Environment Impact Assessment (EIA)

for
Bengaluru Metro Rail Project (Phase3)

for
Bengaluru Metro Rail Corporation Ltd.

November 2025

Prepared by

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Abbreviations and Acronyms

ADB	Asian Development Bank
AFC	Automatic Fare Collection
AIIB	Asian Infrastructure Investment Bank
ATO	Automatic Train Operation
BBMP	Bruhat Bengaluru Mahanagara Palike
BDA	Bangalore Development Authority
BMICAPA	Bangalore-Mysore Infrastructure Corridor Area Planning Authority
BMRCL	Bangalore Metro Rail Corporation Limited
BMTC	Bengaluru Metropolitan Land Transport Authority
DDC	Detail Design Consultant
DFR	Draft Final Report
DPR	Detailed Project Report
FS	Feasibility Study
GBA	Greater Bengaluru Authority
GC	General Consultant
GIS	Geographic Information System
GoI	Government of India
GoK	Government of Karnataka
JICA	Japan International Cooperation Agency
MMI	Multi Modal Integration
NMT	Non-Motorized Transport
O&M	Operation and Maintenance
OCC	Operation Control Centre
OJT	On the Job Training
PPP	Public Private Partnership
RMP	Revised Master Plan
ROW	Right of Way
TOD	Transit Oriented Development
TOR	Terms of Reference

1. Project Summary

1.1 Metro Construction Projects in India

India has experienced rapid urbanization in recent years, with approximately 473 million people—around 30% of the total population—residing in urban areas as of 2021. According to the United Nations' 2018 projections, the number of Indian cities with populations exceeding 2 million is expected to reach around 40 by 2030. Alongside this urban and economic growth, traffic congestion and environmental degradation have become pressing issues, making metro development an extremely important challenge. In particular, due to the high population density and the surge in private vehicle and two-wheeler usage, the development of sustainable public transportation infrastructure is an urgent task.

Source: JST

Figure 1-1: The current situation in Bengaluru

Against this backdrop, the Government of India formulated the “Metro Rail Policy 2017” with the aim of introducing public transport systems strategically from the early stages of urban growth to achieve sustainable urban development. This policy positions metro systems as the core of urban public transportation and promotes their development through integrated urban transport planning and expanded budgeting.

1.2 Significance of Metro Projects in Karnataka

In 2020, the Government of Karnataka formulated the “Comprehensive Mobility Plan for Bengaluru (CMPB)” covering the Bengaluru Metropolitan Region, proposing a 317 km metro network by 2031. Additionally, the "Revised Master Plan 2031" for Bengaluru urban planning was published in 2017. Under these plans, the Bengaluru Metro Construction Project Phase 3 (hereinafter referred to as “this project”) is positioned as a priority project within the metropolitan area.

The proposed Line 3-1 under this project is planned to connect with the ongoing Lines 2B and 6, while Line 3-2 will connect with the East-West Line, improving integration with both existing and under-construction routes.

Furthermore, Karnataka State formulated a Transit-Oriented Development (TOD) policy in 2022, promoting TOD centered around Bengaluru Metro. This project is expected to contribute to further economic growth in the metropolitan area through coordinated development along the metro corridors and by enhancing the developmental impact through real estate development on lands owned by implementing agencies at existing and new stations.

1.3 Project Goals

The following goals are expected to be achieved through this project:

Table 1-1: Project Goals for the Bangalore Metro Construction

Project Goals	
1)	Realization of an efficient and sustainable transportation system
2)	Mitigation of automobile dependency and traffic congestion by promoting public transport use
3)	Reduction of environmental impact through the introduction of clean-energy vehicles and emission reductions
4)	Comprehensive transportation improvements through coordination with other traffic measures
5)	Promotion of compact and sustainable urban growth based on TOD principles

Source: JST

1.4 Project Overview

The scope of the ODA loan project is outlined in Table 1-2. The project includes the construction of two metro lines (Lines 3-1 and 3-2) and components such as civil structures, stations, depot facilities, ancillary works, railway systems, and temporary construction facilities (e.g., yards and worker accommodations). The right-of-way for the double-deck viaduct is 27 meters wide. The specific scope eligible for ODA funding is limited to the development of the railway component. Although the road section, excluding the ramps, is outside the scope of this project, it will be constructed as an integrated structure together with the elevated railway section of the project.

Table 1-2: Project Overview

Project	Bengaluru Metro Rail Project (Phase3)
Objective	This project aims to address the growing transportation demand and traffic congestion in the Bengaluru metropolitan area of India by constructing a high-capacity, rapid transit system. Through alleviating traffic congestion and reducing automobile pollution, the project will contribute to regional economic development, improvement of the urban environment, and ultimately, mitigation of climate change.
Overview	Corridor 3-1（32.2 km、22 stations） Corridor 3-2（12.5 km、9 stations）
Survey Area	Bengaluru Metropolitan Area, State of Karnataka, Republic of India
Implementing Agency	Construction and Operation: Bangalore Metro Rail Corporation Limited (BMRCL)
Other Relevant Authorities and Organizations	Government of Karnataka, Ministry of Housing and Urban Affairs, Government of India (MoHUA)
Project Description	• Civil and architectural works (International Competitive Bidding) • Corridor 3-1: 32.2 km, 22 stations (elevated) • Corridor 3-2: 12.5 km, 9 stations (elevated) • Procurement of trackwork, turnouts, and ventilation & air-conditioning systems (International Competitive Bidding) • Electrical works for stations, depots, and substations (International Competitive Bidding) • Automatic Fare Collection (AFC) system (International Competitive Bidding) • Signalling and Train Control system (International Competitive Bidding) • Communication system (International Competitive Bidding) • Rolling stock (International Competitive Bidding) • Line 3-1: 174 cars (29 trainsets with 6-car formations) • Line 3-2: 60 cars (20 trainsets with 3-car formations) • Construction of two rolling stock depots (International Competitive Bidding) • Consulting services

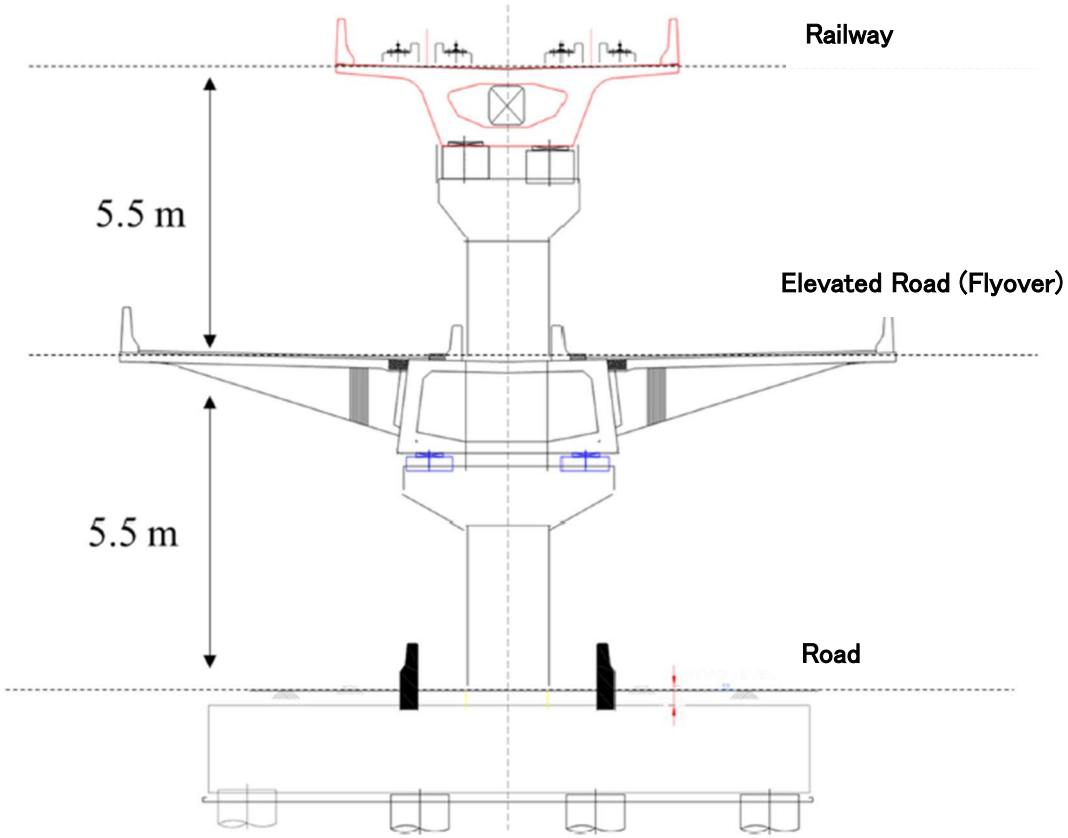
Source: JST

This project is primarily a railway initiative, a double-deck structure will be adopted. Therefore, for reference, an overview of the road component is also provided below.

Table 1-3: Project Overview (Road Component)

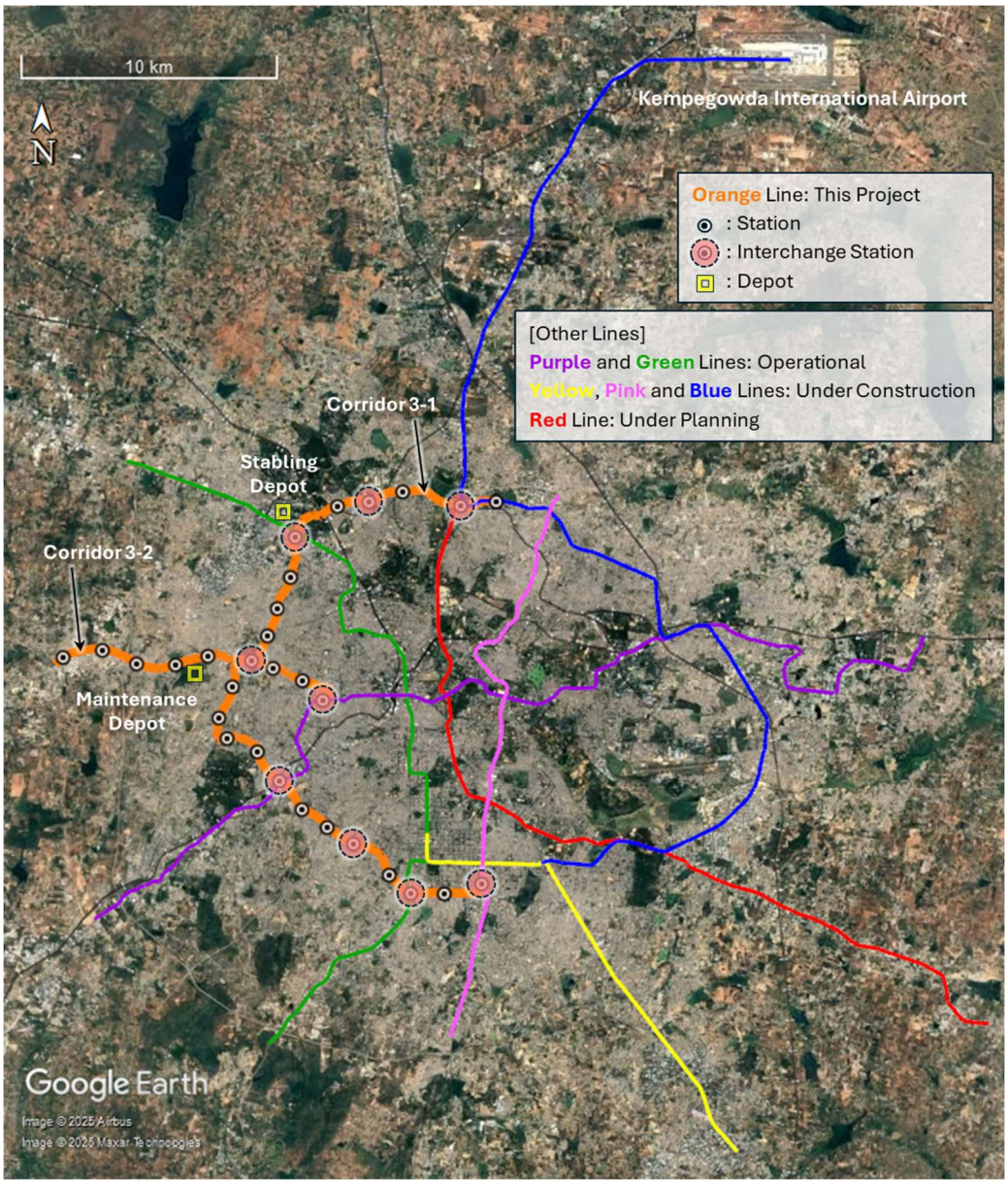
Project	Road
Objective	The objective of this project is to respond to the increasing transportation demand and worsening traffic congestion in the Bengaluru metropolitan area, India, through the development of peripheral ring roads. The project is expected to contribute to the regional economic development.
Overview	An elevated roadway of 29.2 km along the outer ring road, including 9 ramps (both entry and exit) An elevated roadway of 11.45 km along Magadi Road, including 6 ramps (both entry and exit)
Implementing Agency	Construction：BMRCL Operation：Bruhat Bengaluru Mahanagara Palike (BBMP)
Other Relevant Authorities and Organizations	Government of Karnataka

Source: JST



Source: DPR

Figure 1-2: Typical Cross-Section



Source: JST

Figure 1-3: Route map of the project

1.5 The scope of the Environmental Impact Assessment

The following provides supplementary explanations from the perspective of environmental and social impact assessment.

The scope of the ODA loan project does not include the road component. Although the road section is planned to be constructed as a double-deck viaduct sharing the same structure with the metro under this project, it functions independently.

Based on the discussions of the JICA Advisory Committee on Environmental and Social Considerations held during the scoping stage of this study, the indivisibility of the two projects was examined not only in reference to the FAQ definition, but also from the following three perspectives.

(1) Indivisibility in Planning Aspect (in reference to the FAQ definition)

According to the *Frequently Asked Questions (FAQ) on the JICA Guidelines for Environmental and Social Considerations (January 2022 edition)*, "indivisible projects" are defined as projects that meet both of the following conditions:

1. The related project would not be constructed or expanded without the JICA-assisted project; and
2. The JICA-assisted project would not be feasible without the related project.

In this project, the double-deck viaduct was not initially planned as an integrated structure. Rather, it was adopted as the most rational option to ensure efficient spatial use and urban traffic performance, based on the comparative analysis of alternative plans for both the metro and the road. Therefore, the road can be constructed independently even without the metro, and the metro can also be constructed independently without the road. Hence, neither condition (1) nor (2) applies.

(2) Indivisibility in Functional Aspect

Functionally, each project can operate independently and does not depend on the other. Even if one of the two—either the metro or the road—were not operational, it would not affect the functionality of the other. Therefore, even when adopting a double-deck structure, the two projects cannot be regarded as functionally indivisible.

(3) Indivisibility in Structural Aspect

Structurally, the metro and road components do not necessarily depend on a double-deck viaduct for their construction or functionality. Even without such a structure, both could be developed and function based on alternative configurations (e.g., parallel viaducts, underground and surface levels, or other arrangements). Accordingly, the fact that a double-deck structure is adopted does not make the two projects structurally indivisible.

Based on the above, the metro and the road do not meet the definition of an indivisible project from the perspectives of planning, function, or structure.

However, since both projects are to be implemented on the same physical structure, cumulative environmental and social impacts—such as noise, vibration, landscape alteration, and tree cutting—may occur during the construction and operation stages. Therefore, in this preparatory survey, the environmental and social impact assessment, mitigation measures, and monitoring plan have been formulated by taking into account the entire double-deck viaduct structure.

2. Current status of Environmental and Social Conditions

2.1 Pollution

Prior to this study, BMRCL conducted sampling surveys on pollution parameters anticipated to be affected by this project, and the results are summarized below.

2.1.1 Air Quality

(1) Existing Survey Results

The Air Quality Index (AQI) is an indicator designed to communicate the status of air quality to the public in a simple form. It expresses complex air pollutant data into a single number (index value), category name, and color. AQI has six categories: “Good,” “Satisfactory,” “Moderate,” “Poor,” “Very Poor,” and “Severe.” Each category is defined based on the ambient concentrations of air pollutants and the expected health impacts (health breakpoints).

For eight types of pollutants with short-term (maximum 24-hour) standards—PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb—AQI sub-indices and health breakpoints are established.

