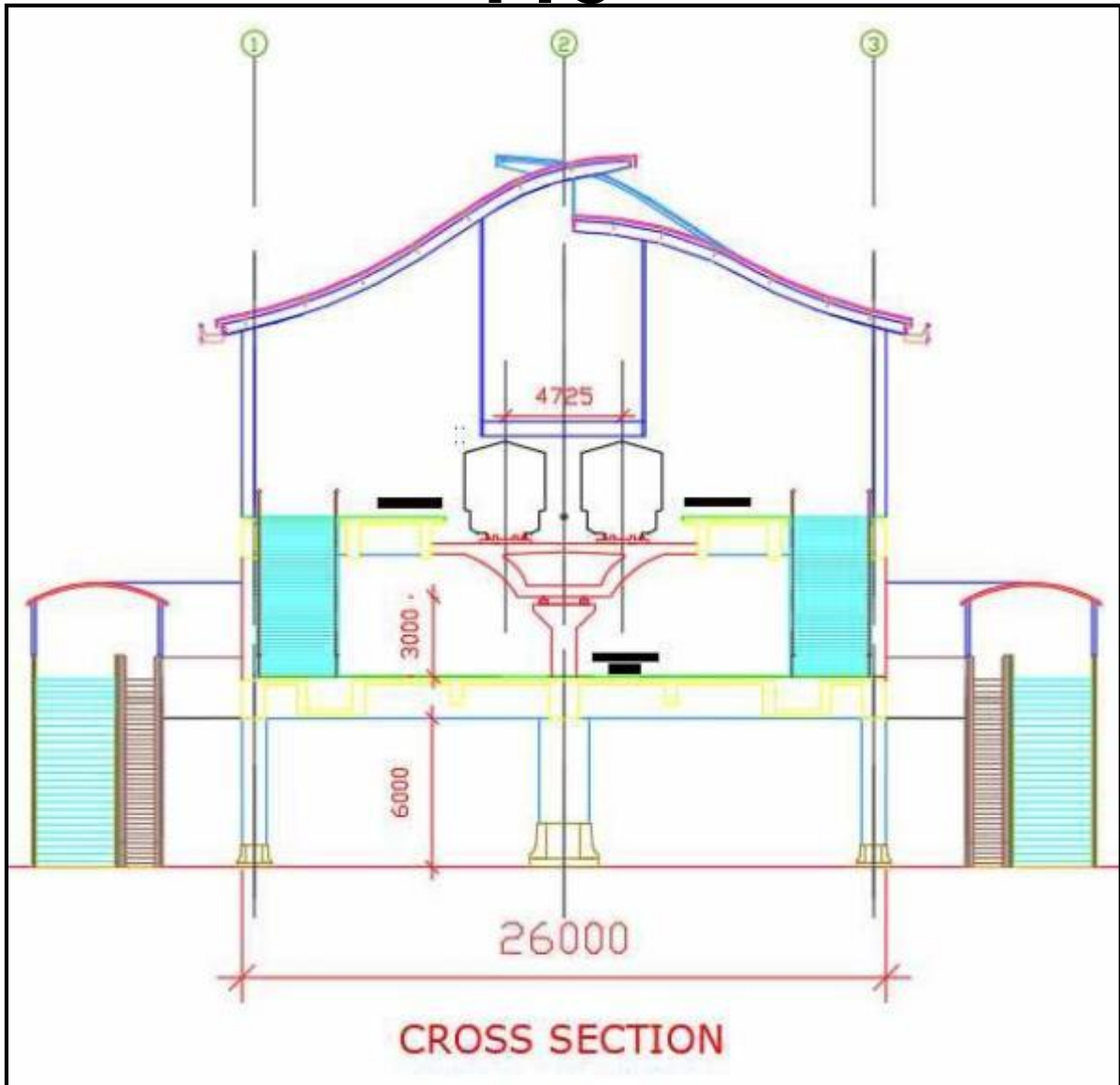


Figure 3.10. Kengeri Suburban Station (Cross-Section)

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Figure 3.11. Proposed Kengeri Suburban Station on Site

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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.

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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

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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).

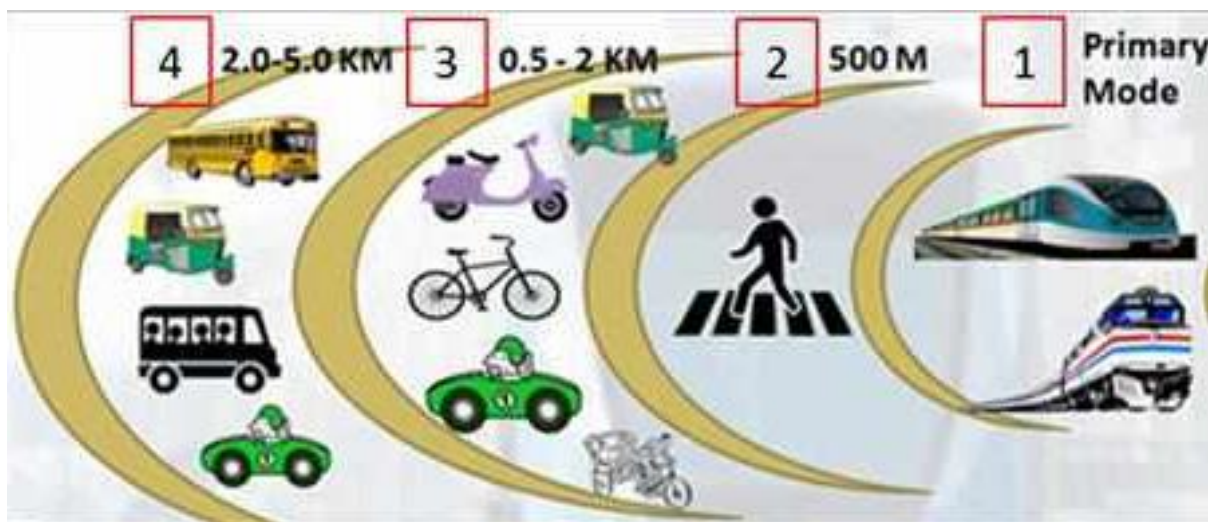


Figure 3.16. Intermodal Integration with Different Modes

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.

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- 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 Bengaluru 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.

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- 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 facilitating traffic 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 pedestrian and 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.

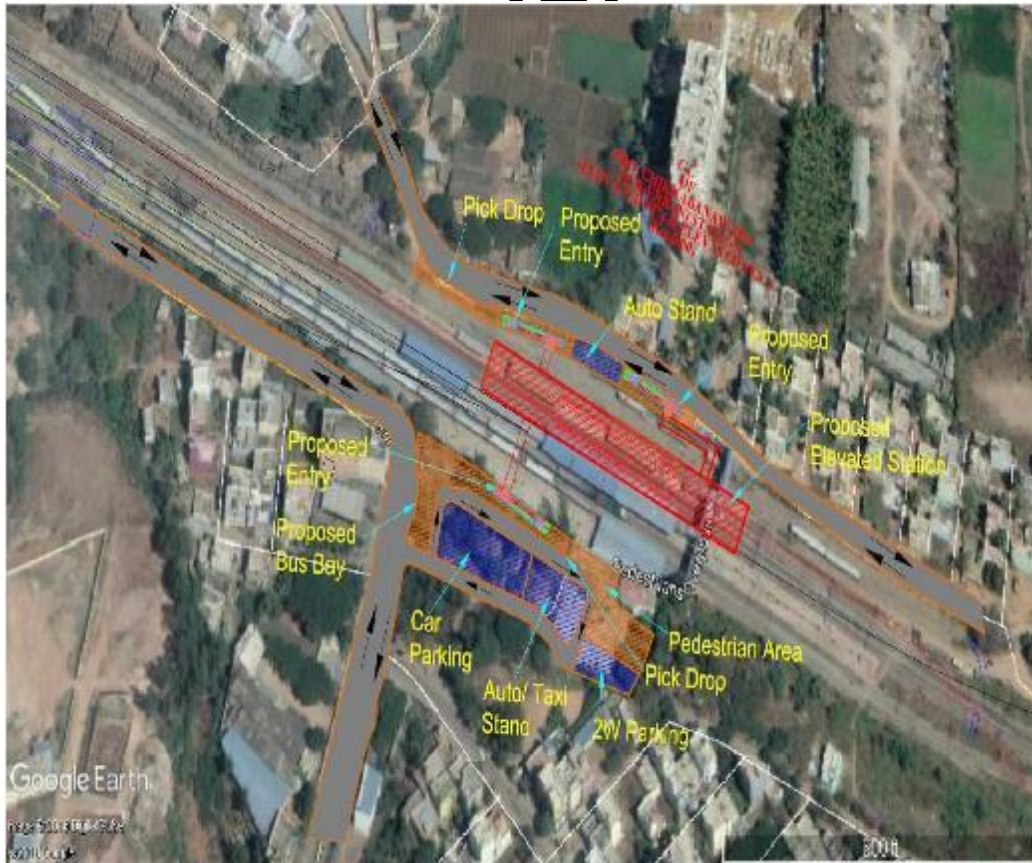


Figure 3.18. Conceptual Intermodal Integration Plan at Chikkabanavara Station

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.

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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

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Corridor	Item	2025	2031	2041
Corridor 1 (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
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

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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

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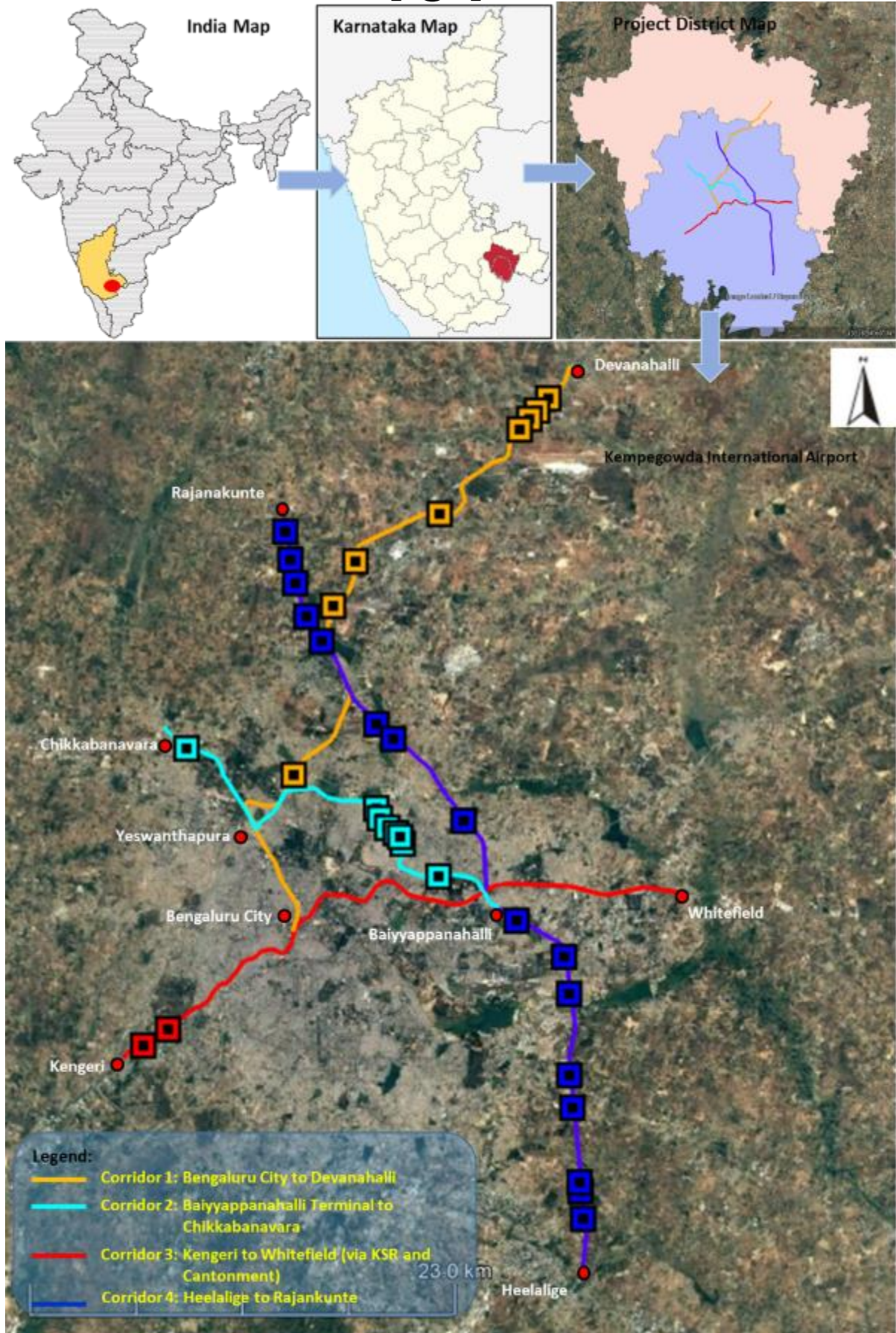


Figure 3.19. Corridor wise Level Crossing Locations

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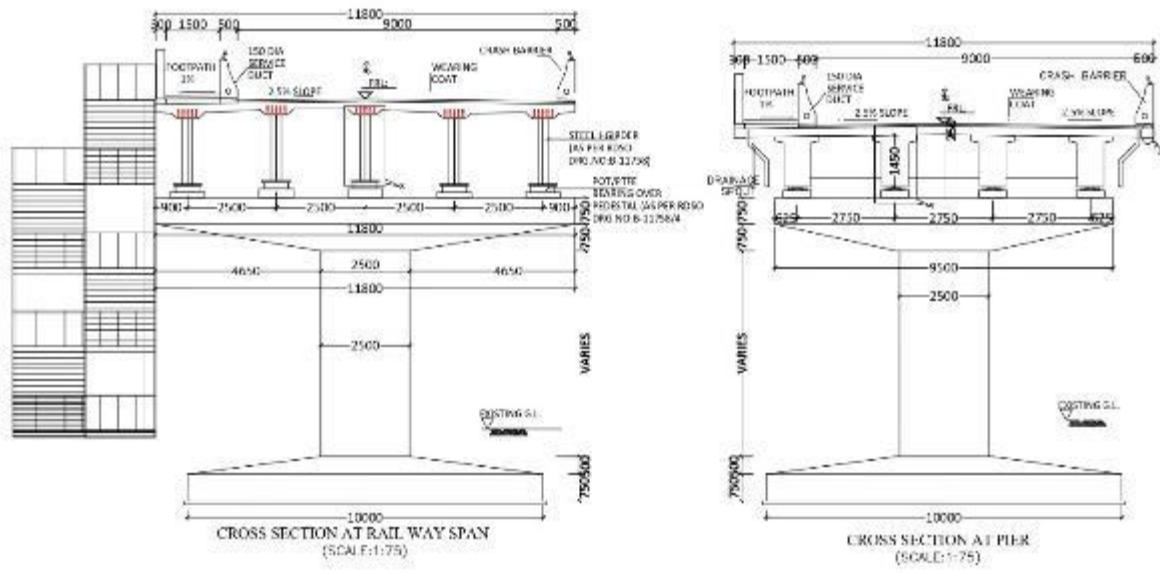
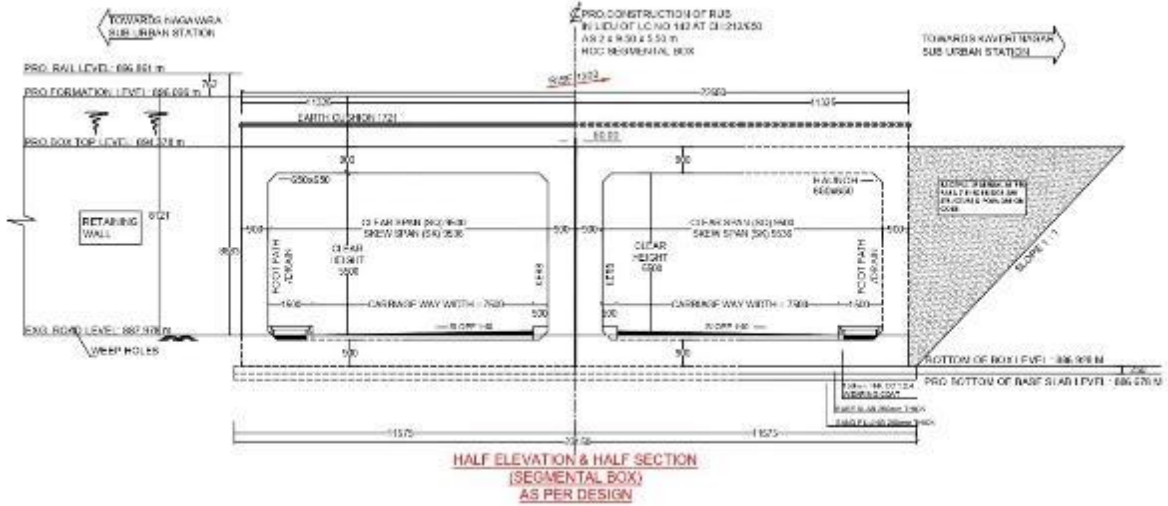


Figure 3.20. Typical Cross Section of RUB & ROB Proposed in BSRP

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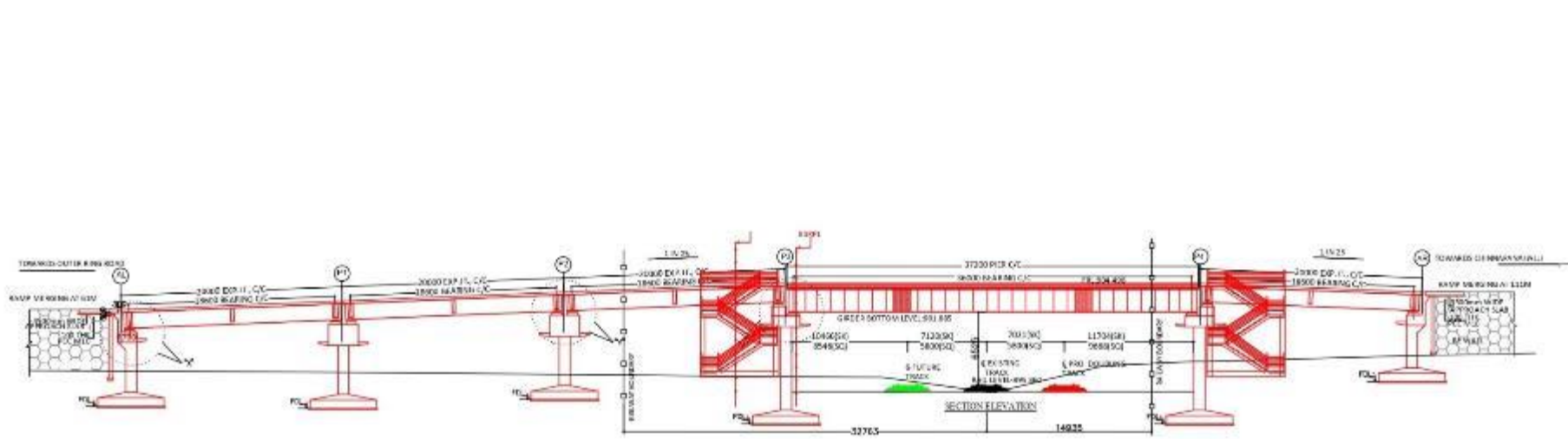


Figure 3.21. Typical Arrangement of RUB Proposed in BSRP

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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 Trucks – 20 nos.

Girder Launching Equipment Vehicles – 04 nos.

Dozers – 10 nos.

Rollers – 10 nos.

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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 m ³
Quantity Construction/ Demolition waste generated in m ³	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 equipment and machineries. 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 CO ₂ & 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
CO ₂	1966166	2301512	2724768	3222739

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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.

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K RIDE		Bengaluru Suburban Railway Project (BSRP) Corridor - 2		LARSSEN & TOUBRO	
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 Description	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 @ Bennanganahalli, 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 / construction vehicle equipment used for the activities	Type of Equipment		Number	
		GTI Machines Mobilized to Site	1		
		Backhoe Loader Mobilized to Site	1		
		Mobile Crane Mobilized 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 Gauge	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		LARSSEN & TOUBRO		
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 Description	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 handling @ 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.	Translocation 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			




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K RIDE		Bengaluru Suburban Railway Project (BSRP) Corridor - 2		LARSSEN & TOUBRO			
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 Description	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			
		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			
		IIIRA		20			
		Training Conducted to Workmen					
		HIV Awareness Training (Lottegahalli)		17			
		Safety Precautions while working in Vicinity of IR Track (Beniganahalli)		8			
		Piling Safety		8			
		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			
		Training man hours FLS		0			
		Training man hours Workmen		48			
Jan-23							
Training man hours Staffs		573					
Training man hours FLS		4					
Training man hours Workmen		24					
Dec-22							
Training man hours Staffs		101					
Training man hours FLS		1					
Training man hours Workmen		23					
Nov-22							
Training man hours Staffs		96					
Training man hours FLS		10					
Training 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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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 Description	Details Required	Remarks
15	Current Activities 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	75
		At grade portion other than elevated portion of alignment	29
		Structures	65
		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.

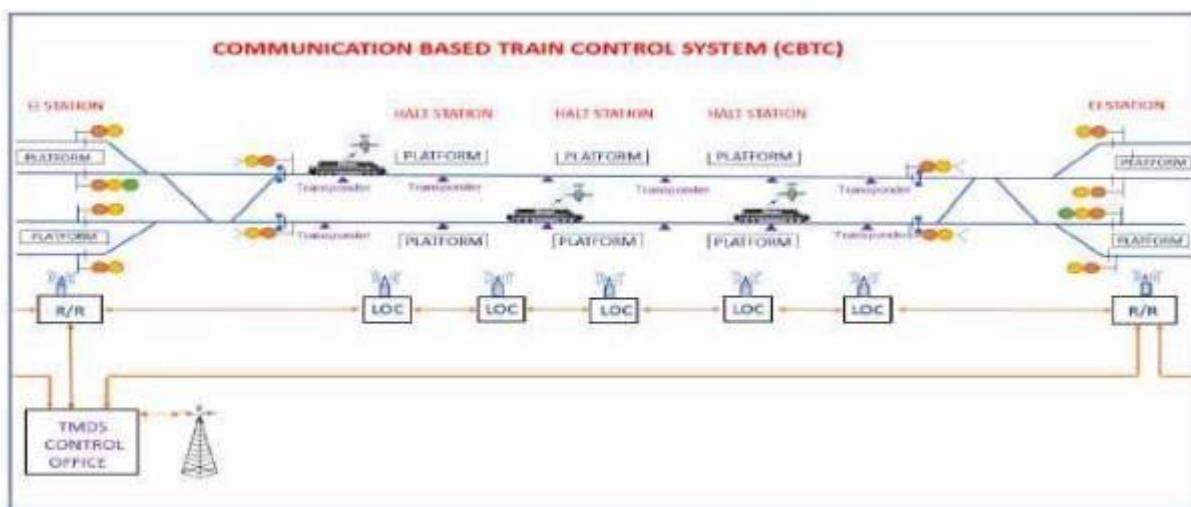


Figure 3.22. Communication Based Train Control System

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:

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- 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.

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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

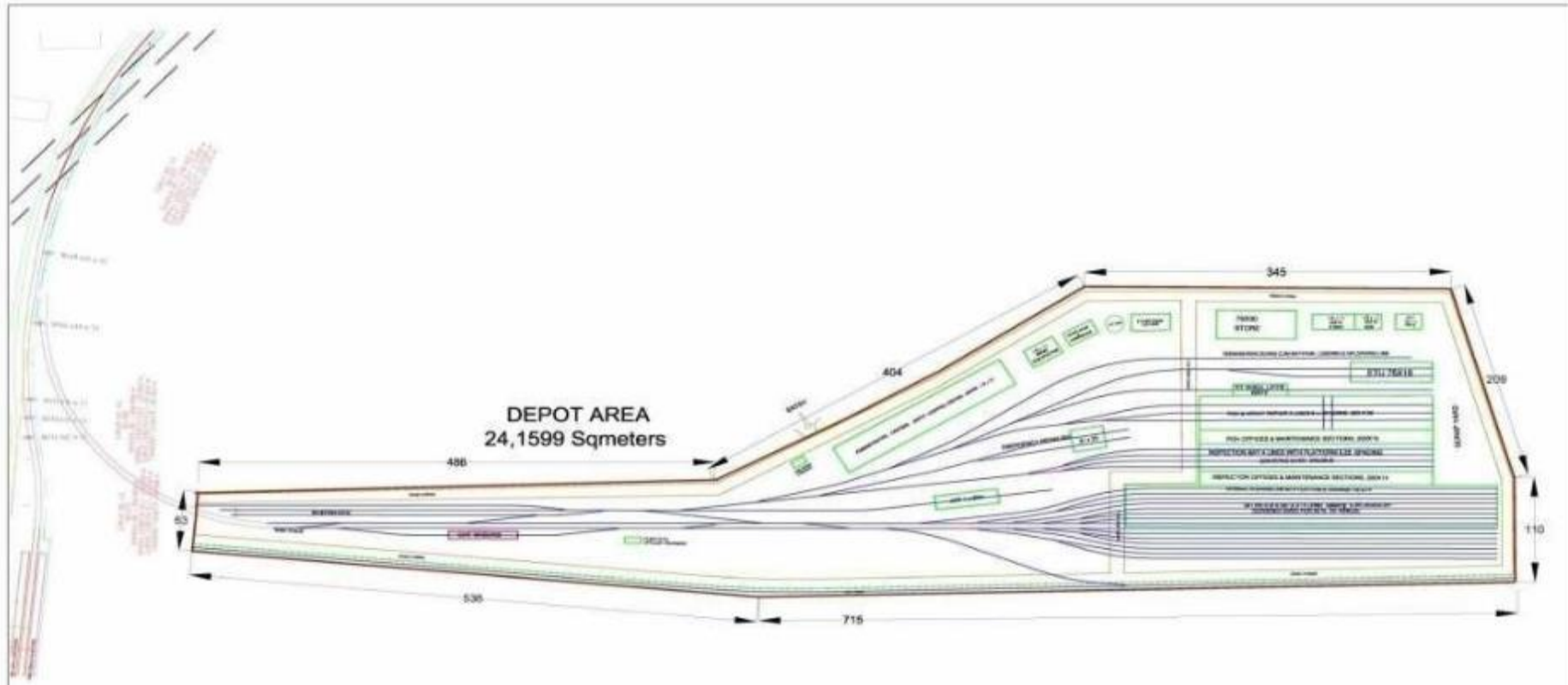


Figure 3.23. Akkupete Depot Location for Corridor-1 near Devanahalli

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

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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 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.