According to the Central Pollution Control Board (CPCB), the Karnataka State Pollution Control Board has established 13 Continuous Ambient Air Quality Monitoring Stations (CAAQMs) covering residential, commercial, industrial, and silent zones. Among these, 10 stations are located in Bengaluru, and the remaining are located in Chikkaballapur, Hubballi, and Kalaburagi (one each). Air quality is monitored continuously, 24 hours a day, along with primary and secondary pollutants and meteorological parameters.

Source: https://www.aqi.in/dashboard/india/Karnataka/bengaluru

Figure2-1: Overview of Air Quality Index (AQI) in Bengaluru, 2021–2025

During the period from January to August 2025, the daily average concentration of $PM_{2.5}$ in Bengaluru was about 27 µg/m³, which was comparable to the range of the same period from 2021 to 2025 (24–32 µg/m³). On the other hand, the daily average concentration of PM_{10} was about 67 µg/m³, exceeding the range of the same period from 2021 to 2025 (41–66 µg/m³).

The project area is located in an urban setting, and the roads along the proposed metro alignment experience heavy traffic, which is a major source of air pollution. In particular, traffic congestion is frequent in sections where buildings and commercial facilities are concentrated.

Before this study, BMRCL had already conducted air quality monitoring at six locations for PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO under the DPR, and the results are presented in the table below.

The values of PM_{10} exceeded the Indian National Standard (100 µg/m³, 24-hour average) at some locations (Hebbal, Nayanda Halli, Kadabagere Cross). All of these sites are located along major arterial roads with high traffic volumes, and the exceedance is considered to be largely attributable to vehicular exhaust and road dust.

Table2-1: Ambient Air Quality Monitoring Results at Six Locations (DPR, BMRCL)

No.	Location	Day	CO (mg/m^3)	NO_2 ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)
National Ambient Air Quality Standards (NAAQS, 2009): CO is 8-hour average; others are 24-hour average			2	80	80	60	100
WHO Guidelines (24-hr avg.)			4	25	40）	15	45
1	Hebbal, Outer Ring Road	Day 1	1.09	19.09	8.16	31.4	102.8
		Day 2	1.12	18.26	7.92	20.0	80.9
2	Peeny vicinity	Day 1	0.86	17.17	7.43	28.4	70.1
		Day 2	0.92	16.37	7.58	18.7	74.2
3	Kottigeplya	Day 1	0.98	17.79	7.97	19.8	83.2
		Day 2	1.14	19.21	8.40	17.3	87.6
4	Nayanda Halli	Day 1	1.14	20.28	8.45	30.5	118.4
		Day 2	1.28	21.82	8.98	27.2	126.0
5	JP Nagar vicinity	Day 1	0.71	15.41	6.86	11.0	64.7
		Day 2	0.79	16.01	7.10	22.3	69.2
6	Kadabagere Cross	Day 1	1.03	18.15	8.02	14.8	94.6
		Day 2	0.99	18.86	8.21	13.9	82.1

Source: BMRCL and RITES (2023) Detailed Project Report for Two Corridors of Bangalore Metro Phase-3

2.1.2 Noise

According to the Central Pollution Control Board (CPCB), ten noise monitoring stations have been installed in Bengaluru city. The Japanese translation of the station locations is as follows:

- **Residential areas**: BTM, Nisarga Bhawan, Teri Dolmur
- **Commercial areas**: Marathahalli, Parisar Bhawan, Yeshwanthpur
- **Silent zones**: NIMHANS, RVCE
- **Industrial areas**: Peenya, Whitefield

Based on 2015 monitoring results (365 days, daytime and nighttime), the main findings are as follows:

- **BTM**: Both daytime and nighttime exceeded the standard 100% of the time. Daytime 65–75 dB(A) occurred 239 times; nighttime 55–65 dB(A) occurred 332 times.
- **Marathahalli**: Daytime did not exceed, but 88% of nighttime exceeded. Daytime 55–65 dB(A) occurred 360 times; nighttime 45–55 dB(A) occurred 43 times.
- **NIMHANS**: Daytime 100% exceeded, in the range of 55–71 dB(A). Nighttime 44–69 dB(A). 90% of daytime exceeded 57 dB(A); nighttime 90% exceeded 56 dB(A).
- **Nisarga Bhawan**: Daytime 65% exceeded; nighttime 100% exceeded. Daytime 55–65 dB(A) occurred 230 times; nighttime 45–55 dB(A) occurred 131 times.
- **Parisar Bhawan**: Daytime 63–70 dB(A); nighttime 53–70 dB(A). 85% of daytime and 100% of nighttime exceeded. 90% of daytime exceeded 65 dB(A); nighttime 56 dB(A).
- **Peenya**: Daytime exceeded only 1%. Daytime 53–91 dB(A); nighttime 51–91 dB(A). 90% of daytime exceeded 56 dB(A); nighttime 53 dB(A).
- **RVCE**: Daytime 100% exceeded. Daytime 55–65 dB(A) occurred 362 times; nighttime 45–55 dB(A) occurred 341 times. 90% of daytime exceeded 52 dB(A).

- **Teri Dolmur:** Daytime 95% exceeded; nighttime 92% exceeded. Daytime 65–75 dB(A) occurred 47 times; nighttime 55–65 dB(A) occurred 166 times.
- **Whitefield**: Both daytime and nighttime exceeded. Daytime 62–71 dB(A); nighttime 56–65 dB(A). 90% of daytime exceeded 64 dB(A); nighttime 58 dB(A).
- **Yeshwanthpur**: Daytime and nighttime 100% exceeded. Daytime exceeded 71 dB(A); nighttime exceeded 62 dB(A), for over 90% of the time.

Before this survey, BMRCL also conducted noise monitoring along major roads near the project alignment. Results were evaluated using India's "Commercial Area" standards (65 dB daytime, 55 dB nighttime), as most sites were adjacent to arterial roads with heavy traffic. Although many sites are generally categorized as "Commercial Area," some are within or adjacent to residential zones, and thus stricter evaluation may be necessary. In addition, IFC Environmental, Health and Safety Guidelines (2007) require daytime residential outdoor noise not to exceed 55 dB(A) and nighttime not to exceed 45 dB(A). At several survey points (e.g., MES Mattikere, 17 Lagere Road), average levels exceeded 55 dB(A), indicating influence from vehicular traffic. Baseline survey was conducted with the examination of appropriateness of applying standards according to land use.

Table2-2: Noise Standards in India

Category	Daytime	Nighttime	Reference
I. Industrial Area	75	70	EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS/02/1992, IVth Edition.
II. Commercial Area	65	55	
III. Residential Area	55	45	
IV. Silence Area	50	40	
Industrial Area/ Commercial Area	70	70	Environmental, Health, and Safety Guidelines, IFC
Residential Area	55	45	

Source: EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS/02/1992, IVth Edition./ Environmental, Health, and Safety Guidelines, IFC

Table2-3: Results of Existing Noise Measurements

Location	Day	Lmax (Maximum Sound Pressure)	Lmin (Minimum Sound Pressure)	LeqD (Daytime Equivalent Sound Level)	LeqN (Nighttime Equivalent Sound Level)
Kumaraswamy Layout	Day-1	84.8	51.7	69.0	69.0
	Day-2	89.2	44.8	63.8	49.8
Vidyapeeta Main Road, Banashankari	Day-1	90.9	39.4	72.2	51.8
	Day-2	92.0	41.0	73.9	53.3
Nayandahalli	Day-1	83.2	44.8	71.8	65.9
	Day-2	92.4	47.7	73.1	65.9
Nagarbavi	Day-1	84.5	41.8	67.3	55.2
	Day-2	83.8	35.8	71.7	52.5
Magadai Main Road Kottigepalya	Day-1	79.7	50.4	66.6	59.0
	Day-2	85.3	50.9	70.0	59.2
17 Laggere Road, Laggere	Day-1	108.2	30.5	86.9	77.4
	Day-2	104.6	29.7	80.4	93.6
Vijaynagar	Day-1	84.1	41.0	64.7	56.5
	Day-2	83.9	38.5	66.1	57.9
Hebbal ORR	Day-1	97.6	42.4	85.7	78.5
	Day-2	90.4	42.5	64.6	61.1
Magadi Main Road	Day-1	85.9	48.6	68.7	63.2

Location	Day	Lmax (Maximum Sound Pressure)	Lmin (Minimum Sound Pressure)	LeqD (Daytime Equivalent Sound Level)	LeqN (Nighttime Equivalent Sound Level)
	Day-2	85.9	47.5	66.2	63.2
MES Matthikere	Day-1	93.9	65.6	83.0	78.7
	Day-2	99.1	58.9	88.1	61.7

Source: BMRCL and RITES (2023) Detailed Project Report for Two Corridors of Bangalore Metro Phase-3

2.1.3 Soil

The soils in the project area can be classified into the following two types:

1. Red loam and sandy loam
2. Lateritic soil

Red loam and sandy loam are widely distributed in areas of granite and gneiss, and extend across hilly to gently sloping terrain. These soils have relatively coarse particles and many voids, which makes them highly permeable and prone to infiltration. As a result, rainwater easily percolates into the ground and dissolved substances are readily leached out, exhibiting characteristics of high permeability and natural fertility.

As part of the DPR, BMRCL collected six soil samples along the planned metro alignment and conducted soil analysis. The results are shown in Table2-4: Results of Existing Soil Survey. According to the test results, most of the soil samples were slightly alkaline, and in almost all locations the soil texture was classified as sandy loam soil.

Table2-4: Results of Existing Soil Survey

No.	Parameter	Unit	S1 Near Hebbal Lake	S2 Near Gorguntapalya Metro Station	S3 Near Summanahalli Society	S4 Nandi Links Grounds, Pantarapalya, Nayanda Halli	S5 Birla Tisya Rajajinagar	S6 Herohalli, Sunkada Katte
1	pH (25°C)	-	7.87	7.81	7.95	7.63	7.42	7.61
2	Electrical Conductivity (1:2 soil-water extract)	mS/cm	828	995	440	371	205	328
3	Available Phosphorus	kg/ha	370.85	458.95	285.6	396.43	360.9	399.27
4	Magnesium	meq/L	1.3	5	3.1	3.9	2.7	1.8
5	Available Potassium	kg/ha	384.36	326.26	165.36	330.73	138.54	330.73
6	Organic Matter Content	%	2.27	3.51	1.13	1.75	0.82	1.65
7	Calcium	meq/L	13.2	32.5	20.3	7.6	9.8	26.5
8	Available Nitrogen	kg/ha	472.9	448.44	240.37	358.75	67.81	241.34
9	Boron	mg/100g	2.35	2.11	1.88	1.09	1.68	1.01
10	Soil Texture	-	Sandy loam	Sandy loam	Loamy sand	Loamy sand	Sandy loam	Sandy loam
11	Sand (%)	%	65.68	71.68	83.68	79.68	75.68	73.68
12	Silt (%)	%	19.28	15.28	9.28	11.28	11.28	11.28

No.	Parameter	Unit	S1 Near Hebbal Lake	S2 Near Gorguntapalya Metro Station	S3 Near Summanahalli Society	S4 Nandi Links Grounds, Pantarapalya, Nayanda Halli	S5 Birla Tisya Rajajinagar	S6 Herohalli, Sunkada Katte
13	Clay (%)	%	15.04	13.04	7.04	9.04	13.04	15.04
14	Zinc	mg/kg	33.41	142.33	15.31	26.9	49.82	33.42
15	Iron	mg/kg	81.48	64.34	66.78	20.39	190.73	95.5
16	Moisture Content	%	16.44	10.15	5.78	4.42	8.94	4.76

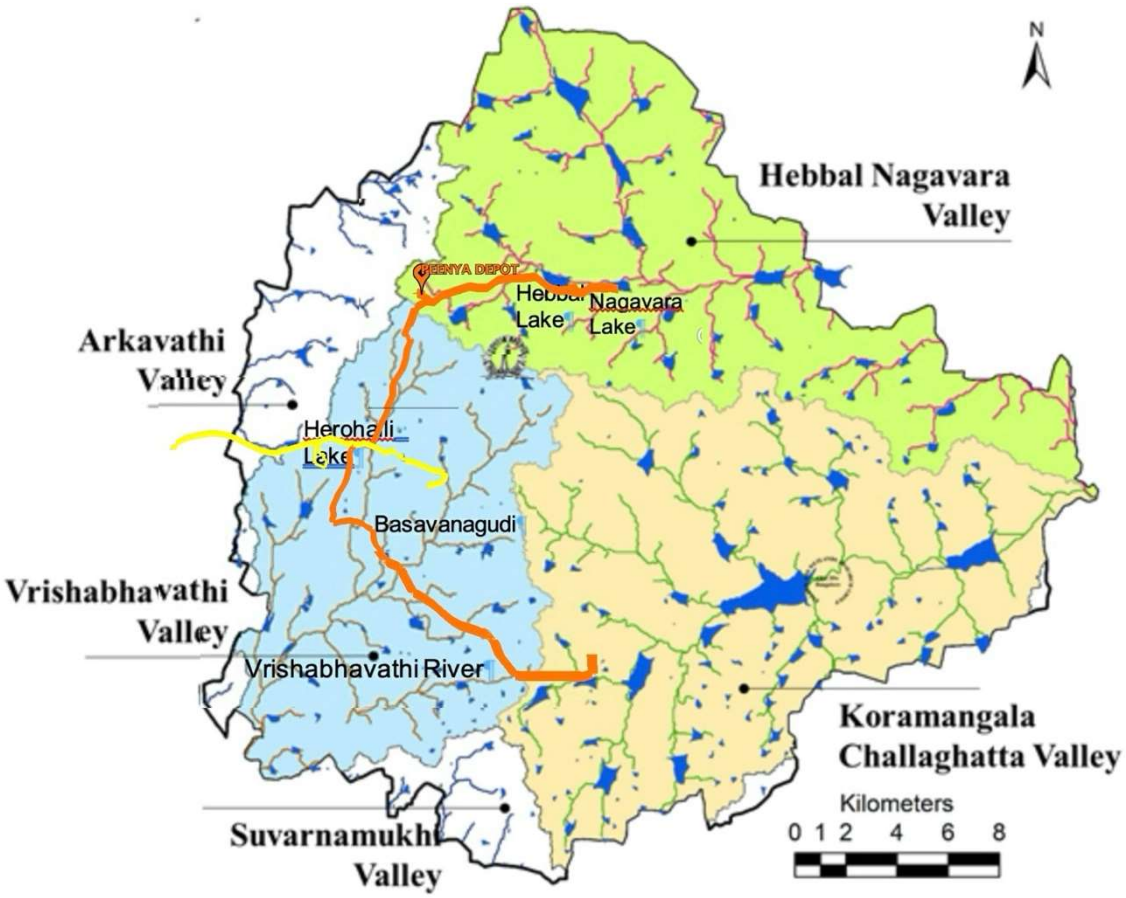
Source: BMRCL and RITES (2023) Detailed Project Report for Two Corridors of Bangalore Metro Phase-3

2.1.4 Water Environment

(1) Water Resources

The project area can broadly be divided into the **Cauvery River basin** (blue area in the figure below) and the **South Pennar River basin** (light green and light orange areas in the figure). The Shimsha River and the Kanva River belong to the Cauvery basin, while the South Pennar River originates from the Nandi Hills and flows southward.

Herohalli Lake is located within the Cauvery basin near the project alignment, while Hebbal Lake and Nagavara Lake belong to the South Pennar basin. These lakes play an important role in urban stormwater management and ecosystem conservation, and therefore require careful handling during both construction and operation.



Source: JST, adapted from a figure prepared by the Indian Institute of Science (IISc). Available at: https://wgbis.ces.iisc.ac.in/energy/water/paper/ETR114/section4.html

Figure2-2: Major Rivers and Lakes along the Valleys

Source: Ground Water Information Booklet Bengaluru Urban District, Karnataka - Government of India Ministry of Water Resources Central Ground Water Board, March 2013

Figure2-3: Drainage Map

Groundwater resources in this area have been evaluated considering sustainable and optimal development. The assessment was carried out based on the Groundwater Estimation Methodology (GEM), 1997. In the evaluation, various hydrogeological units such as command and non-command areas, hilly regions with slopes above 20%, and poor-quality aquifer zones were considered.

- Annual net groundwater availability: 11,723 ha m
- Total groundwater draft for irrigation, domestic, and industrial use: 3,794 ha m
- Current total groundwater extraction (all uses): 16,703 ha m

Thus, the total groundwater draft already exceeds the net annual availability, and groundwater resources are overexploited in all four taluks of the project area, with development levels exceeding 100%. These areas are categorized as “overexploited.” Consequently, the Central Ground Water Board has made it mandatory to register all new groundwater abstraction structures in such taluks.