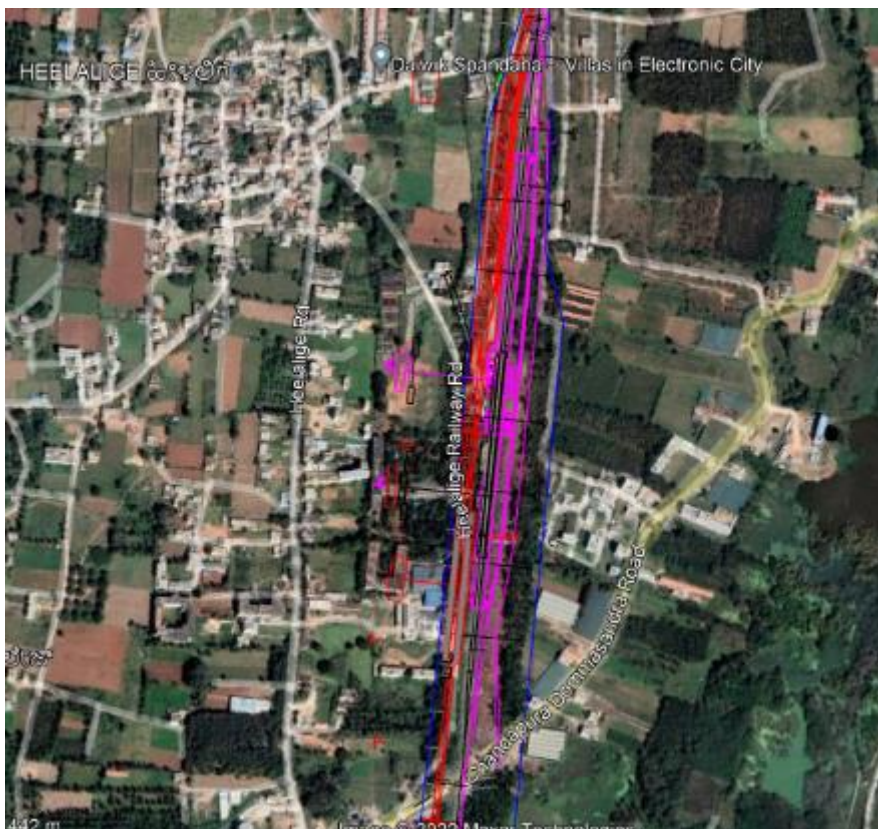


Figure 3.25. Micro Depot Integrated with Heelalige Station in Corridor-4

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

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- 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.

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- 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.

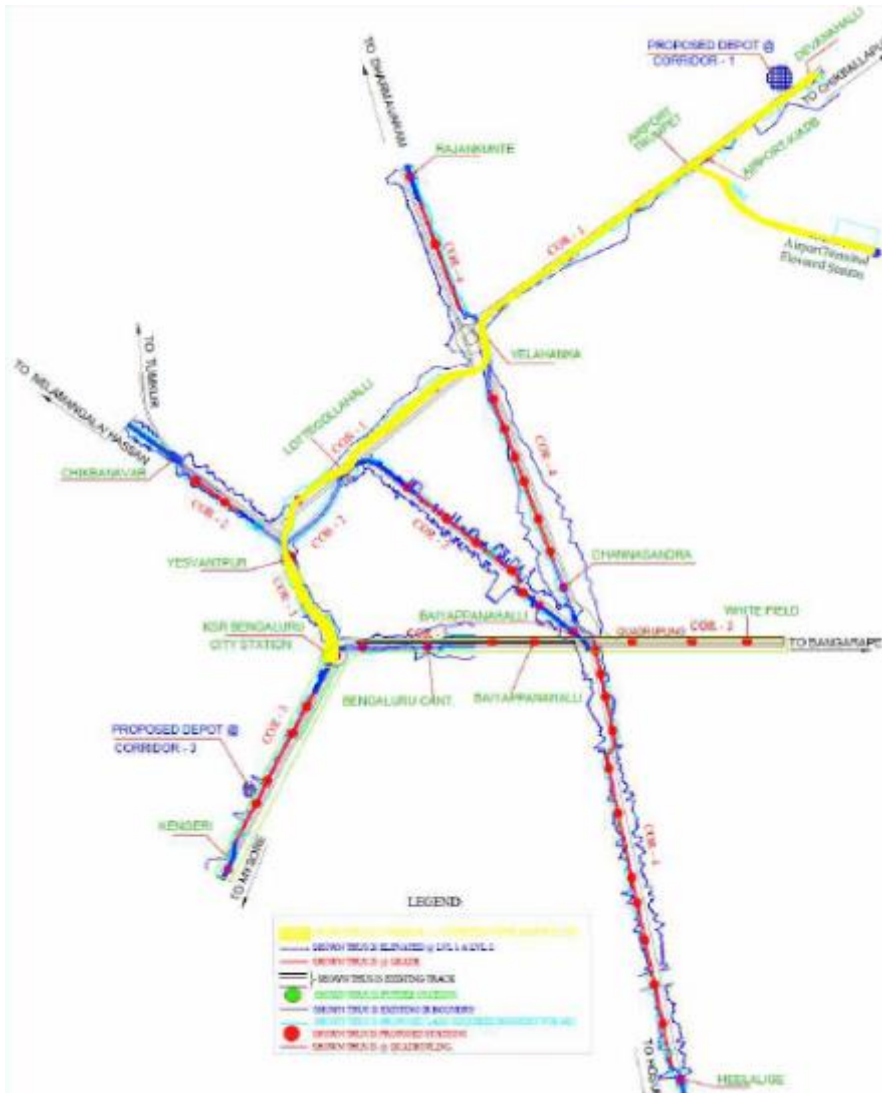


Figure 3.26. Proposed Airport Link

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).

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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

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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

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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:

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- 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-

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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

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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 to increase the efficiency of natural resource usage and prevention of pollution. It also encourages circular economy principles 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

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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 assessment and 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

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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

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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.

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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

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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;

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- 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.

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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 Environmental and Social Standards, as applicable. This section provides an overview of the World Bank’s and EIB’s, policy requirements 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;

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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	√	√	√	√

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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 Applicability of the ESS for the Project is presented in above table, where Risks and Impact 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.

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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

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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.

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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.

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- 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 Ardeshalli, 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);

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- **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, 1972. 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

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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, BESCO,

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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)

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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

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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 construction 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

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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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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.

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Sl. No.	WB's ESS,	EIB's ESS	Description	Equivalent National Environmental Policy and Regulations	Gaps	Addressal of Gaps
				<ul style="list-style-type: none"> • 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

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Sl. No.	WB's ESS,	EIB's ESS	Description	Equivalent National Environmental Policy and Regulations	Gaps	Addressal of Gaps
				<p>however these aspects have been covered through different regulations.</p> <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	-

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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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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.

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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	<ul style="list-style-type: none"> 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.

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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.

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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**.

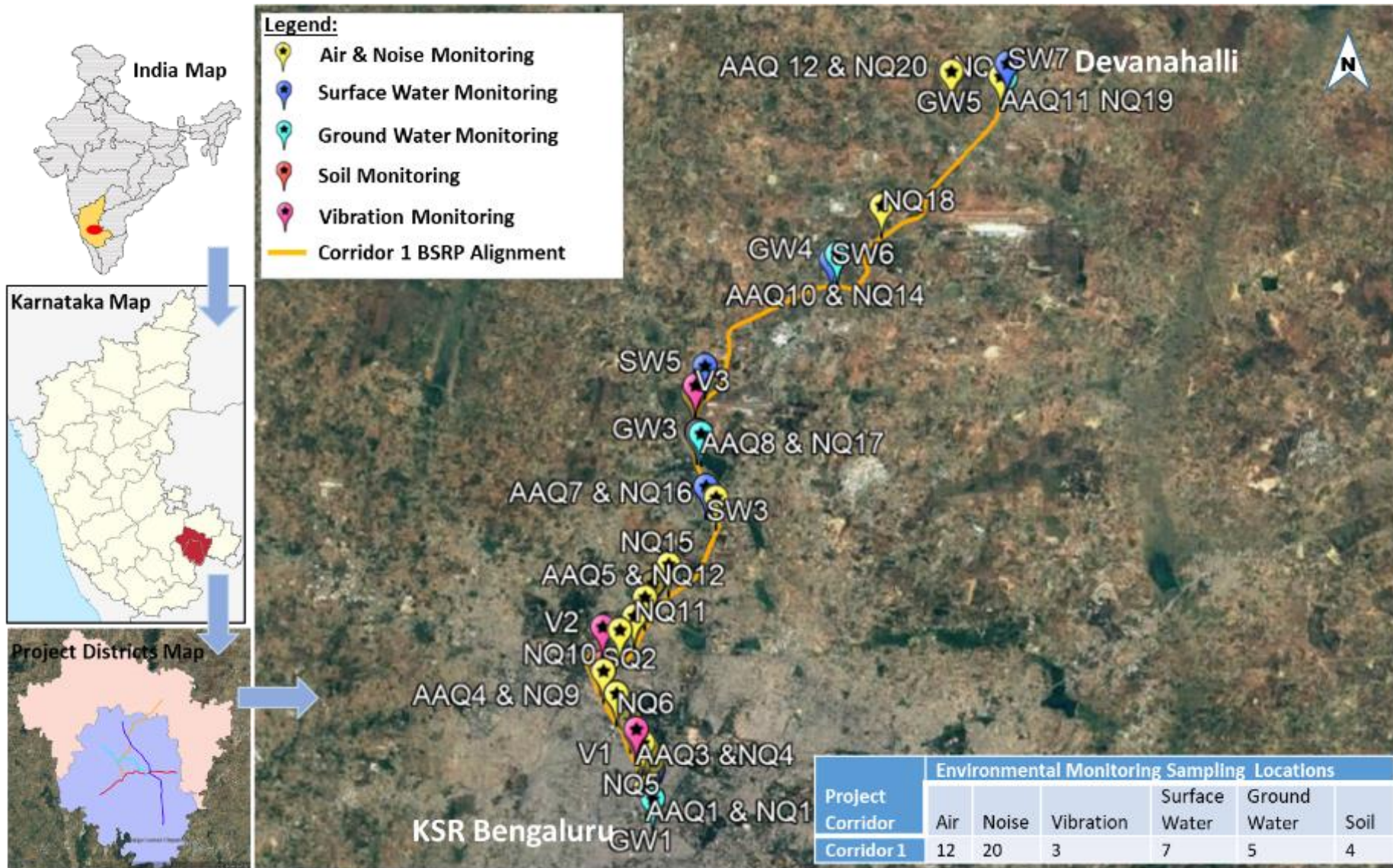


Figure 5.1. Baseline Environmental Monitoring Locations for Corridor – 1: KSR Bengaluru City to Devanahalli

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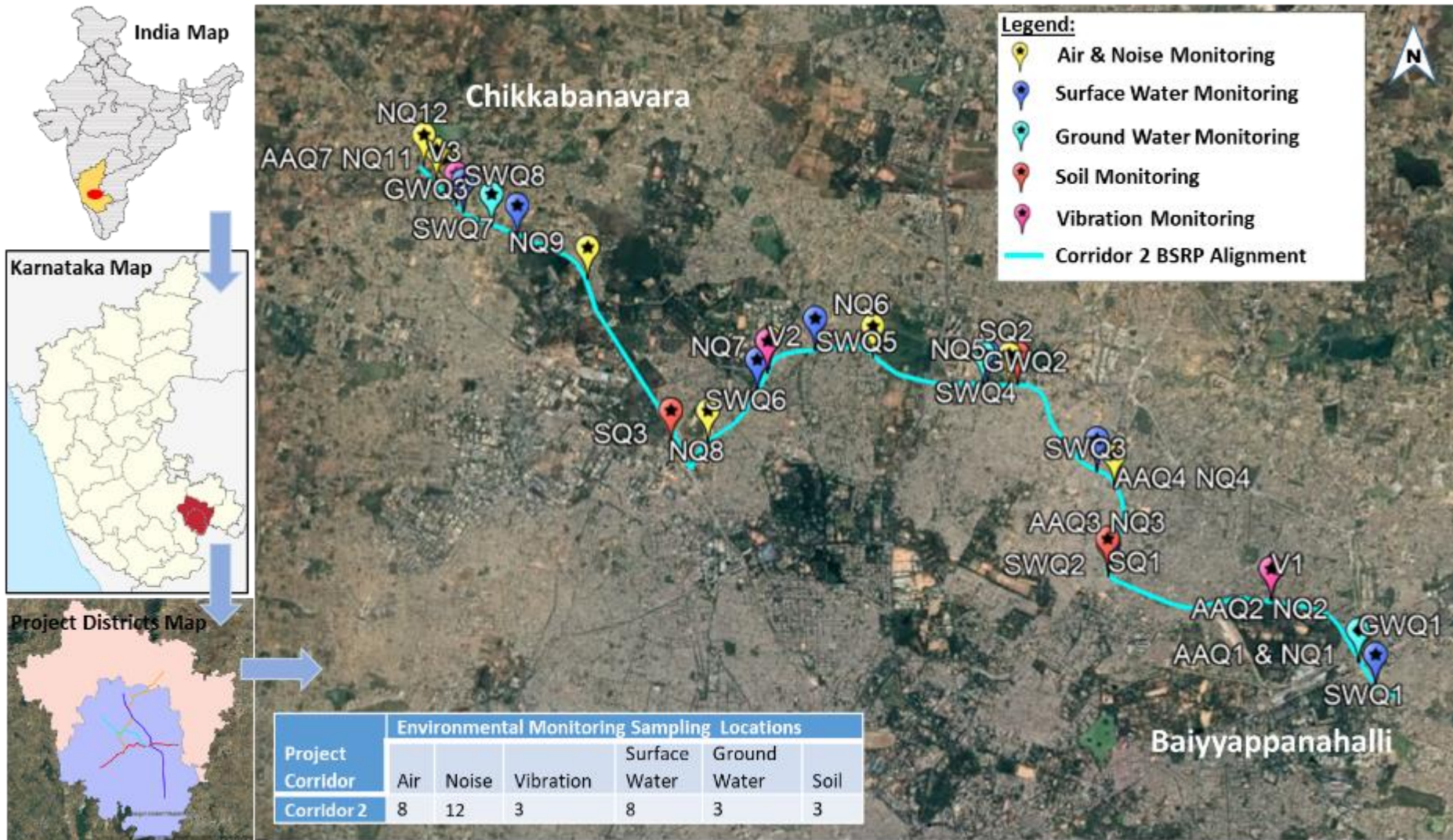


Figure 5.2. Baseline Environmental Monitoring Locations for Corridor 2: Baiyyappanahalli Terminal to Chikkabanavara

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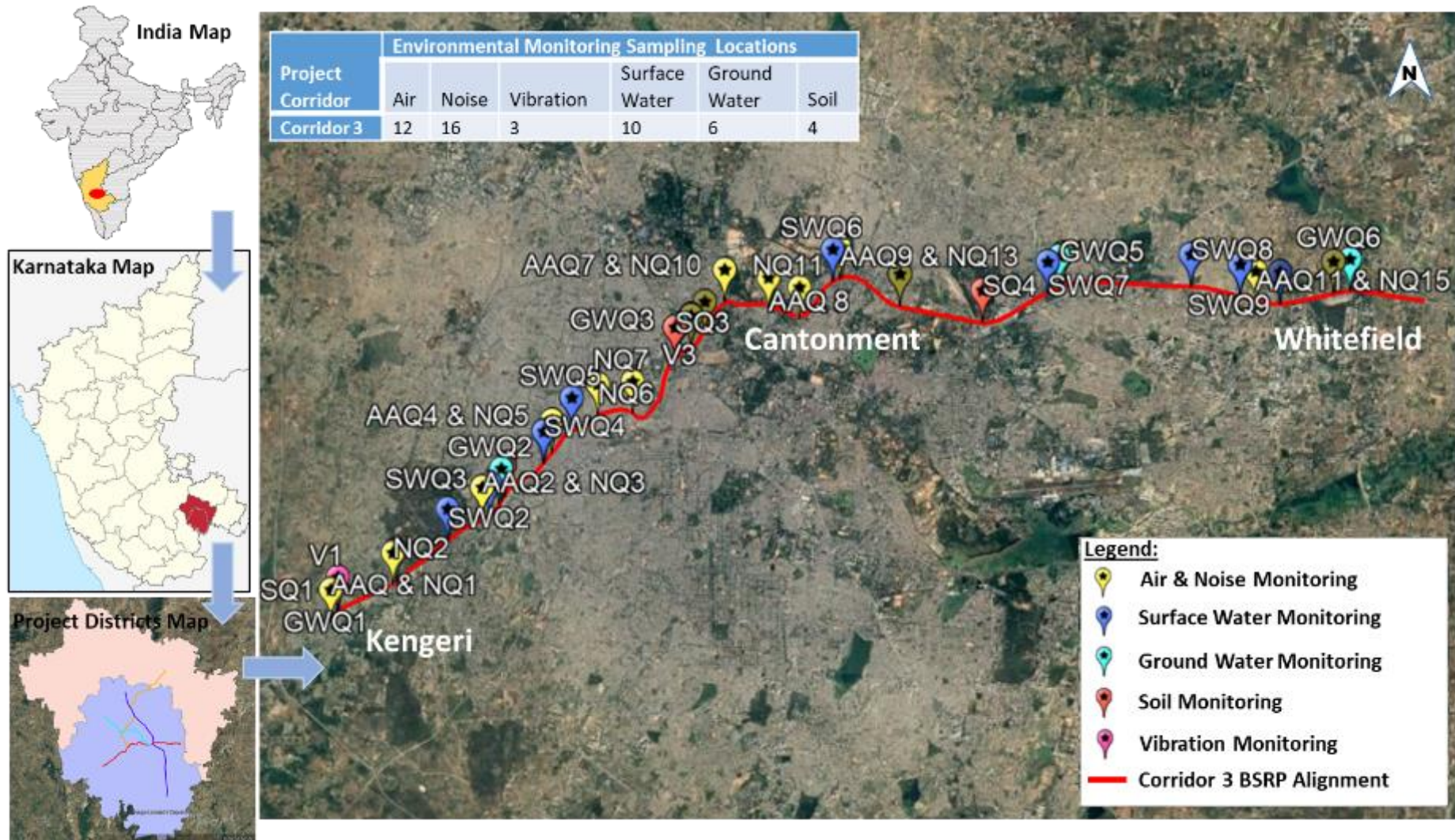


Figure 5.3. Baseline Environmental Monitoring Locations for Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)

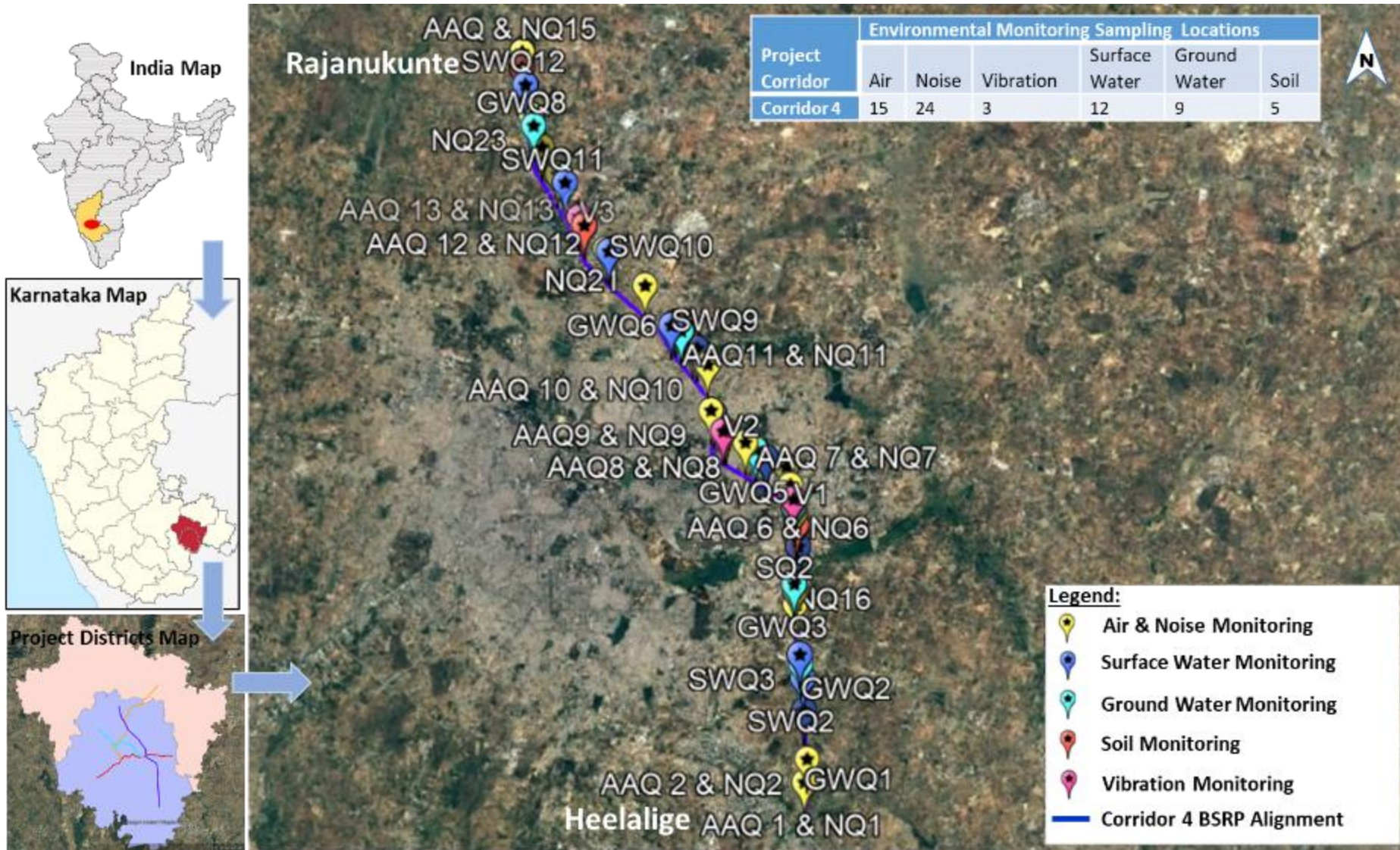


Figure 5.4. Baseline Environmental Monitoring Locations for Corridor – 4: Heelalige to Rajanukunte

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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

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(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

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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.

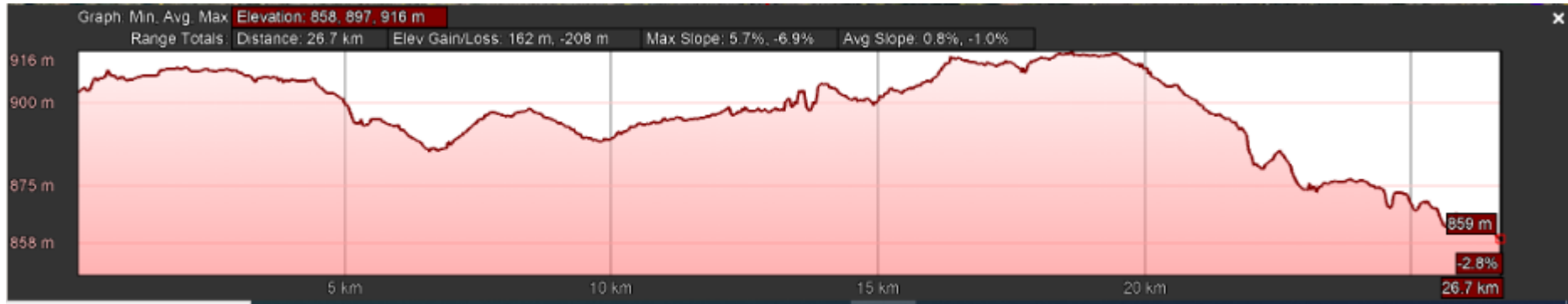
The district is gradually sloping towards south to south-east part forming pediplains intercepted with hills all along the western part. Southern part of the district is more undulating coupled with small hillocks compared with others parts.

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.