(2) Groundwater

Groundwater occurs in weathered zones as unconfined aquifers, and in fractured or jointed rock masses as semi-confined to confined aquifers. Its occurrence, movement, and productivity depend on the distribution of fractures, degree of weathering, topography, geology, and rainfall.

In valley areas, the weathered zone tends to be thicker, and dug wells sometimes reach depths of up to 30 m. Borewell depths vary depending on weathering, lithology, and the presence of massive rock formations.

In Bengaluru Urban District, the main aquifers consist of granite, gneiss, and schist zones such as the Peninsular Gneiss. Lateritic formations of the Tertiary period are distributed in some northern and eastern areas and also contain groundwater. Along river valleys, groundwater recharge occurs in narrow localized bands. Overall, groundwater potential in the area is relatively limited.

Groundwater fluctuation is mainly controlled by topography, lithology, and rainfall. In Bengaluru Urban District, groundwater monitoring is conducted through the Network of Hydrograph Stations (NHS) established by the Central Ground Water Board (CGWB). There are 22 NHS and 13 piezometers in the district, with four rounds of monitoring each year (May, August, November, and January), and additional monthly monitoring in Bengaluru city.

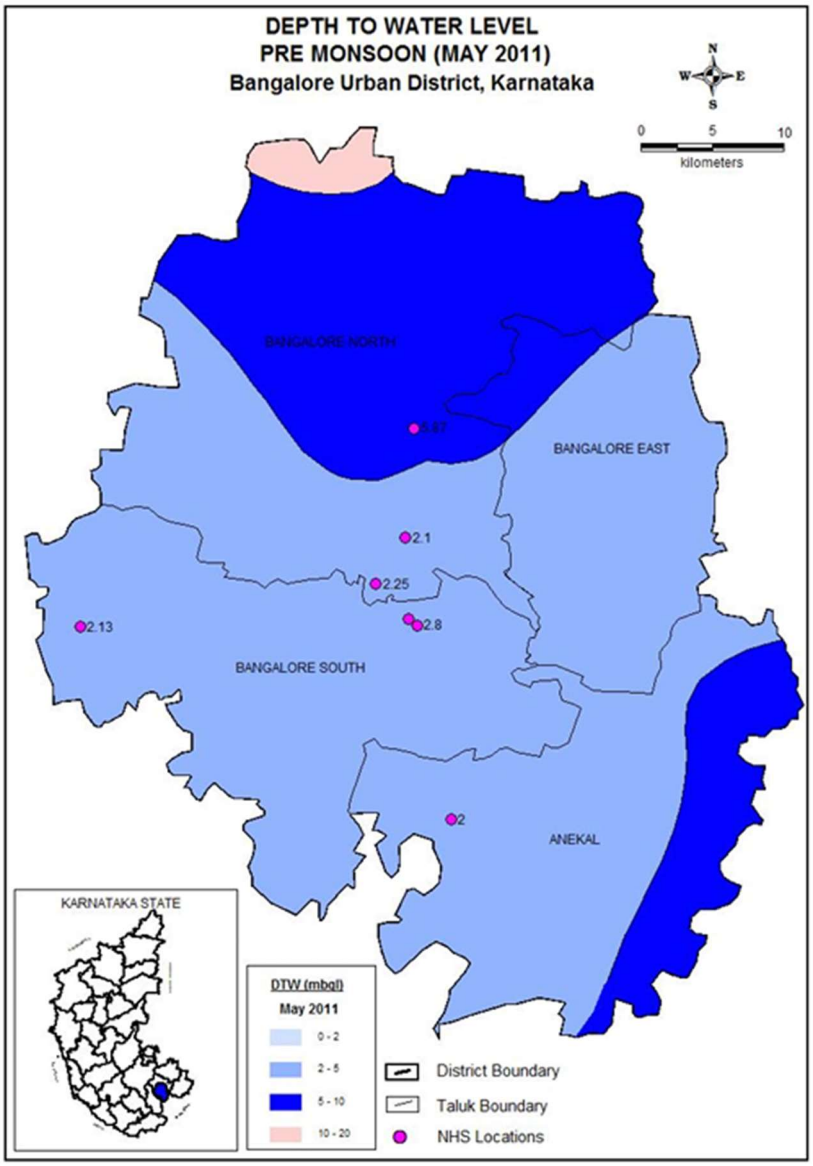
Characteristics of Groundwater Level (2011)

- Urban areas: 1–5 m below ground level (bgl), relatively shallow.
- Peripheral areas: 10–20 m bgl, with large seasonal fluctuations.
- Pre-monsoon: 5–30 m bgl at piezometers, 2–11 m bgl at dug wells.
- Post-monsoon: 2–40 m bgl at piezometers, 0.5–11 m bgl at dug wells. .

Long-term Trend (2002–2011)

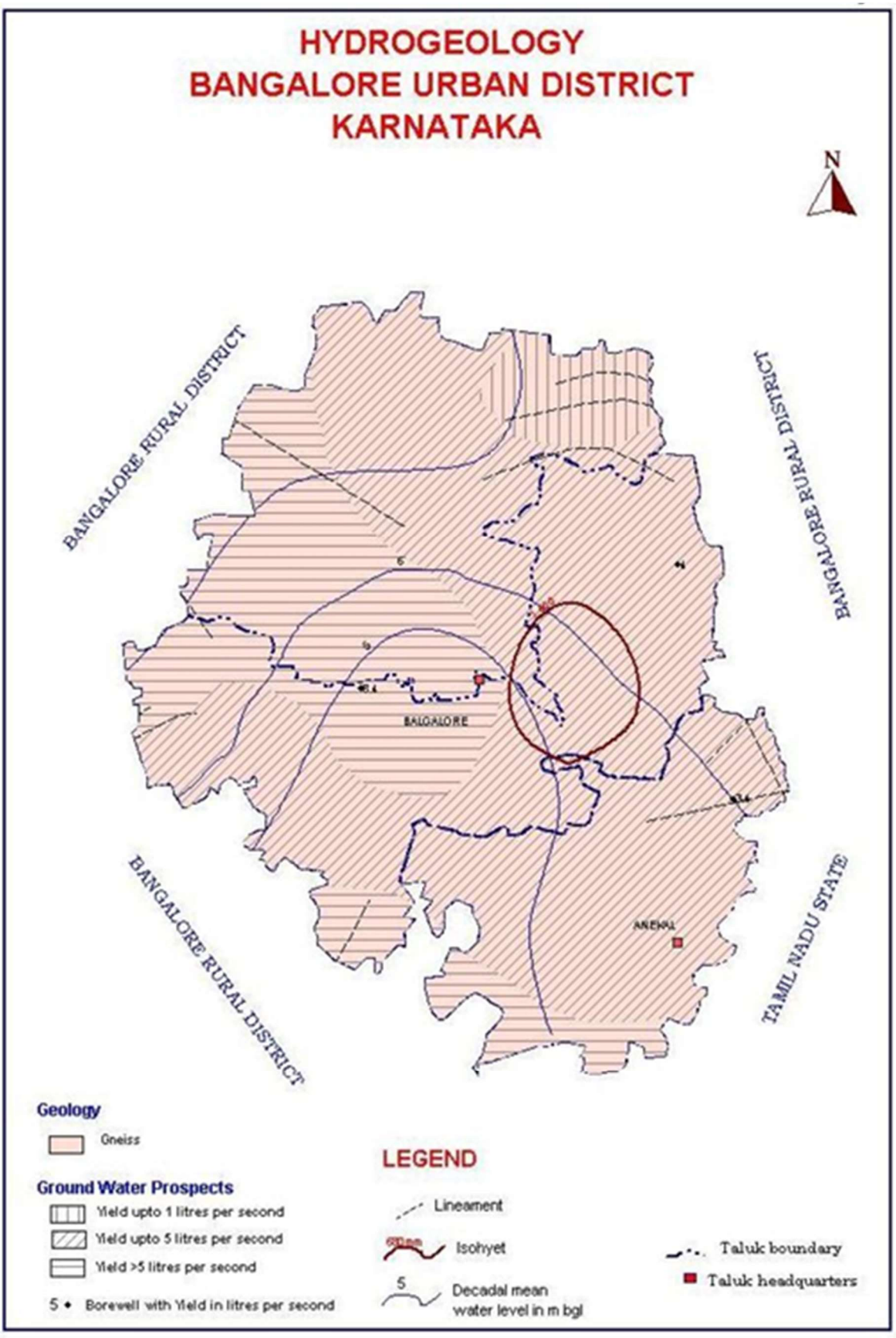
According to NHS data, groundwater levels in Bengaluru Urban District shown a general declining trend. Annual declines of about 0.2–0.5 m have been observed in central areas, while peripheral areas fluctuate with rainfall and recharge conditions. Overall, the long-term trend is a distinct decline.[16].

[16] CGWB, *Ground Water Information Booklet – Bengaluru Urban District, March 2013*



Source: https://cgwb.gov.in/Bengaluru Urban District, Karnataka March 2013

Figure2-4: Depth to Water Level (Pre-Monsoon, May 2011)



Source: https://cgwb.gov.in/Bengaluru Urban District, Karnataka March 2013

Figure2-5: Hydrogeology of Bengaluru

(3) Water Quality

The groundwater quality of this area has been clarified based on the water quality chemical data from NHS wells and exploratory bore wells. The groundwater shows considerable variation in its chemical composition.

- Both shallow and deep groundwater are alkaline, with pH ranging from 7.8 to 8.5.
- Total hardness ranges between 100–600 ppm.
- In most parts of the district, the water is fresh, with electrical conductivity (EC) at 25°C ranging from 250–2000 µmho/cm.
- In most parts of the northern and southern taluks, the water is fresh, with EC between 500–1000 µmho/cm.
- In the northeastern part of the northern taluk and the central part of the southern taluk, EC levels of 2000–3000 µmho/cm have been observed.
- In Anekal taluk, EC is generally in the range of 1000–2000 µmho/cm, but in some central areas it exceeds 2000 µmho/cm, indicating high salinity zones.

Chloride concentrations in many parts of Anekal Taluk, the eastern part of the northern taluk, and the southwestern and eastern parts of the southern taluk range from 250–1,000 mg/L.

With respect to nitrate, most parts of Anekal and southern taluks exceed the permissible limit (>45 mg/L). Elevated nitrate levels are also found in some southwestern and northeastern parts of the northern taluk.

Overall, the groundwater in this area is of the sodium chloride type. Fluoride content is generally below 1 mg/L, but in certain southern parts of the district, levels exceeding 1 mg/L have been recorded. Accordingly, these areas are designated as vulnerable zones for groundwater fluoride contamination.

Prior to this study, to assess the current groundwater quality within the project area, BMRCL collected samples from eight locations along the proposed metro alignment. The analytical results are presented in Table2-5: Results of Water Quality Analysis.

Table2-5: Results of Water Quality Analysis

No.	Analysis Item	Unit	Sampling Location								Indian Drinking Water Standard*1 (Permissible/Upper Limit)	International Standard*2
			W1 Nagavara Lake	W2 Hebbal Lake	W3 Near freedom fighters colony	W4 near Vinayaka Layout Station	W5 Banashankari 3rd Stage	W6 Gopalan Innovation Mall, JP Nagar	W7 Kamashipalya	W8 Herohalli Lake		
			SW	SW	GW	GW	GW	GW	GW	SW		
1.	pH	-	7.49	7.64	6.94	7.90	6.68	7.05	7.45	7.88	6.5–8.5/NR	6.5–8.5 (WHO)
2.	Turbidity	NTU	3.44	2.58	0.47	0.42	0.76	0.52	0.50	2.28	1/5	5 (WHO, recommended value)
3.	Biochemical Oxygen Demand (BOD, 3 days, 27°C)	mg/L	17.0	7.0	13.0	22.0	2.8	5.0	7.33	20.0	Not specified	3 (WHO)
4.	Chemical Oxygen Demand (COD)	mg/L	56.0	24.0	48.0	64.0	8.0	16.0	24.0	56.0	Not specified	10 (EU Directive reference)
5.	Electrical Conductivity (EC)	µS/cm	570	490	1298	450	801	948	1310	430.0	Not specified	2500 (WHO)
6.	Total Dissolved Solids (TDS)	mg/L	395	340.0	890.0	300	545	628	879	280.0	500/2000	1000 (WHO)
7.	Total Hardness (as $CaCO_3$)	mg/L	98.0	100.0	352.0	142.0	234.0	266.0	364.0	78.0	200/600	500 (US EPA)
8.	Total Suspended Solids (TSS)	mg/L	14.0	12.0	6	5	10	8	8	20.0	Not specified	Not specified
9.	Alkalinity (as $CaCO_3$)	mg/L	96.0	112.0	344.0	154.0	238.0	240.0	348	82.0	200/600	Not specified
10.	Ammoniacal Nitrogen	mg/L	0.89	3.36	0.33	0.33	0.44	0.44	0.33	0.33	Not specified	0.5 (WHO)
11.	Nitrate (NO_3)	mg/L	3.08	4.19	43.23	Below detection limit	32.54	22.69	8.65	3.80	45/NR	50 (WHO)
12.	Chloride (Cl^-)	mg/L	67.51	59.68	88.05	29.35	50.87	81.2	93.92	49.89	250/1000	250 (WHO)
13.	Sulfate (SO_4^{2-})	mg/L	55.11	15.19	58.81	15.06	39.51	63.17	69.38	27.74	200/400	250 (WHO)
14.	Sodium (Na)	mg/L	36.8	30.0	40.0	18.0	38.0	48.0	38.0	32.0	Not specified	200 (WHO)

No.	Analysis Item	Unit	Sampling Location								Indian Drinking Water Standard*1 (Permissible/Upper Limit)	International Standard*2
			W1 Nagavara Lake	W2 Hebbal Lake	W3 Near freedom fighters colony	W4 near Vinayaka Layout Station	W5 Banashankari 3rd Stage	W6 Gopalan Innovation Mall, JP Nagar	W7 Kamashipalya	W8 Herohalli Lake		
			SW	SW	GW	GW	GW	GW	GW	SW		
15.	Potassium (K)	mg/L	20.0	15.0	3.2	2.8	8.0	20.4	9.0	15.0	Not specified	Not specified (no health-based guideline)
16	Calcium (Ca)	mg/L	20.8	20.0	76.8	29.6	48.8	55.2	78.4	17.6	75/200	100 (WHO)
17.	Magnesium (Mg)	mg/L	11.17	12.15	38.88	16.52	27.21	31.10	40.82	8.26	30/100	50 (WHO)
18.	Fluoride (F)	mg/L	0.41	0.62	0.89	0.35	0.63	0.55	0.77	0.11	1/1.5	1.5 (WHO)
19.	Iron (Fe)	mg/L	Below detection limit	Below detection limit	0.169	0.081	0.079	0.091	0.068	Below detection limit	1/NR	0.3 (US EPA, aesthetic standard)
20.	Lead (Pb)	mg/L	0.009	0.005	Below detection limit	Below detection limit	Below detection limit	Below detection limit	Below detection limit	Below detection limit	0.01/NR	0.01 (WHO)
21.	Nickel (Ni)	mg/L	Below detection limit	Below detection limit	0.008	Below detection limit	Below detection limit	0.006	Below detection limit	Below detection limit	0.02/NR	0.07 (WHO)
22.	Cadmium (Cd)	mg/L	0.005	Below detection limit	Below detection limit	Below detection limit	Below detection limit	Below detection limit	Below detection limit	Below detection limit	0.003/NR	0.003 (WHO)
23.	Copper (Cu)	mg/L	0.016	0.018	Below detection limit	Below detection limit	Below detection limit	0.006	Below detection limit	0.008	0.005/1.5	2.0 (WHO)
24.	Zinc (Zn)	mg/L	0.994	0.247	0.450	0.009	0.017	0.013	0.017	0.172	5/15	3.0 (WHO)
25.	Dissolved Oxygen	mg/L	5.4	5.3	–	–	–	–	–	5.4	Not specified	6–8 (reference value, environmental water quality)
26.	Total Coliform (CFU/100 ml)	Present/ 100ml	2400	2200	–	–	–	–	–	2800	Not specified	Not detected (WHO)

*1: Bureau of Indian Standards (BIS), IS 10500:2012 - Drinking Water Specification, Government of India

*2: - WHO (2017). Guidelines for Drinking-water Quality, 4th Edition with Addenda.
- US EPA (2022). National Secondary Drinking Water Regulations.
- European Union (Council Directive 98/83/EC)

Source: BMRCL and RITES (2023) Detailed Project Report for Two Corridors of Bangalore Metro Phase-3

The analysis of the water quality samples confirmed the following points.

In some samples, BOD values exceeded 10 mg/L. Although India does not have a standard for BOD, based on the WHO guideline (reference value: organic pollution is indicated when BOD is 3–6 mg/L or higher), there is a high possibility of organic contamination.

In the surface water samples, turbidity exceeded the acceptable limit but remained within the permissible limit.

In contrast, turbidity in the groundwater samples was within the acceptable limit.

Nitrate, Chloride, Sulphate, Fluoride, and Iron were all within the acceptable limit.

Total Dissolved Solids (TDS), Alkalinity, and Hardness exceeded the acceptable limit in samples W3, W5, W6, and W7, but remained within the permissible limit.

Calcium slightly exceeded the acceptable limit in samples W3 and W7.

Magnesium exceeded the acceptable limit in samples W3, W6, and W7, but remained within the permissible limit.

Lead and Nickel were detected in sample W2 but remained within the acceptable limit. At other locations, the concentrations were below the detection limit (BDL).

Cadmium exceeded the acceptable limit in sample W1 but remained within the permissible limit. At other locations, cadmium concentrations were below the detection limit.

Copper also exceeded the acceptable limit in samples W1, W2, W6, and W8, but remained within the permissible limit. At other locations, copper concentrations were below the detection limit.

Dissolved Oxygen (DO) exceeded 5 mg/L in the surface water samples, indicating good oxygen availability.

However, coliform bacteria were detected in all surface water samples, suggesting the possibility of microbial contamination.

(4) Waste

In Karnataka State, municipal solid waste management is one of the core functions of Urban Local Bodies (ULBs). However, rapid urbanization, the diversity of waste, insufficient awareness among residents and stakeholders, lack of appropriate infrastructure, and uncoordinated and unscientific waste management practices have made management increasingly difficult. There are a total of 315 ULBs in the state, including BBMP, and approximately 11,085 tons of municipal solid waste are generated daily from 313 of these ULBs.

To address this situation, the Government of Karnataka has formulated an integrated and sustainable waste management policy, with the following main objectives:

- To provide guidelines for managing waste in an environmentally, financially, and economically sustainable manner.

- To establish an integrated and autonomous operational system for municipal solid waste management (MSWM), developing appropriate measures and technologies for each stage, including collection, storage, segregation, transportation, processing, and disposal.
- To strengthen the capacity of ULBs so that they can stably provide waste management services to citizens.

In Bengaluru city, waste management is carried out by the local authority, BBMP. General solid waste collection is undertaken regularly under contracts with private operators, and the collected waste is transported to disposal sites designated by the State Government or BBMP. Processing and disposal are conducted in accordance with national regulations such as the Solid Waste Management Rules, 2016.

In addition, construction and demolition waste (C&D Waste) is transported and disposed of at facilities permitted by BBMP, in accordance with the Construction and Demolition Waste Management Rules, 2016. Multiple C&D waste treatment facilities exist in the city to accommodate large-scale projects such as infrastructure construction.

Furthermore, hazardous waste that may be generated from railway and rolling stock facilities (e.g., lubricants, waste oil, spent cleaning solutions) is managed in accordance with the Hazardous and Other Wastes (Management and Trans-boundary Movement) Rules, 2016, and treated by authorized recyclers registered with the Karnataka State Pollution Control Board (KSPCB).

Recently, in response to the increasing waste generation in the urban area of Bengaluru, initiatives for recycling and segregation have been promoted, and regular collection and management are carried out under sanitation contracts at city stations and public facilities.

2.2 Natural Environment

2.2.1 Meteorology

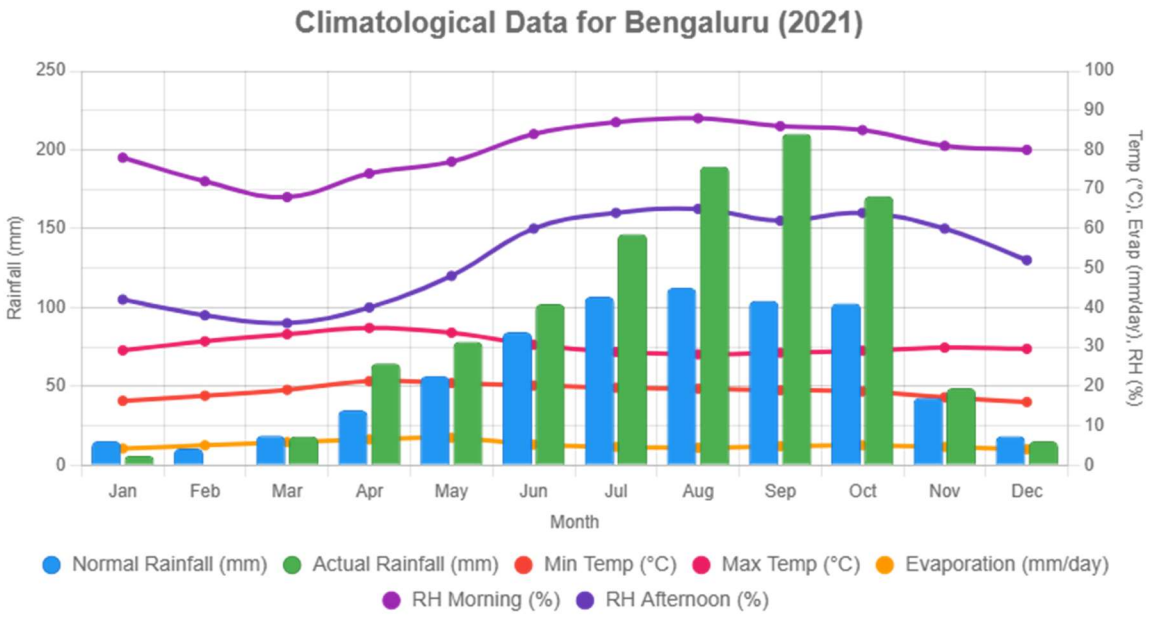
The climate of Bengaluru Urban district is classified as tropical savanna. Temperatures are generally mild throughout the year, with a distinct dry season and wet season. The dry season usually lasts from December to March, during which very few rainy days occur. April to May corresponds to the pre-monsoon period, when rising temperatures are often accompanied by evening thunderstorms. The main rainy season is from June to October under the influence of the southwest monsoon, during which most of the annual rainfall is concentrated; September is typically the wettest month. November marks the transition from the rainy to the dry season, and in some years rainfall continues into this month.

Precipitation data for 1941–1990 and average meteorological data for 1971–2000 are summarized in Table2-6. Weather data for 2021 are shown in Figure2-6.

Table2-6: Meteorological Data of Bengaluru Urban District（TSV）

Month	Precipitation (mm)	Rainy Days	Mean Temperature (°C)	Maximum Temperature (°C)	Minimum Temperature (°C)	Relative Humidity (%)	Mean Wind Speed (km/h)	Mean Cloud Cover (oktas)
Jan	2.3	0.3	23.1	30.4	15.9	50.8	11.2	2.7
Feb	7.1	0.6	25.7	33	18.4	43.6	12.5	2.2
Mar	9.1	2.7	27.9	34.6	21.2	48.8	13.6	3.8
Apr	38.4	6.1	27.5	33.5	21.3	56.2	17.1	5
May	105	4.5	24.9	29.7	20	63	26.6	6.2
Jun	67.7	6.7	24.1	28.5	19.7	72.6	24.8	6.6
Jul	96.3	7.2	23.6	27.8	19.4	74.9	23.6	6.6
Aug	126.6	8.2	23.9	28.3	19.4	73.8	16.1	6.1
Sep	170.4	8	23.5	28	18.9	72.2	11.7	5.3
Oct	141.6	3.4	21.9	26.9	16.8	70.2	12	4.7
Nov	51.4	1.1	20.8	26.5	15.1	68.4	13	4.5
Dec	495.1	0.2	20.9	27.7	14.1	59.9	11.5	3.2

Source: BMRCL and RITES (2023) Detailed Project Report for Two Corridors of Bangalore Metro Phase-3



Source: India Meteorological Department, Ministry of Earth Sciences, Government of India. *Climatological Tables of Observatories in India 1991-2020.* (https://www.imdpune.gov.in/library/public/Climatological%20Tables%201991-2020.pdf retieved on 20th Oct. 2025)

Figure2-6: Climatological Data for Bengaluru (2021)

(1) Temperature

- Maximum monthly mean temperature: 36.5°C (April)
- Minimum monthly mean temperature: 13.3°C (December)

In summer, temperatures can rise to around 36°C, although the average is approximately 30–35°C. There are typically 4–6 very hot days each year, when the temperature rises by about 4–6°C above average. Winter mornings are often foggy or misty, but the afternoons are usually clear.

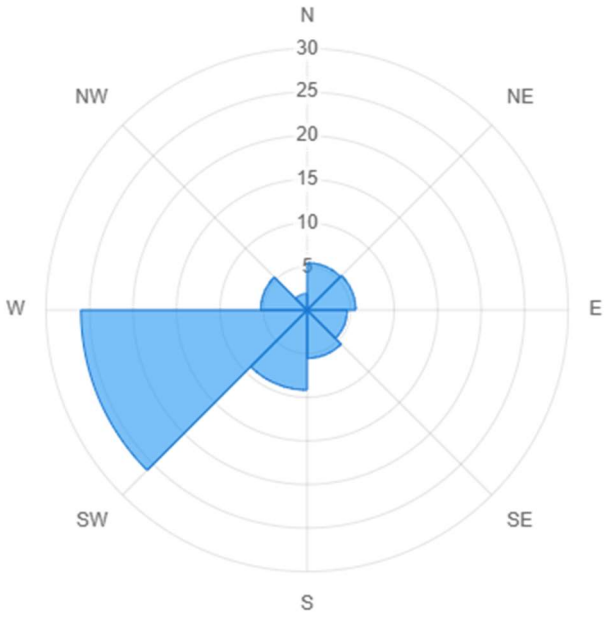
(2) Precipitation

- Annual average rainfall: approx. 1,077.6 mm (1991–2020)
- Maximum monthly rainfall: 208.3 mm (September)
- Minimum monthly rainfall: 1.6 mm (January)

About 81% of the annual rainfall is concentrated during the monsoon season (July–October). The remainder occurs in winter and pre-monsoon seasons, often as thunderstorms. Inter-annual variation in rainfall is large.

(3) Wind speed

- Maximum mean wind speed: 8.1 km/h (July)
- Minimum mean wind speed: 3.7 km/h (April)



Source: India Meteorological Department, Ministry of Earth Sciences, Government of India. *Climatological Tables of Observatories in India 1991-2020.* (https://www.imdpune.gov.in/library/public/Climatological%20Tables%201991-2020.pdf retrieved on 20 October 2025)

Figure2-7: Wind Rose of Bengaluru

(4) Climate Change

According to the Karnataka State Action Plan on Climate Change (KSAPCC), observed and projected climate trends in Bengaluru indicate significant changes in temperature and hydrological parameters. Extreme temperature events—particularly increases in maximum temperatures and unusually warm minimum temperatures—are becoming more frequent. The Indian Institute of Tropical Meteorology (IITM) has developed climate models based on IPCC emission scenarios, which project that the mean temperature in Bengaluru could rise by 2.5–4.5°C by the end of the 21st century.

Rainfall during the monsoon season is projected to increase by 5–15%. However, the number of rainy days may decrease by 15–25%, suggesting that precipitation will become more concentrated and intense within

shorter periods. This implies that even if annual rainfall remains stable, the concentration and intensification of rainfall will increase the risks of flooding, urban waterlogging, and soil erosion. Long-term records of the India Meteorological Department (IMD) also show that over the past 50 years, the frequency of extreme rainfall events has increased, consistent with broader climate change impacts.

Within the transport sector, greenhouse gas (GHG) emissions are one of the most important issues, accounting for about 28–32% of Bengaluru's total emissions. Rapid urbanization, economic growth, and rising income levels have led to motorization increasing at nearly three times the population growth rate. Consequently, transport-related emissions have increased significantly.

The increase in extreme rainfall events and temperatures also presents serious challenges to urban infrastructure. Prolonged heavy rainfall and flooding can weaken road pavements and railbeds, while higher temperatures can reduce the efficiency of signaling and power equipment. These climate stresses can disrupt metro and bus operations, creating risks of service interruptions. The potential impacts of climate change on transport demand are also significant, highlighting the urgent need for resilient transport infrastructure.

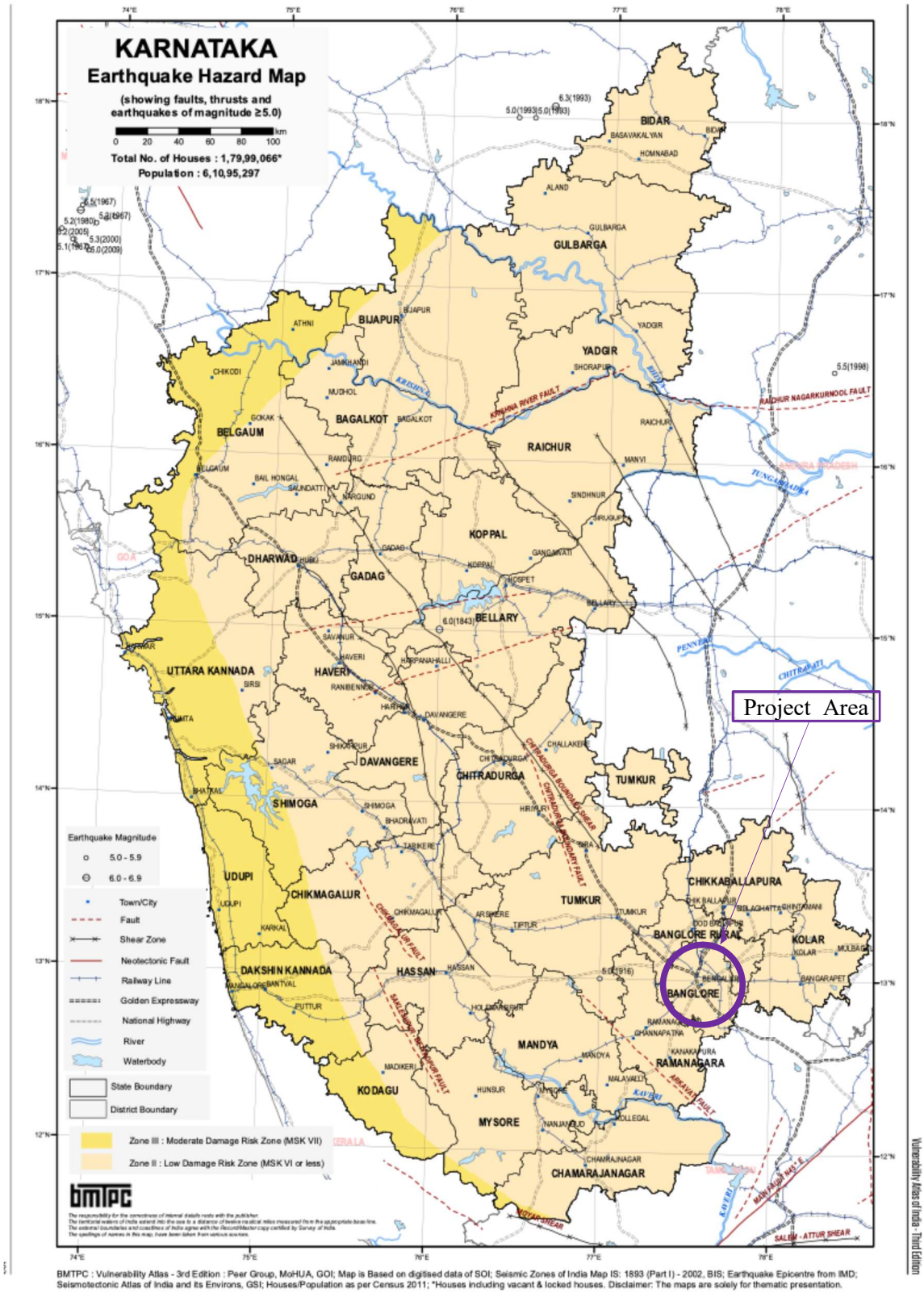
To address these challenges, Bengaluru has initiated multiple climate-resilient transport measures. Specific actions include expanding the Bengaluru Metro (Namma Metro) network operated by BMRCL), promoting the adoption of electric buses and electric two-wheelers, shifting to clean fuels, introducing a Bus Rapid Transit (BRT) system, and integrating non-motorized transport (NMT) such as cycling and pedestrian pathways. In addition, as part of urban planning initiatives, improvements in drainage systems and the use of heat-resistant road construction materials are being advanced to strengthen climate-resilient infrastructure.