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Corridor – 1: KSR Bengaluru City to Devanahalli



Corridor – 2: Baiyappanahalli Terminal to Chikkabanavara

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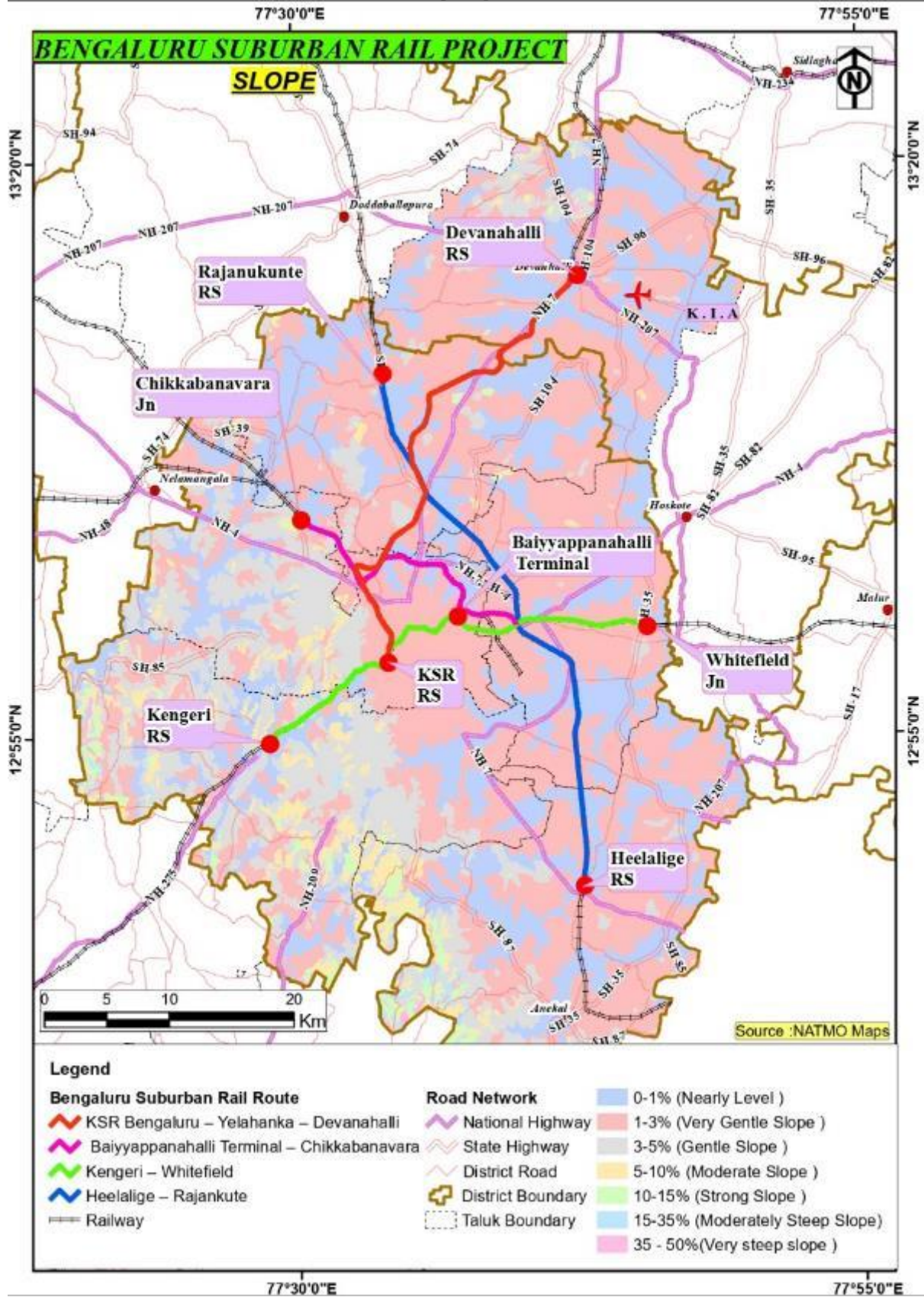
Corridor – 3: Kengeri to Whitefield (via KSR and Cantonment)



Source: Google Earth

Corridor – 4: Heelalige to Rajanukunte

Figure 5.5. Elevation Profile the BSRP Corridors



Source: National Atlas and Thematic Mapping Organisation

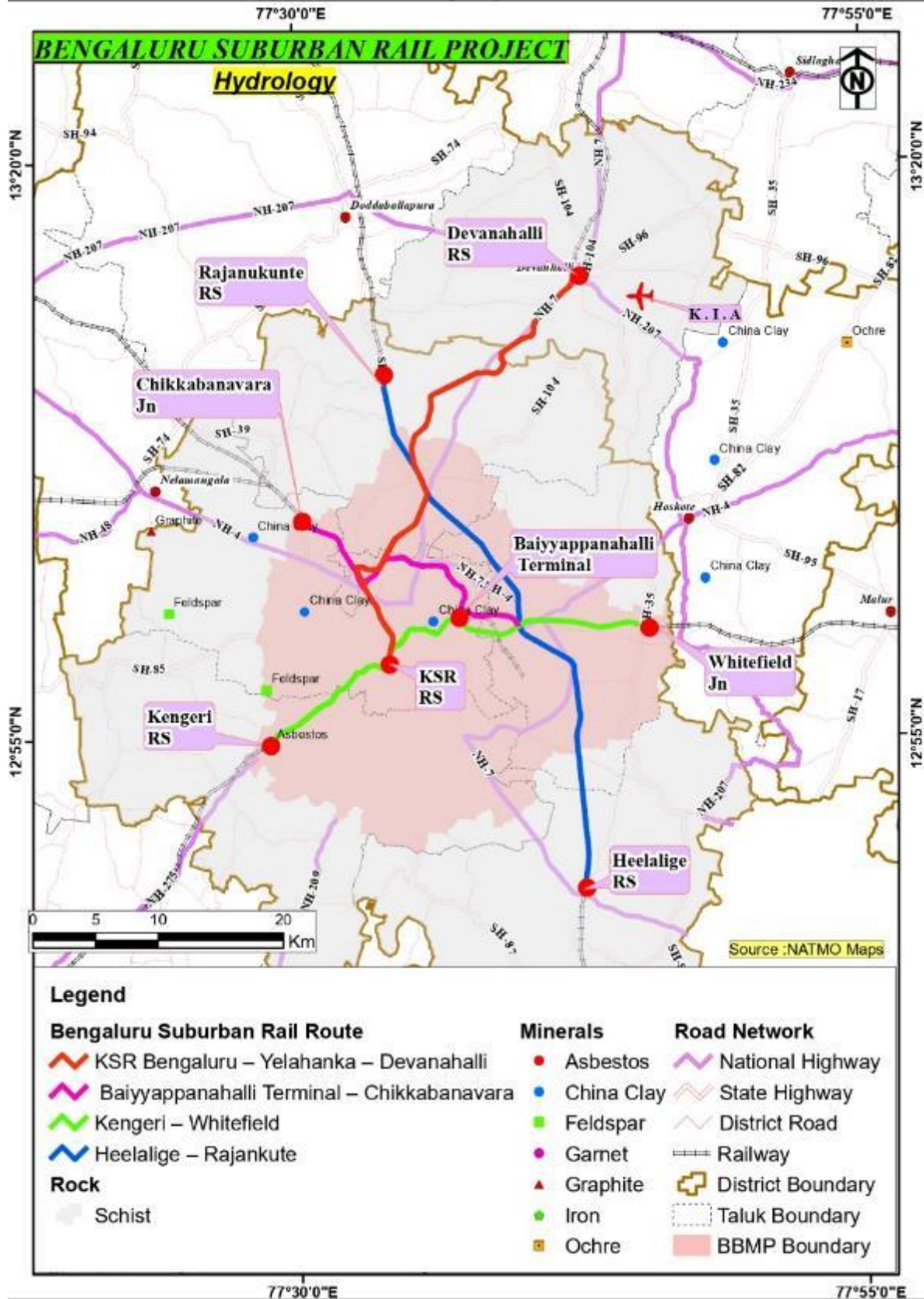
Figure 5.6. Map Showing Slope & Relief Profile of the Project Region

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**.



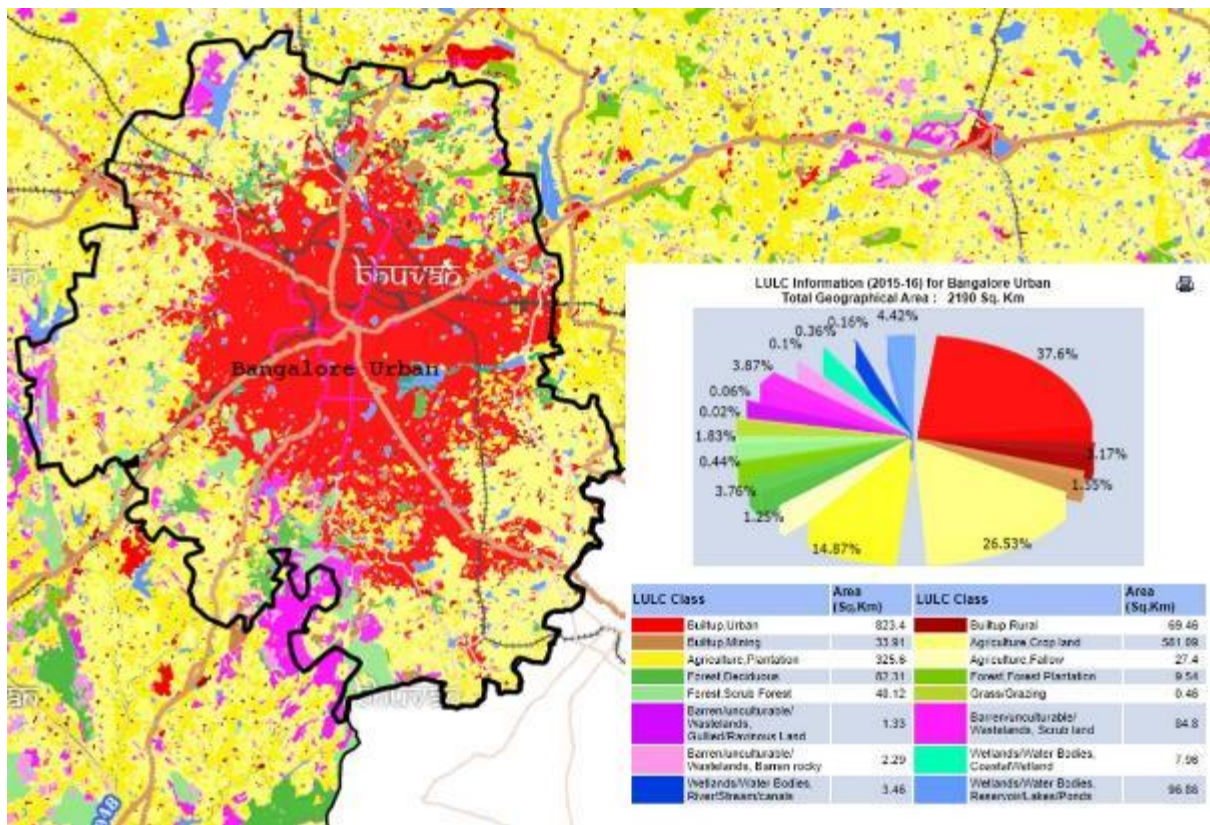
Source: National Atlas and Thematic Mapping Organisation

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

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5.5.3. Land Use

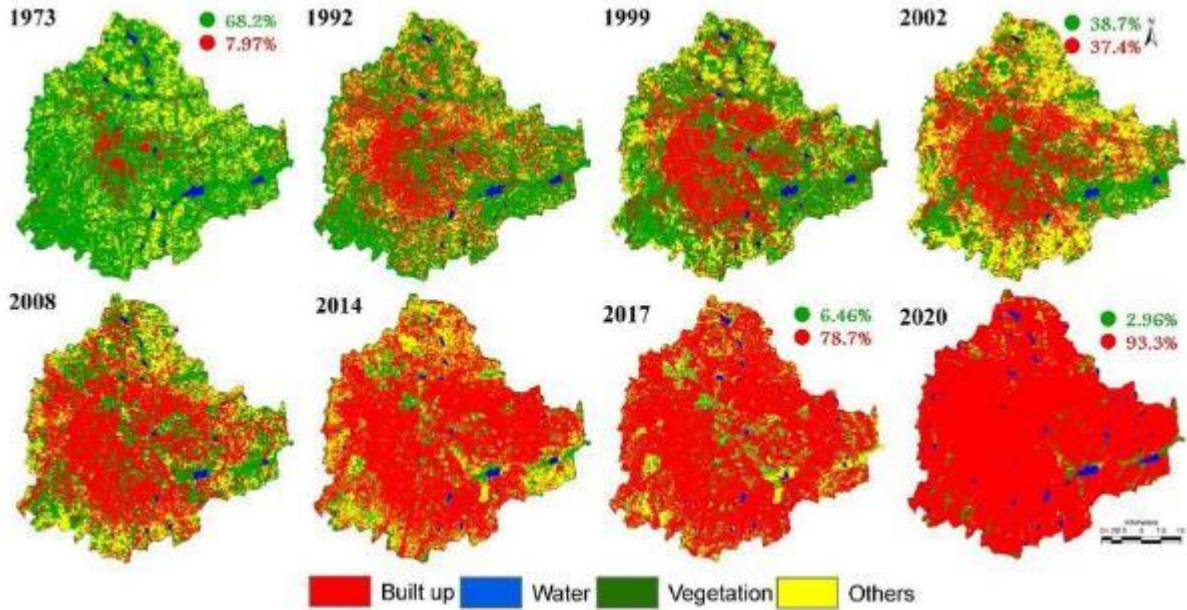
Bengaluru Urban District: Land use characteristics of Bengaluru urban district broadly comprises of Built-up/settlements, Agricultural, Forests, Waterbodies, Barren land/uncultivated land etc. Bengaluru urban district is the smallest district compared to other districts in the State and it is a major 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