2.2.2 Natural Disaster

(1) Earthquakes

Bengaluru Urban district, where the Project is located, falls under Zone II of the Bureau of Indian Standards (BIS) seismic zoning map, which corresponds to a low-damage risk zone. The seismic hazard zonation for Karnataka is shown in Figure2-8.

Although Karnataka is among the less seismically active states in India, historical records note events including an M5.5 earthquake in Chitradurga district in 1936. While most areas are classified as Zone II, certain coastal districts such as Uttara Kannada fall within Zone III (moderate damage risk) and therefore warrant caution.



Source: BMTPC: Vulnerability Atlas – 3rd Edition

Figure2-8: Seismic Hazard Zonation of Karnataka

(2) Floods

Karnataka is located in the southwestern part of India, bounded by the Lakshadweep Sea to the west, Goa to the northwest, Maharashtra to the north, Telangana to the northeast, Andhra Pradesh to the east, Tamil Nadu to the southeast, and Kerala to the southwest. Physiographically, the state can be divided into four broad regions: the Northern Karnataka Plateau, Central Karnataka Plateau, Southern Karnataka Plateau, and the Coastal Karnataka region.

The principal rivers are as follows:

- **Cauvery (Kaveri):** the largest river in the state, originating in Kodagu district.
- **Kabini:** a tributary of the Cauvery, rising in Kerala and flowing east to join at T. Narasipura.
- **Krishna:** the second largest river of the Peninsula; it originates in Maharashtra and flows through Karnataka.
- **Tungabhadra:** the largest tributary of the Krishna, formed by the confluence of the Tunga and Bhadra in Shivamogga district; it flows east and joins the Krishna in Andhra Pradesh before draining into the Bay of Bengal.
- **Ghataprabha:** rises in the Western Ghats and joins the Krishna to the east; notable for Gokak Falls in Belagavi district.
- **Bhima:** rises in the Bhimashankar forest of Pune district (Maharashtra), flows through Karnataka, and joins the Krishna near Kudlur in Raichur district.

  Other rivers include Malaprabha, Manjara, Mandovi, Pennar, and Sharavathi.

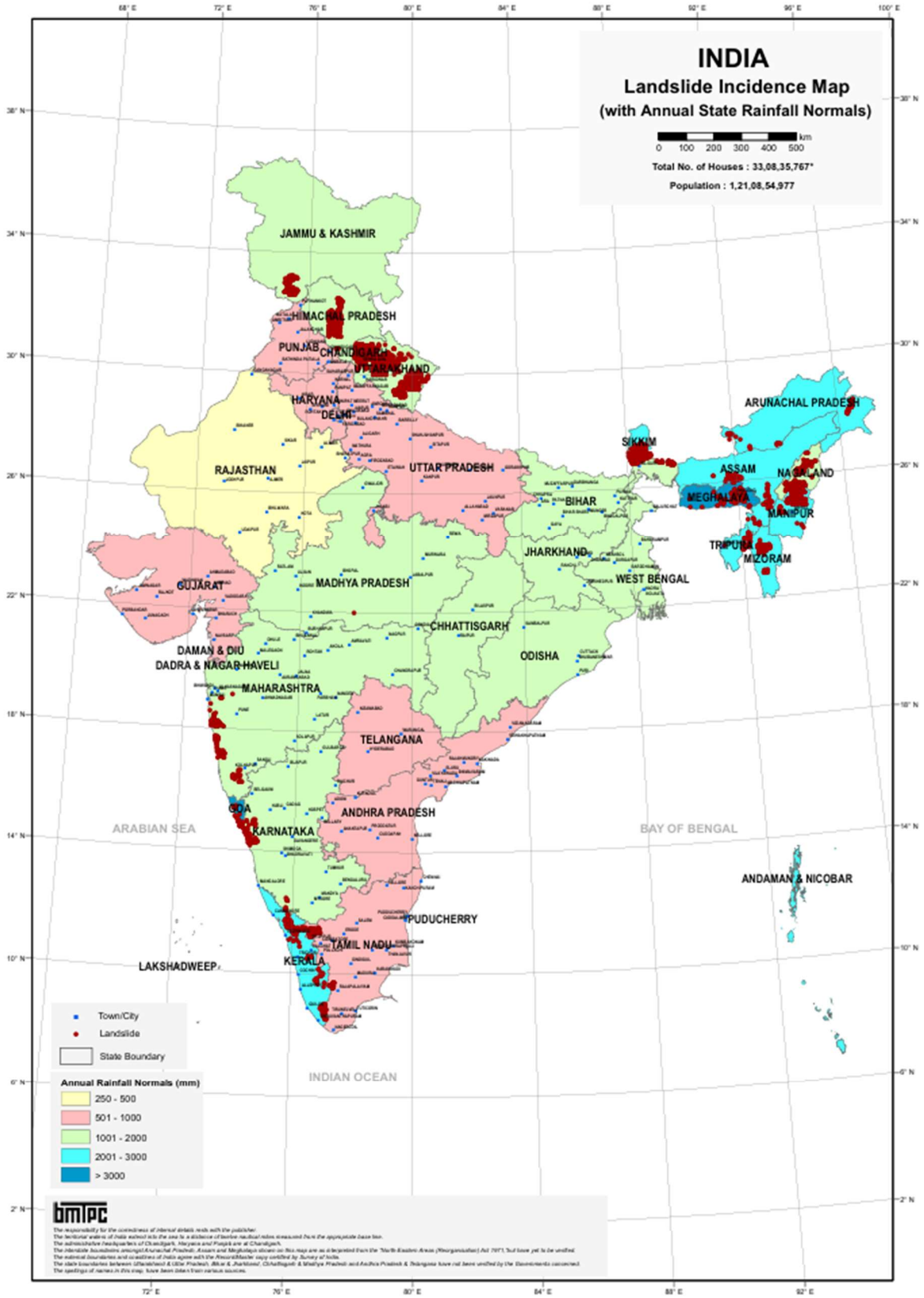
Table2-7: Recent Major Flood Events in Karnataka

No.	Year	Overview of Flood Events
1	2005	Floods occurred in the first week of August 2005 due to heavy rainfall and the release of water from both Koyna and Ujjani dams.
2	2009	Floods occurred in the first week of October 2009 due to heavy rainfall and rising water levels in the Krishna district.
3	2013	Floods occurred in the last week of July 2013 due to heavy rainfall; the Krishna River overflowed at Almatti Dam in Bijapur.
4	2019	Floods occurred in the second week of August 2019 across various parts of Karnataka due to heavy rainfall.
5	2020	Three floods were reported in 2020 (15–20 August, 3–20 September, and 14–18 October).
6	2022	Floods occurred in the last week of July 2022 in Karnataka due to heavy rainfall.

Source: https://ndma.gov.in/sites/default/files/PDF/FHA/Flood_Affected_Area_Atlas_of_India.pdf

(3) Landslide

While landslides have been recorded in the hilly tracts of western Karnataka, the Bengaluru urban area is predominantly flat and there are no significant records of landslide occurences within the city.



BMTPC: Vulnerability Atlas - 3rd Edition: Peer Group, MoHUA,GOI: Map is Based on digitised data of SOI; Landslide Incidence data GSI; Annual Rainfall data IMD. Houses/Population as per Census 2011;
* Houses including vacant & locked houses. Disclaimer: The maps are solely for thematic presentation.

Source: :https://vai.bmtpc.org/eq.html

Figure2-9: Landslide Occurrence Map of India.

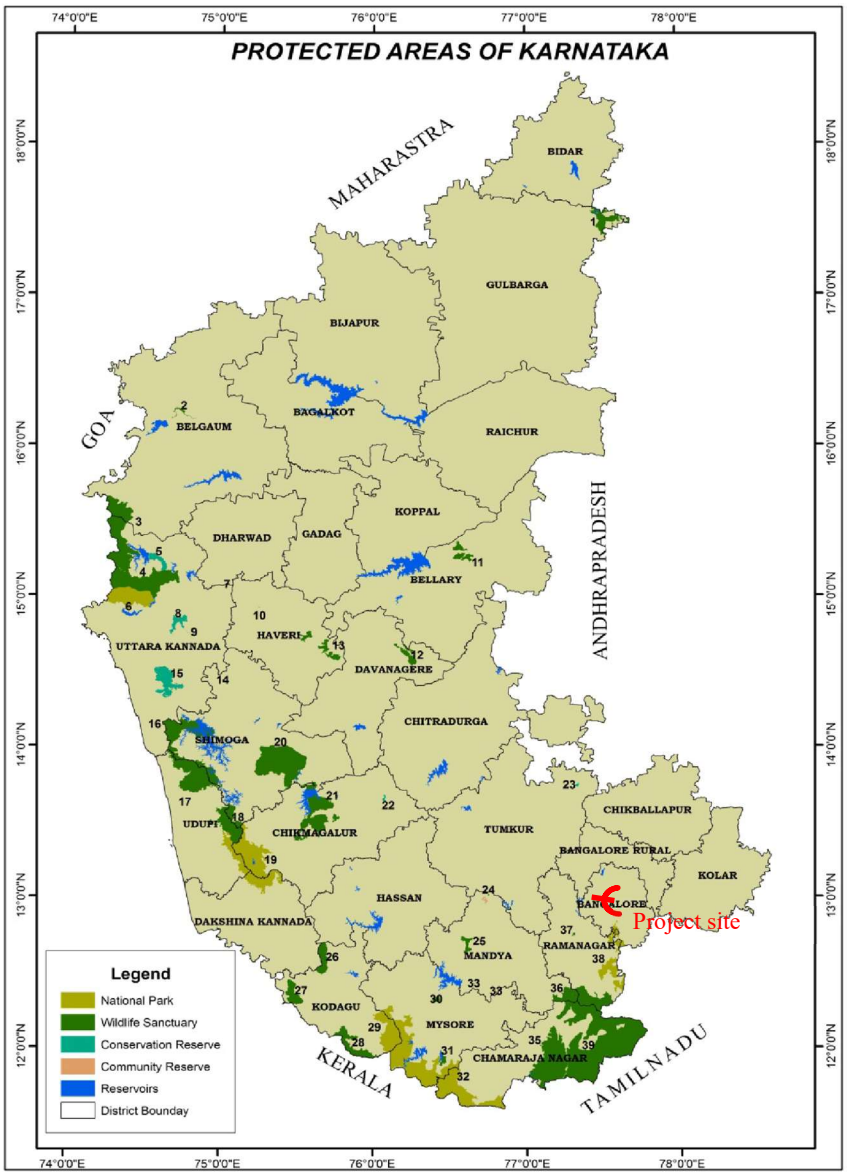
2.2.3 Protected Areas and National Parks

In Karnataka, more than 30 protected areas, including national parks and wildlife sanctuaries, have been designated, as shown in Table2-8.

Table2-8: Location of the Project in Relation to Protected Areas in the State

Sl.	Name	District	Category of Protected Area	Area (km^2)
1	Bandipur National Park & Tiger Reserve	Chamarajanagar	National Park / Tiger Reserve	872.2
2	Nagarahole (Rajiv Gandhi) National Park & Tiger Reserve	Kodagu, Mysore	National Park / Tiger Reserve	643.4
3	Bannerghatta National Park	Bangalore	National Park	260.5
4	Kudremukh National Park	Chikmagalur	National Park	600.3
5	Anshi (Kali) National Park & Tiger Reserve	Uttara Kannada	National Park / Tiger Reserve	814.9
6	Bhadra Wildlife Sanctuary & Tiger Reserve	Chikmagalur, Shimoga	Wildlife Sanctuary / Tiger Reserve	492.5
7	Brahmagiri Wildlife Sanctuary	Kodagu	Wildlife Sanctuary	181.3
8	Pushpagiri Wildlife Sanctuary	Kodagu	Wildlife Sanctuary	102.9
9	Dandeli Wildlife Sanctuary	Uttara Kannada	Wildlife Sanctuary	834.2
10	Cauvery Wildlife Sanctuary	Mysore, Bangalore, Mandya	Wildlife Sanctuary	526.9
11	Biligiri Rangaswamy Temple Wildlife Sanctuary & Tiger Reserve	Chamarajanagar	Wildlife Sanctuary / Tiger Reserve	539.5
12	Malai Mahadeshwara Wildlife Sanctuary	Chamarajanagar	Wildlife Sanctuary	906.9
13	Mookambika Wildlife Sanctuary	Udupi	Wildlife Sanctuary	247
14	Sharavathi Valley Wildlife Sanctuary	Shimoga	Wildlife Sanctuary	431.2
15	Shettihalli Wildlife Sanctuary	Shimoga	Wildlife Sanctuary	395.6
16	Someshwara Wildlife Sanctuary	Udupi	Wildlife Sanctuary	88.4
17	Talakaveri Wildlife Sanctuary	Kodagu	Wildlife Sanctuary	105
18	Adichunchanagiri Peacock Sanctuary	Mandya	Wildlife Sanctuary	0.8
19	Attiveri Bird Sanctuary	Uttara Kannada	Wildlife Sanctuary	2.2
20	Ranganathittu Bird Sanctuary	Mysore	Wildlife Sanctuary	0.7
21	Ankasamudra Bird Conservation Reserve	Ballari	Conservation Reserve	244
22	Bankapura Peacock Conservation Reserve	Haveri	Conservation Reserve	139
23	Basur Amruth Mahal Kaval Conservation Reserve	Chikmagalur	Conservation Reserve	508
24	Ranibennur Blackbuck Sanctuary	Haveri	Wildlife Sanctuary	119
25	Ramadevarabetta Vulture Sanctuary	Ramanagara	Wildlife Sanctuary	3.5
26	Yadahalli Chinkara Wildlife Sanctuary	Bagalkot	Wildlife Sanctuary	96.4
27	Bukkapatna Chinkara Wildlife Sanctuary	Tumkur	Wildlife Sanctuary	129
28	Gudekote Sloth Bear Sanctuary	Ballari	Wildlife Sanctuary	167
29	Daroji Sloth Bear Sanctuary	Ballari	Wildlife Sanctuary	82.7
30	Bhimgad Wildlife Sanctuary	Belgaum	Wildlife Sanctuary	190.4
31	Kokkare Bellur Community Reserve	Mandya	Community Reserve	3.12

Source: Karnataka Forest Department (https://aranya.gov.in/aranyacms/), compiled by the Study Team.