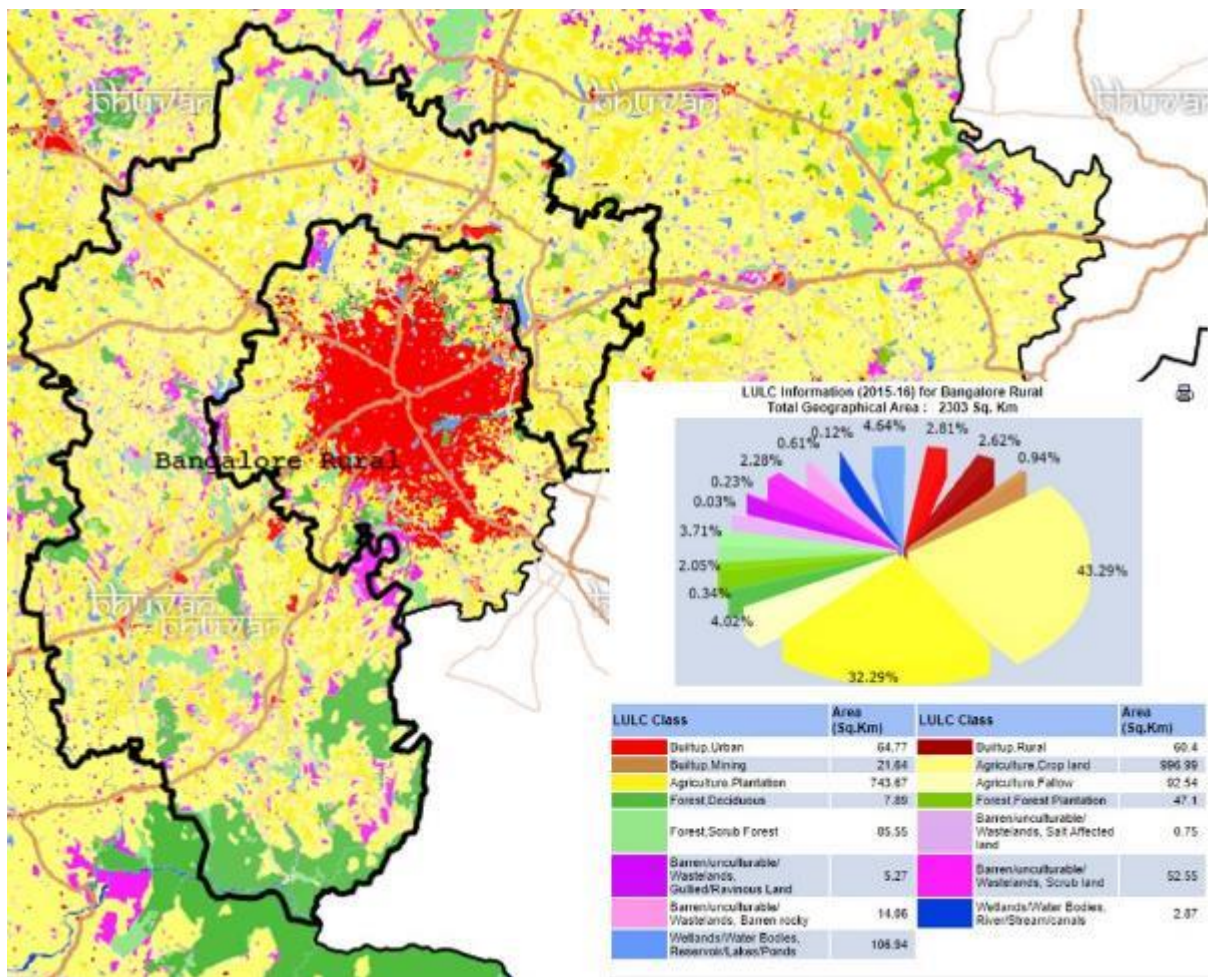
Figure 5.8. Land Use Land Cover Map Depicting Land use in Bengaluru Urban District

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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

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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, Vidyaranyaपुरa, 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, Vidyaranyaपुरa, 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, Narayanapura, 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,

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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

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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

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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)				

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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

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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

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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.

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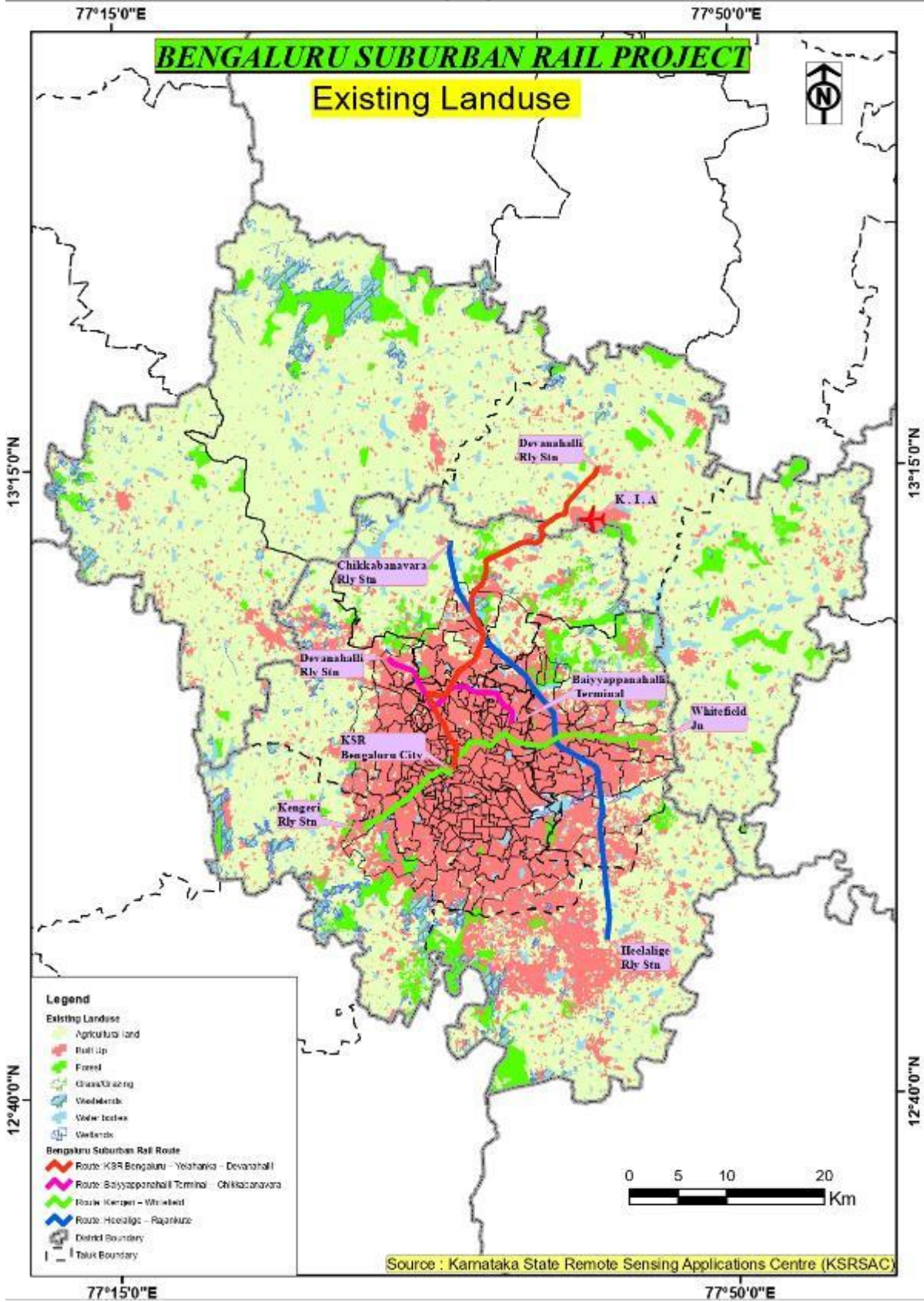


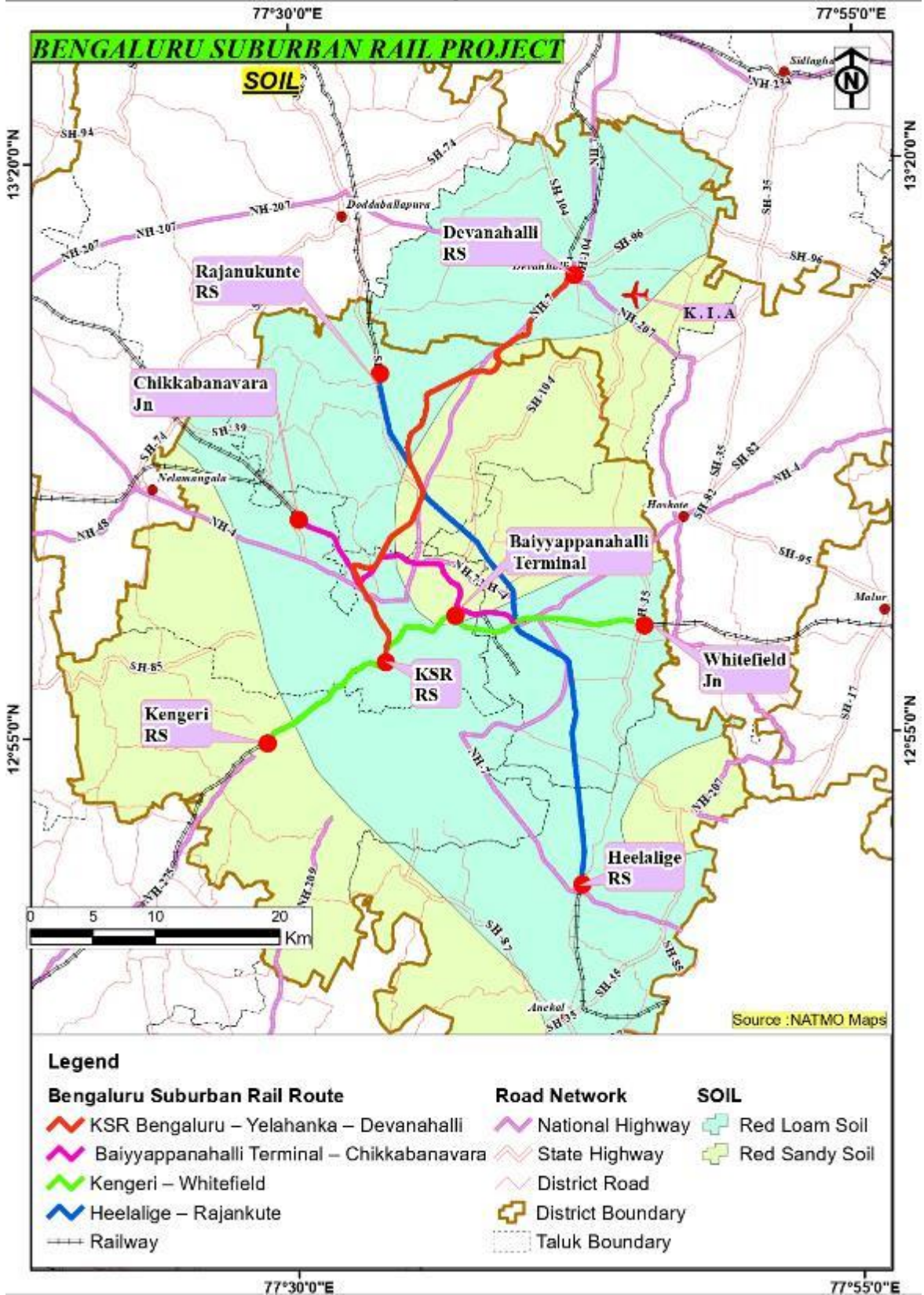
Figure 5.11. Map Showing Land Use along the BSRP Corridors

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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

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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	Nayandanahalli	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

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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

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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 Nayandanahalli	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

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S. No	Parameters	SQ 1 Near Kengeri Railway Station	SQ 2 Nayandanahal li	SQ 3 Near KSR Railway Station	SQ 4 Baiyyappanaha lli
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

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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.

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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

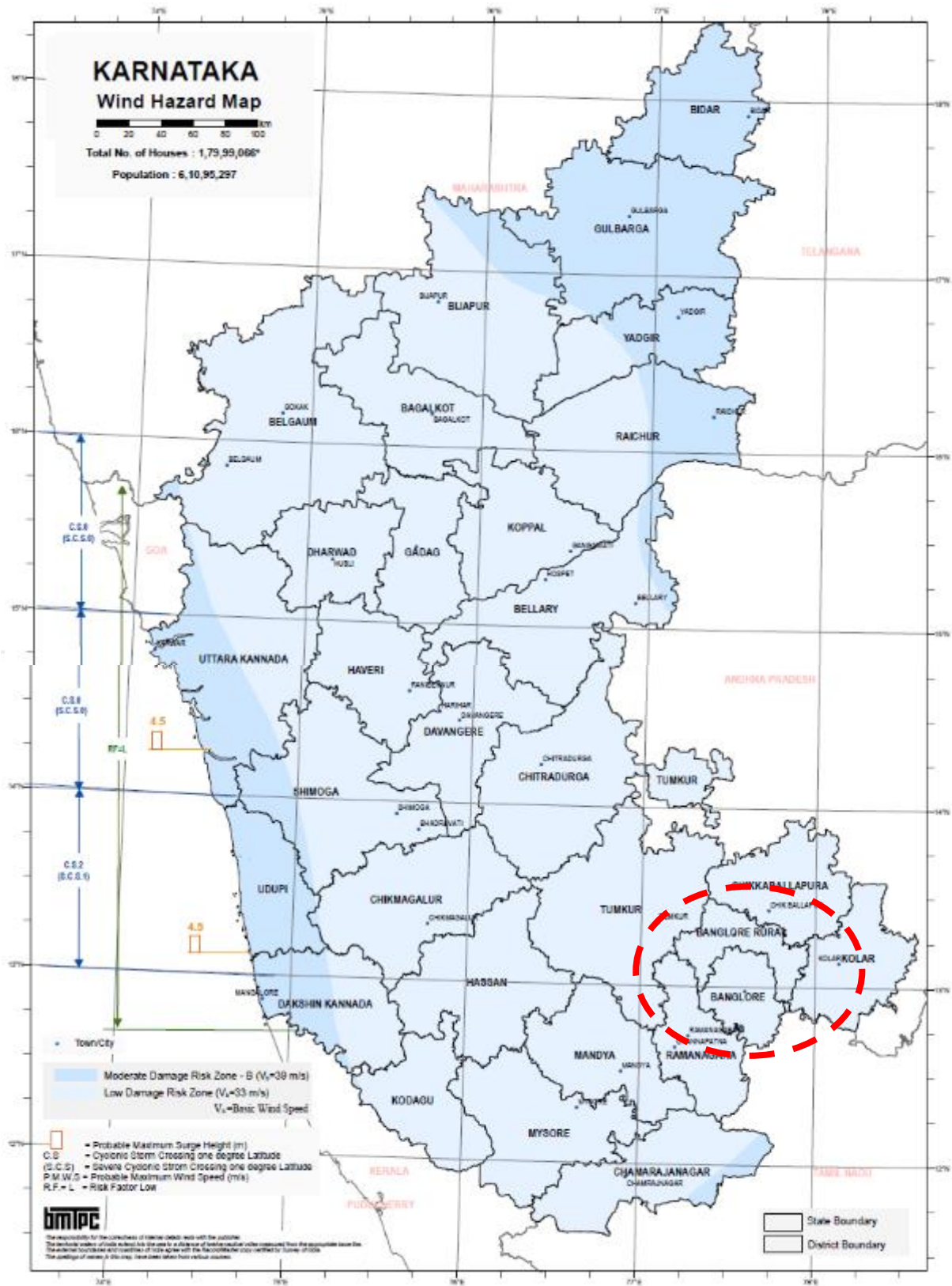
There are no serious threats of wind hazards in the project region. As per Vulnerability Atlas for Karnataka prepared by Building Material and Technology Promotion Council (BMTPC), Bengaluru Urban and Rural Districts are situated in Low Damage Risks Zone. There is low intensity wind flow recorded during 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**.