Map Id	Name of the Protected Area
1	Chincholi (WS)
2	Ghataprabha (WS)
3	Bhimghad (WS)
4	Dandeli (WS and TR)
5	Hombill (CR)
6	Anshi (NP and TR)
7	Attiveri (WS)
8	Bedthi (CR)
9	Shalmala (CR)
10	Bankapura (CR)
11	Daroji (WS)
12	Rangayyanadurga (WS)
13	Ranebennur (WS)
14	Gudavi (WS)
15	Aghanashini (CR)
16	Sharavathi (WS)
17	Mookambika (WS)
18	Someshwara (WS)
19	Kudremukh (WS)
20	Shettihalli (WS)
21	Bhadra (WS and TR)
22	Basur Amruth Mahal Kaval (CR)
23	Jayamangali (CR)
24	Adichunchangiri (WS)
25	Melkote (WS)
26	Pushpagiri (WS)
27	Talacauvery (WS)
28	Bramhagiri (WS)
29	Nagarahole (NP and TR)
30	Arabithittu (WS)
31	Nugu (WS)
32	Bandipur (NP and TR)
33	Ranganathittu (WS)
34	Kokkare Bellur (Com. R)
35	Biligirirangaswamy Temple (WS and TR)
36	Cauvery (WS)
37	Ramadevarabetta (WS)
38	Bannerghatta (NP)
39	Malai Madeshwara Wildlife Sanctuary

Source: Prepared by the Study Team based on Karnataka Forest Department (2017) (https://cag.gov.in/uploads/download_audit_report/2017/Chapter_1_Introduction_of_Karnataka_Report_No_6_of_2017_on_Administration_of_National_Parks_and_Wildlife_Sanctuaries.pdf)

Figure2-10: Location of the Project in Relation to Protected Areas in the State

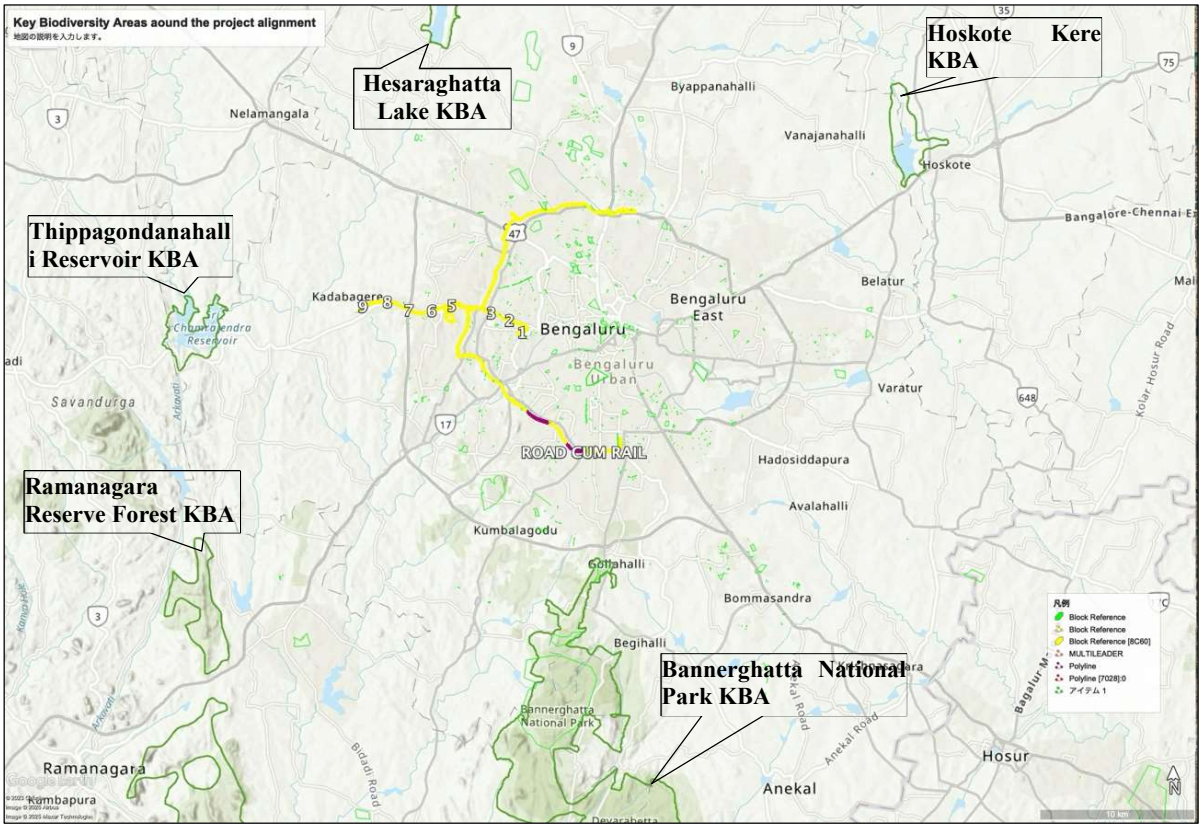
Important habitats within a 10 km radius of the planned alignment have been identified, and their locations and extents are shown in the table below.

Table2-9: Important Habitats within 10 km of the Project Area

No.	Important Habitat	Within 10 km
A	Legally Designated Protected Area	None
A.1	Key Biodiversity Area (KBA)	Yes
A.2	Important Bird and Biodiversity Area (IBA)	Yes
A.3	Ramsar Site	None
A.4	World Heritage Site	None
A.5	UNESCO Man and the Biosphere (MAB) Reserve	None
B	Protected Areas under Indian Law	Yes, Bannerghatta National Park (7.05 km from Line 3-2)

Source: JST

The shortest distance from the southern end of the project alignment to Bannerghatta National Park is 7.1 km, making it the nearest legally designated protected area to the project site. In addition, several Key Biodiversity Areas (KBAs), including Bannerghatta National Park, have been identified around the project area, though all are located more than 7 km away. No internationally designated protected areas (World Heritage Sites, Ramsar Sites, UNESCO Biosphere Reserves) exist in the vicinity of the project area.



Source: JST, based on the Key Biodiversity Areas (https://wdkba.keybiodiversityareas.org)

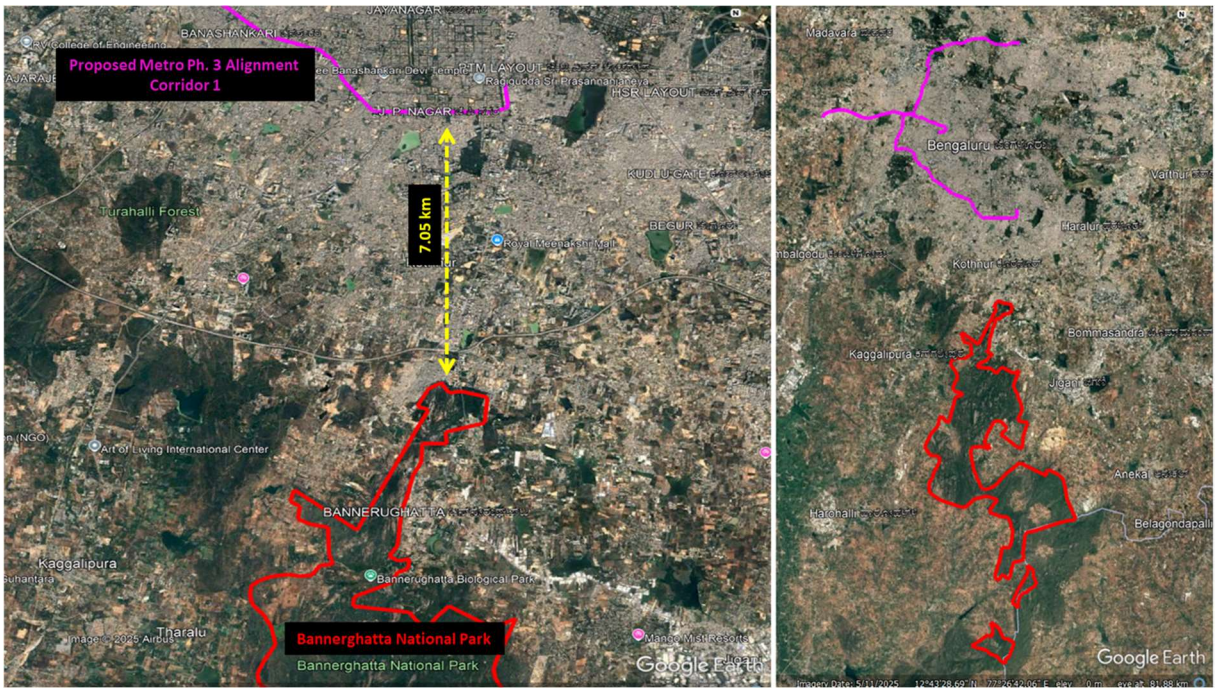
Figure2-11: Key Biodiversity Areas around the Project Area (KBA)

Table2-10: Overview of Protected Area near the Project Area

Protected Area	Name	Details
Bannerghatta National Park	- Established/Area: Established in 1974; approx. 260.51 km² - Purpose: Conservation of forest ecosystems and protection of wildlife - Major Species (IUCN Category): Fauna: Indian Elephant (EN), Indian Leopard (VU), Dhole (NT), Sloth Bear (VU), Bonnet Macaque (VU), etc. Flora: Sandalwood (VU), Neem (LC), etc.	National Park under the Wildlife Protection Act, 1972 (India) KBA

[IUCN Categories] Endangered: EN, Vulnerable: VU, Near Threatened: NT, Least Concern: LC

Source: Prepared by the Study Team based on Karnataka Forest Department (https://aranya.gov.in/aranyacms/)



Source: Prepared by the Study Team

Figure2-12: Relationship between the Project Alignment and Bannerghatta National Park

Bengaluru, once widely recognized for its green spaces and numerous lakes, has experienced rapid and unplanned urban expansion in recent years.

This has resulted in the transformation of vital green lungs into clusters of residential complexes and commercial hubs. Despite these changes, the city—known as the *"Garden City of India"*—continues to host two prominent botanical gardens, Cubbon Park and Lalbagh Botanical Garden, both centrally located within the city.

Cubbon Park, located approximately 5 km from the proposed metro alignment, was established in 1870 by John Meadeand has a history spanning over a century. The park houses a diverse collection of indigenous and exotic flora, comprising around 68 genera and 96 species, with an estimated 6,000 trees and plants. Indigenous species include *Artocarpus* spp., *Cassia fistula*, *Ficus* spp., and *Polyalthia* spp., while exotic species include *Araucaria*, Bamboo, *Castanospermum australe*, *Grevillea robusta*, and *Millettia*.

Lalbagh Botanical Garden, another renowned botanical garden located approximately 3.8 km from the

proposed alignment, spans an area of 97 hectares (240 acres). It is home to approximately 1,854 plant species belonging to 673 genera and 890 cultivars. Lalbagh also supports a range of wild bird species and other forms of urban wildlife, making it a significant ecological hotspot within the city.

In 1982, the Bangalore Green Belt Division was established with the objective of increasing green cover within the Bengaluru Metropolitan Region. The division was later expanded to include the entire Bengaluru Urban District. Natural vegetation in the area includes *Albizia amara*, *Albizia lebbeck*, *Anogeissus latifolia*, *Acacia* spp., *Shorea talura*, and *Santalum album*.

The Bengaluru Urban Forest Division covers a total geographical area of 21,741 hectares, of which forestlands—including both notified and other government-owned lands—account for 4,298.43 hectares, or approximately 1.97% of the total area. These forests are classified as tropical dry deciduous, typically comprising species such as *Acacia* spp., *Albizia* spp., *Wrightia tinctoria*, *Ziziphus* spp., and *Pongamia* spp.

According to the Working Plan of the Bengaluru Urban Forest Division (2002–03 to 2011–12), the administrative area is divided into five territorial ranges, including Reserved Forests, Protected Forests, and Government-owned lands. The details of forest distribution by range are in Table2-11.

Table2-11: Forest Area under Bengaluru Urban Forest Division

No.	Division Name	Notified Forest (ha)	Other Government Land (ha)	Total Forest Area (ha)
1	Anekal	34.07	112.00	146.07
2	Bengaluru	504.33	86.67	1237.96
3	Kaggalipura	1831.24	252.97	2139.18
4	K.R. Puram	395.70	701.45	1911.01
5	Yelahanka	380.00	-	440.30
	Total	**3145.34**	**1153.09**	**5874.52**

Source: Bengaluru Urban Forest Division Working Plan (2002–03 to 2011–12)

Some government-owned lands managed by the Forest Department are not formally notified as reserved forests, but have been transferred from the Revenue Department, where afforestation and social forestry projects have been implemented. Such lands are occasionally reallocated for other government projects, resulting in gradual reduction of forest area.

In addition, the Social Forestry Division manages unnotified forest lands such as C&D waste sites, gomala (grazing lands), tank beds, and plantations, which may become candidate forest areas in the future.

According to the Bengaluru Urban Forest Division, the major reserved forests within proximity of the project alignment are listed in the table below.

Table2-12: Forests in Bengaluru Urban Division and Proximity to Metro Alignment

No.	Name of Reserved Forest	Distance to Alignment (km)
1	Jarakabande Reserved Forest	15.0
2	Marasandra Reserved Forest	11.0
3	Kumbaranahalli Reserved Forest	18.5
4	Govindapura Reserved Forest	6.0
5	Arkavathi Reserved Forest	24.0
6	Madappanahalli Plantation	20.0

No.	Name of Reserved Forest	Distance to Alignment (km)
7	Jarakabande Sandal Reserved Forest	7.5
8	Sulikere Reserved Forest	17.0
9	Turahalli Gudda Protected Forest	10.0
10	Basavanathara Reserved Forest	5.0
11	Doresanipalya Reserved Forest	3.5
12	Jyothipura Reserved Forest	30.0
13	Mandoor Reserved Forest	10.5
14	B.M. Kaval Reserved Forest	14.0
15	Kadugodi Reserved Forest	4.5
	Total Forest Area	**2897.63 ha**

Source: Prepared by the Study Team

The urban green areas managed by the Bengaluru Urban Forest Division do not correspond to national parks, wildlife sanctuaries, or other protected areas governed by the Ministry of Environment, Forest and Climate Change (MoEFCC).

The Reserved Forests and Protected Forests listed above are defined under the Indian Forest Act (1927), not under the Wildlife Protection Act (1972).

Under the Indian Forest Act, forests are broadly classified into two categories: Reserved Forests, which are strictly protected, and Protected Forests, where certain activities may be restricted by the government as necessary. Compared with Reserved Forests, the level of legal protection for Protected Forests is relatively moderate.

Most of these forests are located in or around urban and peri-urban areas and mainly consist of managed plantations and social forestry lands, rather than pristine natural forests or habitats of rare species.
Therefore, they do not qualify as “critical habitats” or “critical forests” as defined in Appendix 1 of the JICA Guidelines for Environmental and Social Considerations (2022).

2.2.4 Ecosystem

The forests of Bengaluru Urban District are classified as dry deciduous forests, dominated by native species such as *Albizia amara*, *Dalbergia lanceolaria*, *Cassia fistula*(Golden Shower), and *Acacia catechu* (Cutch Tree). *Lantana camara*, an invasive shrub species, is also commonly found.

Although there are no large-scale forests near the project alignment, certain sections are well planted with roadside trees, which play an important role in providing greenery and environmental functions in the urban context. To minimize construction impacts, transplantation and replantation of roadside trees will be required.

Many species of flora and fauna have been recorded in the Bengaluru Urban District. In particular, Bannerghatta National Park, located about 7 km south of the project alignment, has been recognized as a Key Biodiversity Area (KBA) supporting species such as the Indian pangolin, slender loris, and leopard. Open-source databases such as iNaturalist also report the presence of wild primates such as the bonnet macaque (*Macaca radiata*) in urban areas.

BMRCL conducted an ESIA survey at the preparatory stage, which included an inventory of important

habitats and rare, threatened, and endangered species within the project-affected area. No critical habitats or rare and threatened species were identified in the alignment area. However, according to eBird and iNaturalist records, several threatened species have been observed in the wider Bengaluru Urban District, and some of these species may potentially occur near the project corridor.

Table2-13: Rare and Threatened Species Potentially Distributed in Bengaluru Urban District

No.	Scientific Name	Common Name	IUCN Category
1	*Santalum album*	Indian Sandalwood	VU
2	*Pterocarpus marsupium*	Malabar Kino	NT
3	*Shorea roxburghii*	White Meranti	VU
4	*Mesua ferrea*	Ceylon Ironwood	NT
5	*Pterocarpus santalinus*	Red Sanders	EN
6	*Macaca radiata*	Bonnet Macaque	VU
7	*Panthera pardus*	Leopard	VU
8	*Elephas maximus*	Asian Elephant	EN
9	*Crocodylus palustris*	Mugger Crocodile	VU
10	*Python molurus*	Indian Python	NT
11	*Varanus bengalensis*	Benal Monitor	NT
12	*Lissemys punctata*	Indian Flapshell Turtle	NT
13	*Anhinga melanogaster*	Oriental Darter	VU
14	*Pelecanus philippensis*	Spot-billed Pelican	VU
15	*Sterna aurantia*	River Tern	NT
16	*Ciconia episcopus*	Asian Woolly-necked Stork	VU
17	*Phylloscopus tytleri*	Tytler's Leaf Warbler	NT
18	*Aquila rapax*	Tawny Eagle	NT
19	*Falco chicquera*	Red-necked Falcon	VU
20	*Circus macrourus*	Pallid Harrier	VU
21	*Pelargopsis amauroptera*	Brown-winged Kingfisher	VU
22	*Clanga clanga*	Greater Spotted Eagle	NT

[IUCN Categories] Endangered: EN, Vulnerable: VU, Near Threatened: NT

Source: Prepared by the Study Team with reference to birdwatching records in Bengaluru Urban District (eBird, iNaturalist).

2.2.5 Topography and Geology

(1) Topography

The project area lies on the Deccan Plateau in southeastern Karnataka between longitudes 77°22′–77°52′ E and latitudes 12°39′–13°18′ N. The terrain comprises rocky uplands, plateaus, and flat-topped hills. Most of the district forms a pediplain (sub-peneplain) with scattered hillocks across the western part. Overall ground surface gently slopes toward the south and southeast. Residual soils mantle much of the area over granitic gneiss bedrock. General elevations range from about 850 m to 950 m above mean sea level.