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Source: Building Material and Technology Promotion Council

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

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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

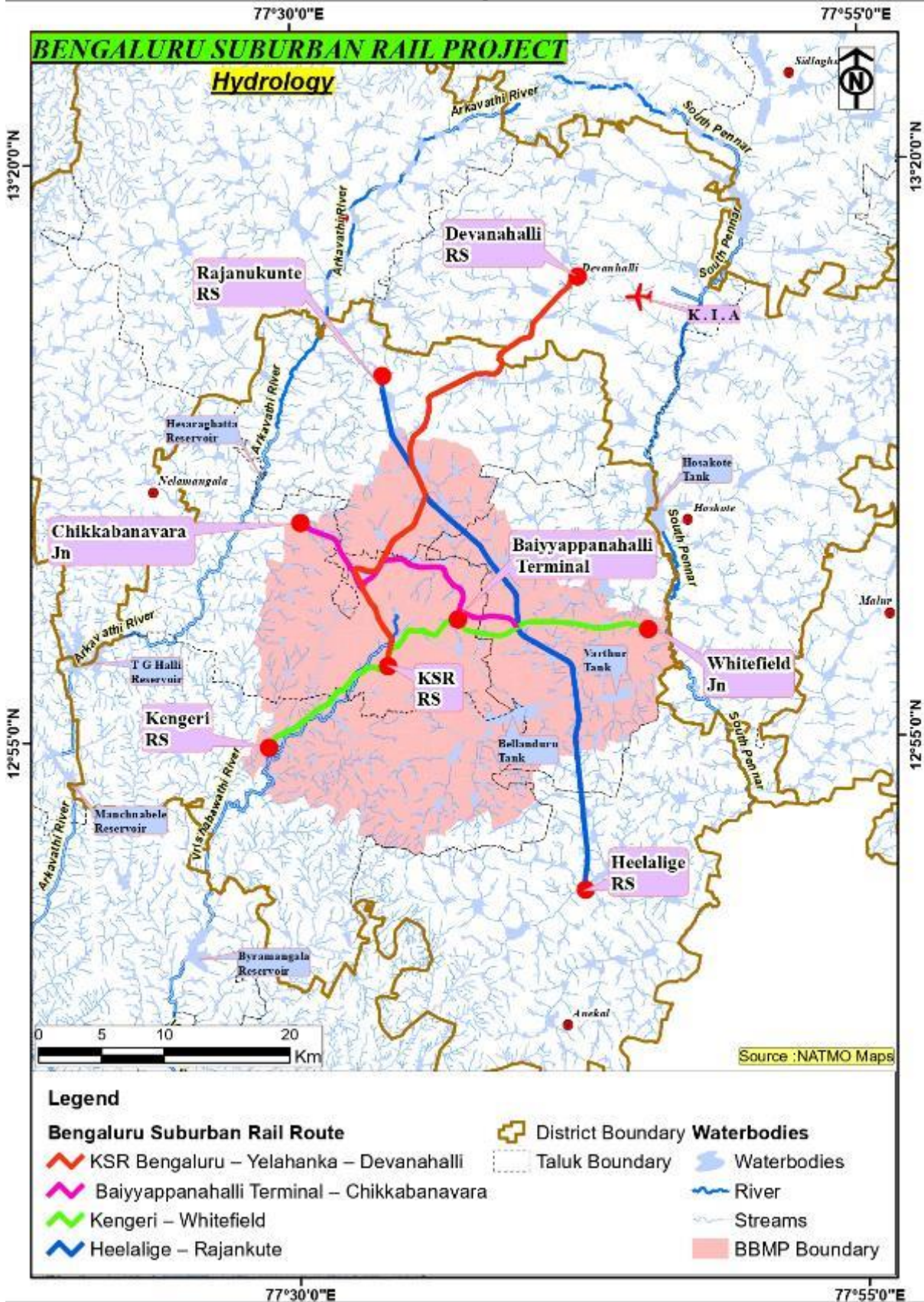
Bengaluru Urban District: The Arkavati river flows in the district for a small distance in Bengaluru North taluk. The South Pinakini touches the borders of the district to the northeast of the Anekal taluk. The Vrishabhavathi, a tributary of the Arkavati, flows in the district before joining the Arkavati 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 from 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

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Corridor 1 & Corridor 4 abuts number of lakes as it 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 perennial 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 spread over 102 acres 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 intersects lake and divides it into 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 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, it is open for public walking and recreational activities. After the rejuvenation works, fishery department introduced fishes into the lake to restore the biodiversity of the lake. However, still the lake receives sewage water from nearby houses 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: Doodanekundi lake is spread across an area of 137 acres of land which is located near Doodanekundi and Kagadapura villages. It is one of the largest lakes 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 increased 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

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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.

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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

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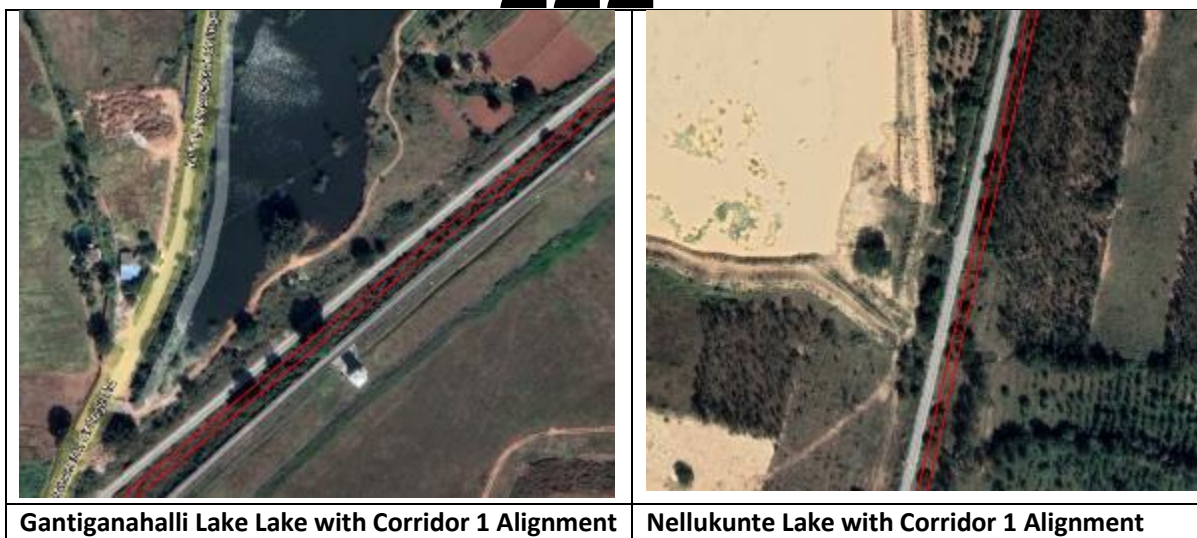


Figure 5.17. Google Earth Imagery showing BSRP alignment abutting the Lakes in the Project

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

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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	-	-

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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

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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

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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**.



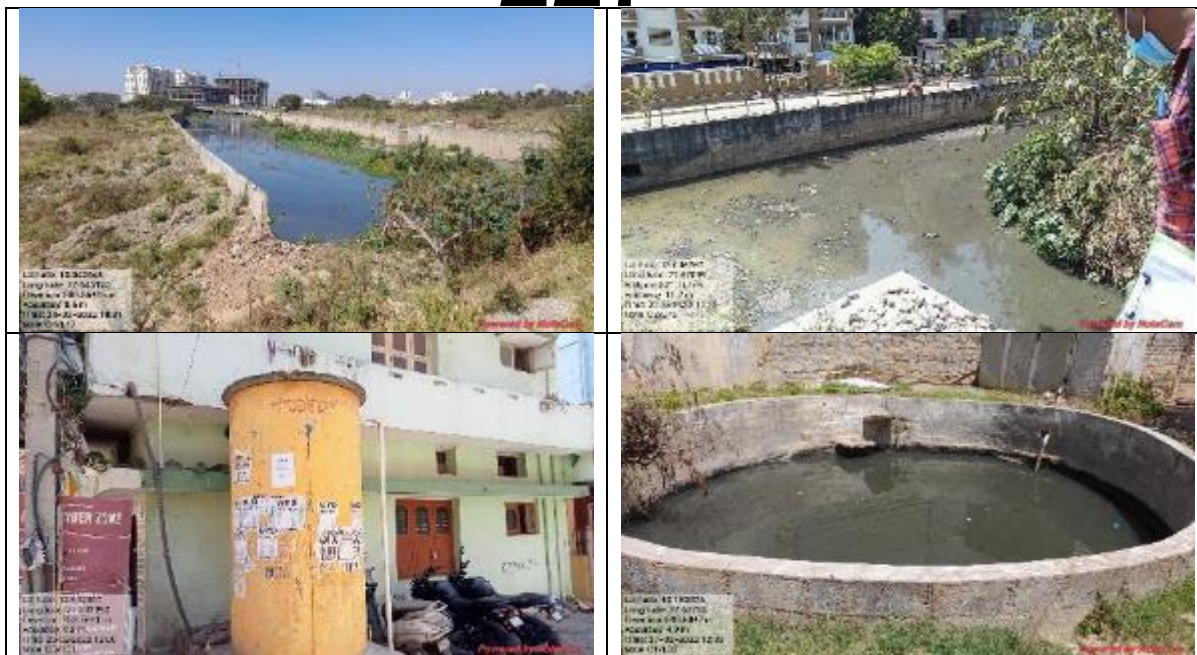


Figure 5.18. Photographs of Waterbodies Present along BSRP Corridors

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**.

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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

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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 Geddalhalli	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.**

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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	°C	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

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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

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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	°C	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

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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	°C	27.8	28.1	27.9	27.4	Not specified

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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

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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	°C	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

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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 Benegannahalli 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

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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	°C	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

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S.No	Parameters	Unit	SW-6 Drain	SW-7 Benegannahalli 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	°C	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

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S. No	Parameters	Unit	SW-1 Gottamaranah alli 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

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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	°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

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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

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S. No	Parameters	Unit	SW-7 Banniganahalli 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

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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 $\mu\text{S}/\text{cm}$ to 1840 $\mu\text{S}/\text{cm}$. 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 28.2 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 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 $\mu\text{S}/\text{cm}$ to 3320 $\mu\text{S}/\text{cm}$. 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 $\mu\text{S}/\text{cm}$ to 3220 $\mu\text{S}/\text{cm}$. 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

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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 μ S/cm to 3790 μ S/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

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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	Nayandanahalli	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.**

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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	°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

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S.No	Parameters	Unit	GW 1 KSR Bengaluru	GW 2 Lottegollahalli	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	°C	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

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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

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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 Nayandanahalli	GW 3 Near KSR Railway Station	GW 4 Sarvangnagar	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	°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

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S. No	Parameters	Unit	GW 1 Near Kengeri Railway Station	GW 2 Nayandanahalli	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

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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	°C	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

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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	°C	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

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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

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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 $\mu\text{S}/\text{cm}$ to 2360 $\mu\text{S}/\text{cm}$. 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 $\mu\text{S}/\text{cm}$ to 2380 $\mu\text{S}/\text{cm}$. 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 $\mu\text{S}/\text{cm}$ to 2740 $\mu\text{S}/\text{cm}$. 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.

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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 $\mu\text{S}/\text{cm}$ to 2490 $\mu\text{S}/\text{cm}$. 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 ($\text{PM}_{2.5}$), 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**.

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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	Gnanabharathi 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 Institute	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	Lottogollanahalli 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

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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"E	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

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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”.

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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

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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

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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 – 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

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Observations:

Corridor 1:

PM₁₀: The maximum and minimum concentrations for PM₁₀ were recorded as 91.7 µg/m³ 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/m³.

PM_{2.5}: The maximum and minimum concentrations for PM_{2.5} were recorded as 43.8 µg/m³ 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/m³.

SO₂: The maximum and minimum SO₂ concentrations were recorded as 13.6 µg/m³ and <5.0 µg/m³. 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/m³.

NO_x: The maximum and minimum NO_x concentrations were recorded as 28.7 µg/m³ and 5.4 µg/m³. 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/m³

CO: The maximum and minimum CO concentrations were recorded as 1.22 mg/m³ and 0.16 mg/m³. 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/m³ to 1.10mg/m³.

HC: The maximum Methane HC concentrations were recorded as <0.1 µg/m³ and the minimum concentration of <0.1 µg/m³ was observed at all locations.

Corridor 2:

PM₁₀: The maximum and minimum concentrations for PM₁₀ were recorded as 97.0 µg/m³ and 51.2 µg/m³ 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/m³.

PM_{2.5}: The maximum and minimum concentrations for PM_{2.5} were recorded as 40.5 µg/m³ and 20.6 µg/m³ 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/m³.

SO₂: The maximum and minimum SO₂ concentrations were recorded as 20.4 µg/m³ and 5.1 µg/m³. 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/m³.

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NO_x: The maximum and minimum NO_x concentrations were recorded as 25.1 µg/m³ and 14.3 µg/m³. 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/m³

CO: The maximum and minimum CO concentrations were recorded as 1.05 mg/m³ and 0.46 mg/m³. 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/m³ to 0.96 mg/m³.

HC: The HC concentrations were recorded below the detection limit as <0.1 µg/m³ at all locations.

Corridor 3:

PM₁₀: The maximum and minimum concentrations for PM₁₀ were recorded as 97.7 µg/m³ and 42.7 µg/m³ 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/m³.

PM_{2.5}: The maximum and minimum concentrations for PM_{2.5} were recorded as 39.4 µg/m³ and 17.0 µg/m³ 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/m³.

SO₂: The maximum and minimum SO₂ concentrations were recorded as 12.3 µg/m³ and 5.1 µg/m³. 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/m³.

NO_x: The maximum and minimum NO_x concentrations were recorded as 28.1 µg/m³ and 11.5 µg/m³. 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/m³.

CO: The maximum and minimum CO concentrations were recorded as 1.20 mg/m³ and 0.25 mg/m³. 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/m³ – 0.95mg/m³.

HC: The maximum Methane HC concentrations were recorded as <0.1 µg/m³ and the minimum concentration of <0.1 µg /m³ was observed at all locations.

Corridor 4:

PM₁₀: The maximum and minimum concentrations for PM₁₀ were recorded as 80.5 µg/m³ and 36.7 µg/m³ 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/m³.

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PM_{2.5}: The maximum and minimum concentrations for PM_{2.5} were recorded as 36.7 µg/m³ and 13.5 µg/m³ 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/m³.

SO₂: The maximum and minimum SO₂ concentrations were recorded as 19.3 µg/m³ and 5.1 µg/m³. 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/m³.

NO_x: The maximum and minimum NO_x concentrations were recorded as 26.6 µg/m³ and 10.4 µg/m³. The maximum concentration was recorded at Industry, Rajanukunte and the minimum concentration was recorded at Tata Service Center, Chinnappanahalli. The average values were observed to be in the range of 11.4 – 21.3 µg/m³.

CO: The maximum and minimum CO concentrations were recorded as 0.72 mg/m³ and 0.19 mg/m³. 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/m³ – 0.70mg/m³.

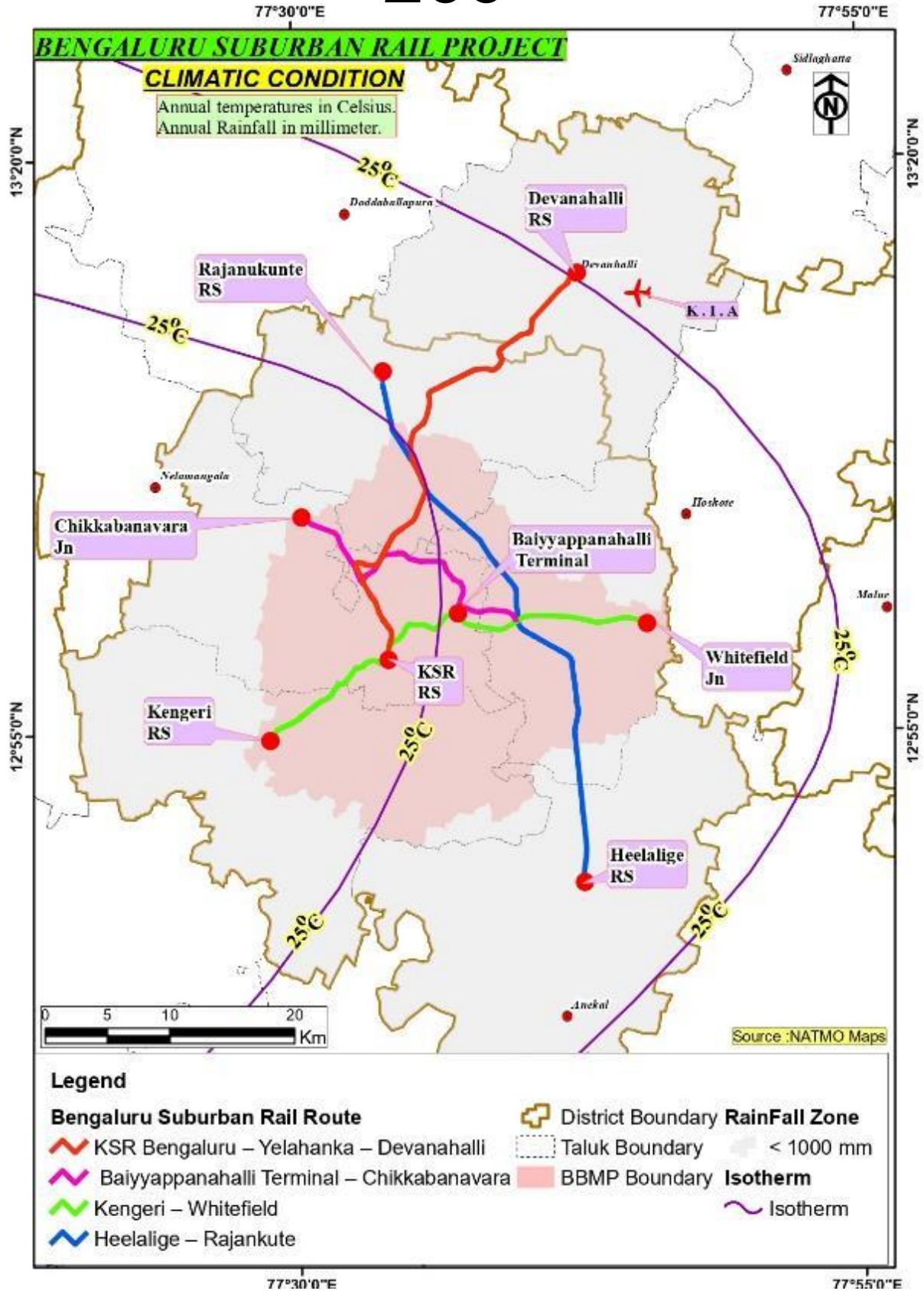
HC: The maximum Methane HC concentrations were recorded as <0.1 µg/m³ and the minimum concentration of <0.1 µg/m³ was observed at all locations.

The overall concentrations of PM₁₀, PM_{2.5}, SO₂, NO_x, 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**.

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Source: National Atlas and Thematic Mapping Organisation

Figure 5.19. Climatic Condition for Project Region

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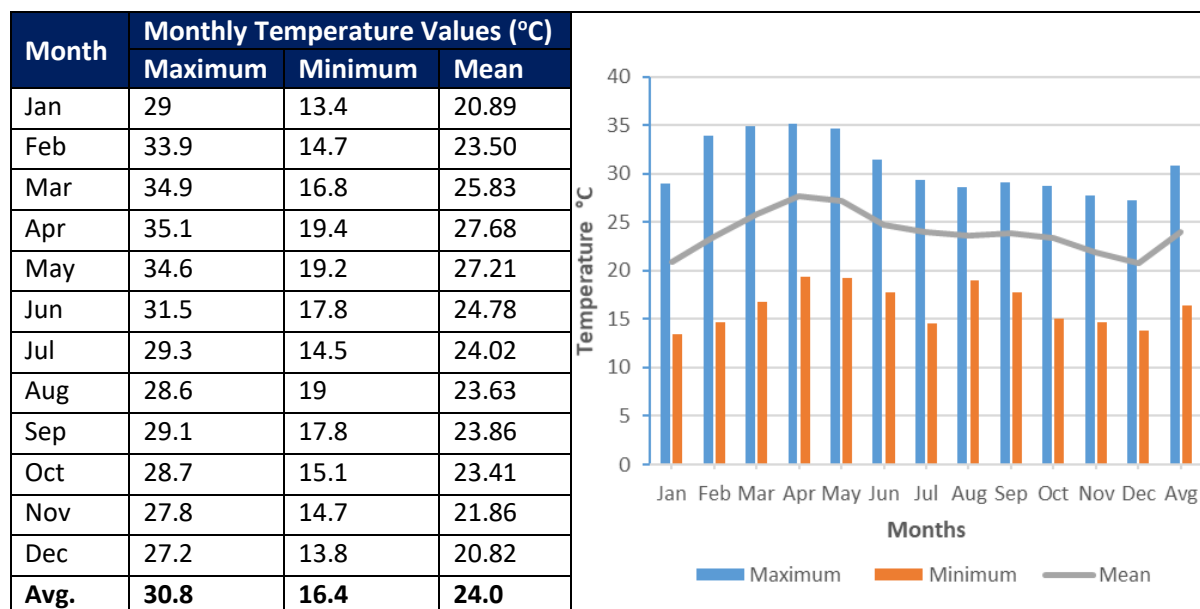
India Meteorological Department (IMD) is the nodal agency responsible for monitoring and recording the climatic parameters. Long-term climatic data were obtained for the project districts to establish a general trend. Monthly average data for 30 years (1971-2000) were considered for analyzing the climatic 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**.

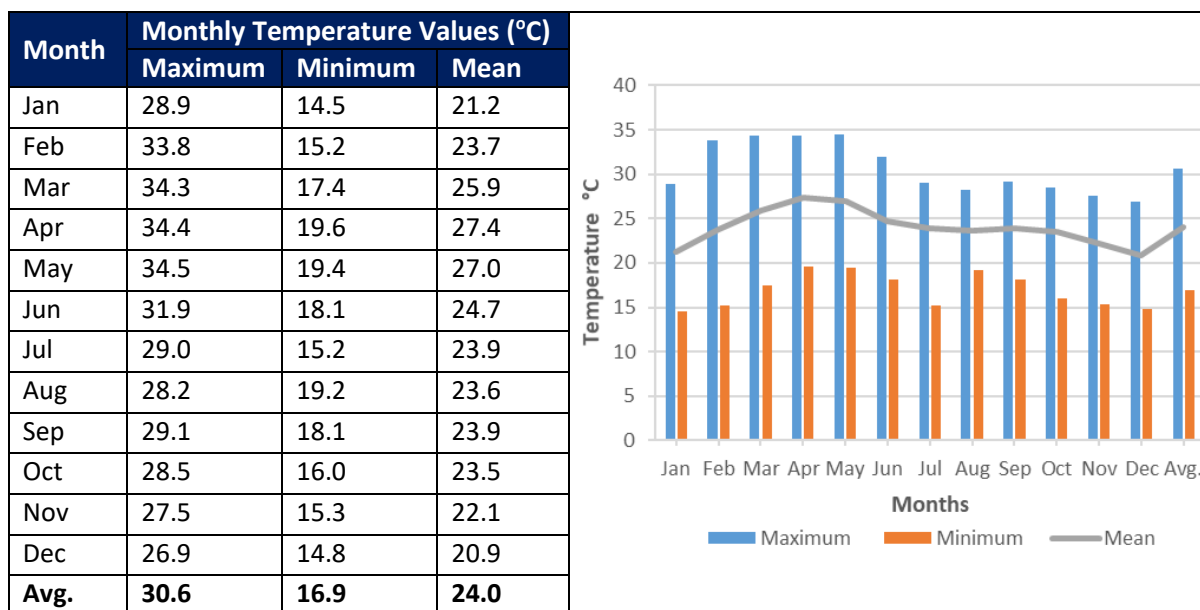
Table 5.23. Temperature Profile of Bengaluru Urban District



Source: Data Collected from IMD, Pune.

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Table 5.24. Temperature Profile of Bengaluru Rural District



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

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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**.