(2) Geology

Bengaluru Urban District belongs to the Peninsular Gneissic Complex of the Indian Shield. Bedrock is dominated by Archean gneisses and schists intruded by younger igneous bodies (e.g., granites/dykes).

Regionally occurring surficial formations include laterite and alluvium; stratigraphic summaries for the broader state commonly list units such as the Upper Vindhyan Supergroup, Deccan Traps, and inter-trappean beds, though within the district the prevailing lithology is the Archean gneiss–schist complex with lateritic and alluvial veneers.

2.3 Social Environment

2.3.1 Administrative Division

India consists of 28 states and 8 union territories. Karnataka is administratively organized into 4 divisions and 31 districts, further subdivided into sub-districts/talukas, blocks and villages. Each district is headed by a Deputy Commissioner.

Bengaluru Urban District (state capital), together with Bengaluru Rural and Ramanagara Districts, forms the Bengaluru Metropolitan Region (BMR; total area 8,005 km²). The Bengaluru Metropolitan Region Development Authority (BMRDA) was established in 1985 to oversee regional development; within BMR, urban development is implemented by several local development authorities under BMRDA, including the Bengaluru Development Authority (BDA).

The project area falls within the Bengaluru Metropolitan Area (BMA), the 1,294 km² core of BMR comprising:

1. the BBMP city area (708 km²) plus 251 surrounding villages under BDA jurisdiction (together totaling 1,206.97 km²), and
2. the Bengaluru–Mysuru Infrastructure Corridor Area Planning Authority (BMICAPA) area (87.03 km²).

Source: BDA, Revised Master Plan for Bengaluru - 2031 (Draft): Volume-3

Figure2-13: Location Relationship of Karnataka State, BMR, and BMA

2.3.2 Land Use

The project area is in the urban sector of Bengaluru Urban District. District-wide land-use/land-cover shares are: built-up 67.84%, green area 16.22%, barren land 13.69%, and water bodies 2.25% (Table2-14).

Table2-14: Land Use/Land Cover in Bengaluru Urban District

No.	Land Use/Land Cover	Area (km²)	Share (%)
1	Built-up Area (Buildings)	481	67.84
2	Water Bodies	16	2.25
3	Green Area	115	16.22
4	Barren Land	97	13.69
No.	Land Use/Land Cover	Area (km²)	Share (%)

Source: BMRCL and RITES (2023) Detailed Project Report for Two Corridors of Bangalore Metro Phase-3

Along the alignment, land use is predominantly a mix of commercial and residential zones, with parks and water bodies occurring intermittently. Commercial uses concentrate along arterial roads with residential

neighborhoods behind them; densities and traffic volumes are highest in the city center and at major junctions. Side-of-alignment land use is summarized in Table2-15.

Table2-15: Land Use along the Proposed Project Alignment

No.	Metro Station	Chainage (km)	LHS Land Use	RHS Land Use
	3-1 Line: JP Nagar 4th Phase – Kempapura			
1	Start – JP Nagar 4th Phase	-0.330–0.042	Commercial, Residential	Commercial, Residential
2	JP Nagar 4th Phase – JP Nagar 5th Phase	0.042–1.789	Commercial, Residential, Vacant Land	Commercial, Residential, Vacant Land
3	JP Nagar 5th Phase – JP Nagar	1.789–3.089	Commercial, Residential, Vacant Land	Commercial, Residential, Vacant Land
4	JP Nagar – Kadirenahalli	3.089–4.261	Commercial, Residential, Public Facilities, Vacant Land	Commercial, Residential, Vacant Land
5	Kadirenahalli – Kamakya Junction	4.261–6.247	Park, Residential, Commercial	Commercial, Residential, Public Facilities, Park
6	Kamakya Junction – Hosakerehalli	6.247–7.472	Residential, Commercial, Public Facilities, Vacant Land	Commercial, Residential, Vacant Land
7	Hosakerehalli – Dwaraka Nagar	7.472–8.658	Commercial, Residential, Public Facilities	Commercial, Residential, Public Facilities
8	Dwaraka Nagar – Mysore Road	8.658–10.162	Commercial, Residential, Vacant Land, Water Body	Commercial, Residential, Vacant Land, Water Body
9	Mysore Road – Nagarbhavi Circle	10.162–11.651	Commercial, Residential, Vacant Land, Water Body	Commercial, Residential, Vacant Land, Water Body
10	Nagarbhavi Circle – Vinayaka Layout	11.651–13.091	Commercial, Residential, Public Facilities, Park	Commercial, Residential, Public Facilities, Park
11	Vinayaka Layout – Papireddy Palya	13.091–14.381	Commercial, Residential, Park	Commercial, Residential, Park
12	Papireddy Palya – BDA Complex, Nagarbhavi	14.381–15.711	Commercial, Residential, Public Facilities	Commercial, Residential, Public Facilities
13	BDA Complex, Nagarbhavi – Sumanahalli Cross	15.711–17.290	Commercial, Residential, Vacant Land, Public Facilities	Commercial, Residential, Vacant Land, Public Facilities
14	Sumanahalli Cross – Chowdeshwari Nagar	17.290–18.576	Residential, Commercial	Residential, Commercial
15	Chowdeshwari Nagar – Freedom Fighters Colony	18.576–19.675	Commercial, Residential, Vacant Land, Agricultural Land	Commercial, Residential, Vacant Land, Agricultural Land
16	Freedom Fighters Colony – Kanteerava Nagar	19.675–21.067	Commercial, Residential, Agricultural Land, Public Facilities	Commercial, Residential, Agricultural Land, Public Facilities
17	Nagarbhavi	21.067–22.797	Commercial, Residential, Public Facilities, Park	Commercial, Residential, Public Facilities, Park
18	Peenya – Muthyala Nagar	22.797–25.064	Commercial, Residential, Vacant Land	Commercial, Residential, Vacant Land
19	Muthyala Nagar – BEL Circle	25.064–26.302	Commercial, Residential, Park, Water Body	Commercial, Residential, Park, Water Body
20	BEL Circle – Nagashetty Halli	26.302–27.722	Park, Water Body, Commercial, Vacant Land	Park, Water Body, Commercial, Vacant Land
21	Nagashetty Halli – Hebbal Railway Station	27.722–30.149	Commercial, Residential, Park, Water Body	Public Facilities, Vacant Land, Commercial, Residential
22	Muthyala Nagar – BEL Circle	25.064–26.302	Commercial, Residential, Vacant Land, Public Facilities	Commercial, Vacant Land, Residential

No.	Metro Station	Chainage (km)	LHS Land Use	RHS Land Use
23	BEL Circle – Nagashetty Halli	26.302–27.722	Commercial, Residential, Park	Commercial, Residential, Public Facilities, Park
	3-2 Line: Hosahalli – Kadabagere			
1	Start – Hosahalli	-0.450–0.00	Park, Residential, Commercial	Commercial, Residential
2	Hosahalli – KHB Colony	0.00–1.648	Commercial, Residential	Public Facilities, Vacant Land, Commercial, Residential
3	KHB Colony – Kamakshipalya	1.648–2.971	Park, Residential, Commercial	Commercial, Vacant Land, Residential
4	Kamakshipalya – Sumanahalli Cross	2.971–3.907	Commercial, Residential, Water Body	Commercial, Residential, Public Facilities, Water Body
5	Sumanahalli Cross – Sunkadakatte	3.907–5.660	Vacant Land, Public Facilities, Commercial, Residential	Commercial, Residential, Vacant Land, Public Facilities
6	Sunkadakatte – Herohalli	5.660–6.981	Vacant Land, Residential, Public Facilities	Water Body, Residential, Commercial
7	Herohalli – Byadarahalli	6.981–8.562	Commercial, Residential	Public Facilities, Park, Commercial, Residential
8	Byadarahalli – Kamath Layout	8.562–10.006	Vacant Land, Commercial, Residential	Vacant Land, Commercial, Residential

Source: BMRCL and RITES (2023) Detailed Project Report for Two Corridors of Bangalore Metro Phase-3 population

2.3.3 Population

(1) Population

The decennial Population Census conducted by the Government of India provides the only comprehensive dataset on demographic characteristics. As of Census 2011, Karnataka's population was 61.10 million; Bengaluru Urban District 9.62 million; BMA 9.04 million; and BBMP city 8.43 million. Thus, the BMA accounts for about 94% of Bengaluru Urban District's population. In the Revised Master Plan 2031 (RMP-2031), the BMA population was projected at 13.5 million for 2021 and 20.3 million for 2031.

Within the surveyed area, 32 notified slums housed 63,038 persons (≈ 3.06% of BBMP's population). The sex ratio is 922 females per 1,000 males. Among wards examined, Kottegepalya is comparatively dense (good access to education, health, banking and transport), while Marenahalli has low density.

Table2-16: Population, density, number of households in the target area of this project (2011）

Administrative divisions	Area (km^2)	Population (persons)	population density (person/km2)	Sex ratio (females per 1,000 males)
BBMP（a）	708	8,443,675	11,867	923
Villages within BMA (b)	585	600,989	1,026	854
BMA Whole (a+b)	1,294	9,044,664	6,972	918
Bengaluru City District	2,196	9,621,551	4381	916
Karnataka	191,791	61,095,297	319	973
India as a whole	3,287,240	1,210,854,977	382	943

Source: BDA, Revised Master Plan for Bengaluru - 2031 (Draft): Volume-3

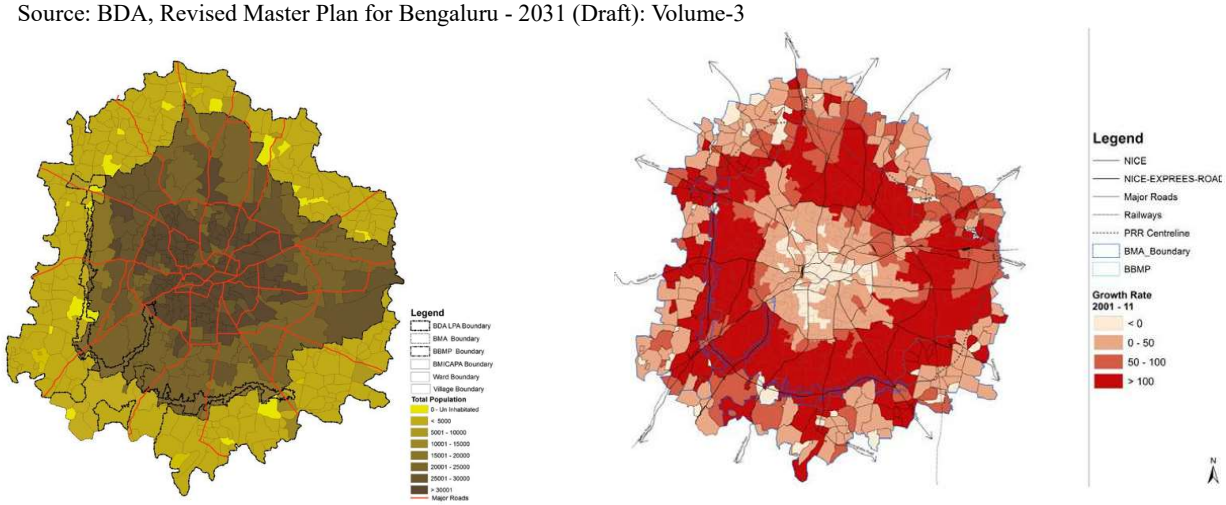
(2) Trends in population and population density

BMA population and density trends for 2001 and 2011 are shown in Table2-17 and Figure2-14. It is shown in. Districts outside the outer ring road show a positive high growth rate, The share of the population outside the BBMP Outer Ring Road within the BMA is also increasing. The population density is higher in the districts within the outer ring road, but the density is decreasing as you move from the center to the periphery. The density change rate is highest in districts outside the outer ring road at 2.18 times, while in the city center it is low at 1.17 times.

Table2-17: Population and population density trends in BMA

Administrative divisions	Population (persons)			Population distribution when the population in BMA is set to 100 (%)		Population density (persons/km^2)	
Administrative divisions	2001	2011	Change multiplier	2001	2011	2001	2011
Inside BBMP: Inside the Outer Ring Road	4,241,540	4,960,809	1.17	69.05	54.85	19,556	22,872
Inside BBMP: Outside the Outer Ring Road	1,598,615	3,482,866	2.18	26.03	38.51	3,232	7,041
Outside BBMP but within BMA	302,163	600,989	1.99	4.92	6.64	515	1,026
BMA Wide	6,142,318	9,044,664	1.47	100	100.00	4,735	6,972

Source: BDA, Revised Master Plan for Bengaluru - 2031 (Draft): Volume-3



Source: BDA, Revised Master Plan for Bengaluru - 2031 (Draft): Volume-3

Figure2-14: BMA population (left) and growth rate (right)

(3) Number of households

According to the 2011 the number of households in the BMA has increased, while the average household size has decreased compared to 2001.

Table2-18: Number of Households in BMA (2001) - 2011）

Administrative divisions	Number of households			Number of people in the household		
	2001	2011	Change multiplier	2001	2011	Change multiplier
In BBMP (a)	1,387,508	2,101,831	1.51	4.46	4.02	0.90

Inside BMA and outside BBMP (b)	68,166	151,913	2.23	4.52	3.97	0.88
BMA Whole (a+b)	1,455,674	2,253,744	1.54	4.47	4.01	0.90

Source: BDA, Revised Master Plan for Bengaluru - 2031 (Draft): Volume-3

2.3.4 Language

The official language of Karnataka is Kannada. According to the 2011 census results, the mother tongue of residents of Karnataka and Bengaluru urban districts is shown in the table below.

Table2-19: Mother tongue of Karnataka and Bengaluru(%)

language	Bengaluru City District	Karnataka	nationwide
Kannada	44.47	66.46	3.61
Tamil	15.99	3.45	5.70
Telugu	13.99	5.84	6.70
Urdu	12.11	10.83	4.19
Hindi	4.55	1.43	43.63
Malayalam	2.94	1.22	2.88
Marathi	1.92	3.29	6.83
Tulu		2.61	-
Lambadi		1.59	-
Konkani		1.29	
Other languages	4.82	4.1	

Source: 2011 Census of India, Government of India National Sample Survey Office, C-16 Population By Mother Tongue

2.3.5 Religious minorities and scheduled castes (SC)/scheduled tribes (ST)

In India, "Scheduled Castes (SC)" and "Scheduled Tribes (ST)" include religious minorities among the disadvantaged socio-economic groups and are legally designated under Articles 341 and 342 of the Constitution for special protection.

"Scheduled Castes (SCs)" are castes or communities that have historically faced untouchability and social discrimination, are often geographically or socially marginalized, and are designated under Article 341 of the Constitution to ensure special safeguards for their rights and interests.

"Scheduled Tribes (STs)" are tribes or tribal communities designated under Article 342 of the Constitution. They traditionally maintain distinct cultural and social practices, often outside the framework of organized religions, with their own customary traditions, attire, food habits, and cultural identity that distinguish them from other communities.

(1) Religious minorities

According to the results of the 2011 census, there are many Hindus, followed by Muslims and Christians. In Karnataka and the urban districts of Bengaluru, the proportion of Jains is higher than that of Sikhs and Buddhists.

Table2-20: Religion in Karnataka and Bengaluru (%)

Administrative divisions	Hindus	Muslims	Christians	Sikhs	Buddhist	Jain	Other	Not stated

Bengaluru City District	80.29	12.97	5.25	0.14	0.06	0.86	0.01	0.43
Karnataka	84.00	12.92	1.87	0.05	0.05	0.72	0.02	0.27
India (all)	79.8	14.2	2.3	1.7	0.7	0.4	0.7	0.2

Source: Government of India National Sample Survey Office、2011 Census of India, C -1 Population By Religious Community - 2011

(2) Scheduled castes

According to the results of the 2011 Population Census, Scheduled Castes number 1,283 across India, accounting for 16.6% of the total population.. Karnataka has 101 scheduled castes (SC), with 10,474,992 people (5.2% of the national SC population) belonging to scheduled castes (SC). 28.0% of the slum population in Karnataka is SC.

Table2-21: Scheduled castes (SC) in Karnataka and Bengaluru urban districts

Administrative divisions	Number of households	Number of people (persons)	Male (person)	Female (person)	Literacy Rate (%)
Bengaluru City District	-	1,198,385	607,725	590,660	-
Karnataka	2,178,501	10,474,992	5,264,545	5,210,447	65.33
All over India	41,694,863	201,378,372	103,535,314	97,843,058	66.07

Source: Government of India National Sample Survey Office、2011 Census of India, Table A-10 (Appendix) District Wise Scheduled Caste Population

(3) Scheduled tribes (ST)

According to Article 342 of the Constitution of India, a total of 763 tribes have been notified as Scheduled Tribes (STs) nationwide (including overlaps across states).

In Karnataka, 50 tribes with a total population of 4,248,987 persons (6.95% of the state population) belong to the Scheduled Tribes category.

At the scoping stage of this study, no designated Scheduled Tribe protected areas (Scheduled Areas) were identified within the project area.

Similarly, during the preparation of the ESIA and RAP, no Scheduled Areas established to protect the habitation and livelihood rights of Scheduled Tribes have been confirmed within the project sites.

Table2-22: Scheduled tribes (ST) in Karnataka and Bengaluru urban districts

Administrative divisions	Number of households	Number of people (persons)	Male (person)	Female (person)	Literacy Rate (%)
Bengaluru City District	-	190,239	99,164	91,075	-
Karnataka	875,742	4,248,987	2,134,754	2,114,233	62.08
All over India	21,511,528	104,545,716	52,547,215	51,998,501	58.95

Source: Government of India National Sample Survey Office、2011 Census of India, Table A-11 (Appendix) District Wise Scheduled Tribe Population

2.3.6 Economy

(1) Economy

According to the Economic Survey Report 2023–2024 prepared by the Karnataka Department of

Planning, Programme Monitoring and Statistics, the economic situation of the state is as follows.

In 2023–24, Karnataka's Gross State Domestic Product (GSDP) accounted for 8.4% of India's total GDP.

The tertiary (service) sector, which contributes the highest share to GSDP, increased slightly from 65.41% in FY2022–23 to 66.72% in FY2023–24.

Within this sector, real estate, professional services, and ownership of dwellings contributed the most (38.32%), followed by computer-related services and research & development (28.16%), manufacturing (12.47%), and trade and repair services (8.61%).

The shares of the primary (agriculture) and secondary (industry) sectors in total GSDP declined slightly compared with FY2022–23—from 13.66% to 13.04% and from 20.92% to 20.24%, respectively.

In terms of Gross State Value Added (GSVA), the tertiary sector accounts for 67%, followed by the secondary sector (20%) and the primary sector (13%).

Karnataka leads India in the growth of high-tech industries, including electronic semiconductor design and manufacturing, information and communication technology, biotechnology, and, more recently, nanotechnology.

Approximately 40% of the state's GSDP is derived from exports of electronic technology, computer software, and biotechnology products.

Bengaluru Urban District, where these industries and related infrastructure are highly concentrated, records the highest Gross District Domestic Product (GDDP) in the state—INR 859,154 crore, accounting for 37.8% of Karnataka's GSDP—followed by Dakshina Kannada (5.5%) and Belagavi (4.0%).

(2) GDP per capita

Karnataka's GDP per capita grew by about 8% to 14% per year, except for 2020-2021, which turned negative due to the impact of the COVID-19 pandemic, as shown in the table below, and posted a high year-on-year increase of about 20% in FY2021–22. Bengaluru Urban District's GDP per capita in FY2022–23 was INR 760,362, significantly higher than the State average of INR 304,474. Both the level and the growth rate exceed the all-India figures.

Table2-23: Changes in GDP per capita in Karnataka (2015 year - 2024)

Administrative divisions	unit	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Karnataka	INR	148,108	169,898	185,840	205,245	222,141	221,781	266,866	304,474	332,926
YoY Growth Rate	%	13.91	14.71	9.38	10.44	8.23	-0.16	20.33	14.09	9.34
India as a whole	INR	94,797	104,880	115,224	125,946	132,341	127,244	150,906	169,496	200,162
YoY Growth Rate	%	9.4	10.6	9.9	9.3	5.1	-3.9	18.6	12.3	8.7

Source: Per Capita Net State Domestic Product at Current Prices (2011–12 series), as of Feb. 2025.

(3) Employment

According to the India Skills Report 2023[17], Karnataka ranks sixth among Indian states in employability. According to the Periodic Labour Force Survey (PLFS) 2022-23[18], Karnataka's labour force participation rate (LFPR; ages 15–59) is 62.9% and the employment rate is 61.2%, which is higher than the 61.6% and 59.5% of all India. Karnataka's unemployment rate is 2.6%, which is lower than the overall India rate of 3.4%.

Table2-24: LFPR, Worker Population Ratio (WPR), and Unemployment Rate in Karnataka (2022–23)

Administrative divisions	Percentage of the working-age population (Population aged 15-59)			Employment rate			Unemployment rate		
	man	woman	whole	man	woman	whole	man	woman	whole
Karnataka	81.8	43.2	62.9	79.6	42.1	61.2	2.6	2.5	2.6
India as a whole	83.2	39.8	61.6	80.2	38.5	59.5	3.6	3.2	3.4

Source: Annual Report, PLFS 2022-23

The number of people employed in the state decreased by 0.12% from 24.12 million people at the end of March 2023 to 24.09 million at the end of June 2023. Public-sector employment was 10.20 million (42.34%) and private-sector employment 13.89 million (57.66%), with the public sector decreasing by 0.37% and the private sector increasing by 0.07% between June and March 2023. Manufacturing is the largest industry, followed by information and communications, defense, and social security.

According to the 2011 census, the number of workers living in and employed by the BMA rose from 38.9% in 2001 to 44.0% in 2011. In terms of industry, industry accounts for 23.45% and IT industry accounts for 14.97%.

[17] INDIA SKILLS REPORT 2023, ROADMAP TO INDIA'S SKILLS & TALENT ECONOMY 2030
[18] Annual Report, PLFS 2022-23 Table-6, Page no.A-20, NSSO, MOSPI, GOI

Table2-25: Number of Employees by Industry in Karnataka (2022-23) (Unit:100,000))

Industry	March 2022 Number of Employees			March 2023 Employment rate		
	public	private	whole	public	private	whole
Agriculture, forestry and fishing	0.259	0.114	0.374	0.259	0.115	0.374
Mining and quarrying	0.074	0.071	0.145	0.073	0.071	0.145
Manufacturing	0.584	6.007	6.591	0.584	6.016	6.600
Electricity, gas and air-conditioning supply	0.363	0.010	0.373	0.369	0.010	0.378
Water supply; sewerage & waste management	0.053	0.002	0.054	0.053	0.002	0.054
Construction	0.284	0.016	0.300	0.284	0.016	0.300
Wholesale & retail trade; repair of motor vehicles	0.088	0.310	0.398	0.076	0.317	0.393
Transportation & storage	1.334	0.224	1.558	1.339	0.223	1.562
Accommodation & food services	0.006	0.253	0.259	0.006	0.254	0.260
Information & communication	0.212	4.351	4.563	0.210	4.355	4.565
Financial & insurance activities	0.896	0.258	1.154	0.931	0.257	1.187
Real estate	0	0.001	0.001	0.000	0.001	0.001
Professional, scientific & technical activities	0.324	0.088	0.412	0.324	0.088	0.412
Administrative & support services	0.009	0.629	0.638	0.009	0.630	0.639
Defence & social security	3.065	0.000	3.065	3.064	0.000	3.064
Education	1.753	1.120	2.873	1.751	1.113	2.865
Human health & social work	0.87	0.383	1.253	0.871	0.382	1.253
Arts, entertainment & recreation	0.021	0.022	0.043	0.021	0.022	0.043
Others	0.013	0.013	0.026	0.013	0.013	0.026
Total	10.207	13.871	24.078	10.238	13.884	24.122

Source: Karnataka Economic Survey 2023-24

2.3.7 Poverty Line

In India, the "Below Poverty Line (BPL)" benchmark is used to identify households unable to afford essential items such as food, health care, and education.

From the monthly consumption expenditure data of 120,000 households, the Planning Commission of India applied the Tendulkar methodology to calculate the monthly consumption expenditure per capita based on a mixed reference period. The table below shows the number of people below the poverty line and poverty line for India as a whole and Karnataka.

Table2-26: Poverty Line, Population Below Poverty Line and Poverty Headcount Ratio

Administrative divisions	Poverty Line (INR per capita per month)		Population Below Poverty Line (million)			Poverty Ratio (%)		
	Rural	Urban	Rural	Urban	Total	Rural	Urban	Total
Karnataka	902	1,089	9.28	3.696	12.976	24.53	15.25	20.91
National average	816	1,000	216.65	53.12	269.78	25.70	13.70	21.92

Source: Planning Commission (GoI), Press Note on Poverty Estimates, 2011–12 (July 2013).

2.3.8 Literacy and education

According to the 2011 Population Census, the literacy rate in BMA is 88.30%, which is higher than the literacy rate in Karnataka at 75.36%. The literacy rate in Karnataka by gender is 82.47% for men and 68.08% for women, while the literacy rate in Bengaluru urban district is 91.71% for men and 85.44% for women, which is higher than the literacy rate in Karnataka for both men and women.

Also, according to the results of a 2017 sample survey on final educational attainment, Karnataka shows a higher share of population with secondary or higher education than the all-India average.

Table2-27: Educational Attainment – Share of Population by Highest Level Completed

Administrative divisions	literacy rate	Primary or below	Middle	Secondary	Higher secondary	Graduate & above
BMA	88.30	-	-	-	-	-
Bengaluru Urban District	88.71	-	-	-	-	-
Karnataka	75.36	17.0	12.6	20.5	12.2	11.4
National average	74.9	18.9	16.2	12.5	11.9	10.6

Source: Household Social Consumption on Education in India (July 2017 - June, 2018) Government of India National Statistical Office, Statement 3.4.1

2.3.9 Health and Hygiene

(1) Overall Health Profile

According to the Health Dossier 2021 and recent state-level statistics, both non-communicable diseases (NCDs) and communicable diseases jointly contribute to the health burden in Karnataka and Bengaluru Urban District. While NCDs—such as cardiovascular diseases, diabetes, chronic respiratory diseases (including COPD), cancers, and stroke—account for the majority of adult mortality, infectious diseases continue to play a significant role, especially in dense urban settlements and among vulnerable groups.

To clarify the major causes of death, the latest available sources (Health Dossier 2021, FR374 Karnataka, NFHS-5) indicate the following leading contributors:

• Non-communicable diseases (NCDs):
– ischaemic heart disease
– stroke
– chronic obstructive pulmonary disease (COPD)
– diabetes
– cancers

• Communicable diseases:
– lower respiratory infections (including pneumonia)
– diarrhoeal diseases
– tuberculosis

• Maternal and neonatal causes:
– preterm birth complications
– neonatal sepsis
– birth asphyxia

• Injuries:
– road traffic injuries
– falls
– self-harm

Disability-adjusted life years (DALYs) further illustrate this burden:

• Communicable, maternal, neonatal, and nutritional diseases (CMNNDs): **20.95%** of total DALYs

• Non-communicable diseases: **65.42%**

• Injuries: **13.63%**

These proportions indicate that infectious diseases remain important public health issues, even as NCDs dominate overall mortality patterns.

(2) Maternal, Neonatal, and Child Health (MNCH)

Karnataka has seen improvements in maternal and child health outcomes.

- Maternal mortality rate decreased from 178 (2007–09) to 92 (2019) per 100,000 live births.
- Neonatal mortality rate declined from 50 (2005) to 21 (2019) per 1,000 live births.
- Stillbirth rates continue to decrease, reaching 5 per 1,000 births in 2018.

These improvements contribute to reduced DALYs under the maternal and neonatal categories, but challenges remain, particularly in slum areas.

Table2-28: Neonatal and infant mortality rates in Karnataka

Indicator	Karnataka (2019)	India (2019)
Number of infant deaths (persons/1,000 births)	21	30
Crude death (persons/1,000)	6.2	6.0
Crude birth rate (persons/1,000)	16.9	19.7
Maternal mortality rate (persons / 100,000 live births)	92	113
Neonatal mortality rate (persons/1,000 live births)	16	23
Mortality rate among children under 5 years of age (persons/1,000 people)	28	36
Stillbirth rate (persons/1,000 births)	5	4
Life expectancy at birth in 2014-2018 (years)	69.4	69.4
Ratio of men to women at birth (number of females per 1000 males)	924	899

Source: Health Dossier 2021: Reflections on Key Health Indicators – Karnataka

(3) infectious disease

Communicable diseases continue to impose a notable health burden in Karnataka. DALY estimates show that CMNNDs account for nearly one-fifth of the total disease burden, driven mainly by:

- neonatal preterm birth
- diarrheal diseases
- drug-sensitive tuberculosis

The below table provides selected infectious disease mortality data for Karnataka.

Table2-29: Mortality from infectious diseases in Karnataka

item	Karnataka (2019)	India (2019)
Number of Malaria Deaths Reported	0	79
Reported deaths from Kala-azar (visceral leishmaniasis)	0	0
Number of reported dengue deaths	13	168
Number of reported Kala-azar cases	0	3,706

Source: Health Dossier 2021: Reflections on Key Health Indicators – Karnataka

Lower respiratory infections, including pneumonia, remain a leading cause of under-five mortality in Karnataka, largely driven by indoor air pollution and incomplete immunization.

(4) Non-Communicable Diseases (NCDs)

Non-communicable diseases constitute the largest portion of DALYs (65.42%). Leading conditions include:

- ischaemic heart disease
- chronic obstructive pulmonary disease (COPD)
- self-harm
- type 2 diabetes

Major risk factors include high blood pressure, high fasting blood glucose, smoking, obesity, and ambient particulate matter.

(5) Additional Clarifications on Major Causes of Death and Child Respiratory Diseases

To address the comments raised by the Advisory Committee, this subsection has been updated to clearly distinguish between infectious and non-communicable diseases as major causes of death in Karnataka, based on the latest available sources including NFHS-5 and FR374 Karnataka. Urban–rural differences in health conditions have also been reflected, noting the higher prevalence of hypertension, diabetes, and obesity in urban areas, and greater exposure to indoor air pollution in rural areas.

Information on child respiratory diseases has been added, highlighting that lower respiratory infections (including pneumonia) remain among the leading causes of under-five mortality in Karnataka, influenced by indoor air pollution, overcrowding, immunization gaps, and low birth weight.

(6) Summary

In this EIA Report, the health profile has been sorted to reflect both mortality data and DALY-based disease burden, capturing the combined impact of major non-communicable diseases and infectious diseases.

This integrated approach provides a more accurate basis for assessing potential health risks related to air quality deterioration, noise, vibration, and environmental changes associated with the project.[19]

[19] **(Reference sources used for this subsection)**
– Health Dossier 2021: Reflections on Key Health Indicators – Karnataka
– NFHS-5 Karnataka State Report (2019–21)
– FR374 Karnataka (Monarch submission, 2025)
– Annual Highlights 2023–24: Health & Family Welfare Department, Karnataka

2.3.10 Traffic accident

Although Karnataka's fatality rate is below the all-India average, the State accounted for 8.6% of India's road deaths in 2022 (5th highest among States/UTs). The main crash types are rear-end collisions, head-on collisions, and side-impact collisions.

Table2-30: Road Accident Rates in Karnataka

Item	Karnataka (2022)	Country of India (2022)
Number of traffic accidents	39,762	461,312
Mortality from traffic accidents (persons/100 accidents)	29.4	36.5
Number of deaths due to traffic accidents	11,702	168,491
Number of deaths due to traffic accidents on state roads under the management of the State Department of Public Infrastructure	3,278	41,012
Accident Factors (Number of Accidents/Fatality)		
Rear-end collision	9,808／2,653	98,668／32,907
Head-on collision	8,411／2,180	77,886／26,413
Side-impact collision	6,833／1,642	71,146／20,357
Others	5,700／2,262	76,058／25,320
Hit-and-run	3,017／1,176	67,387／30,486
Vehicle overturn	1,478／371	20,070／9,827
Run-off-road	2,069／670	20,590／9,862
Fixed object	1,286／394	15,368／7,307
With parked vehicle	1,160／354	14,139／6,012

Source: Ministry of Road Transport & Highways (MoRTH) - Road Accidents in India 2022

2.3.11 Cultural heritage

According to RMP-2031, there are no internationally designated sites (e.g., UNESCO World Heritage) within the BMA. However, there are two cultural heritage sites designated by the Archaeological Survey of India (ASI) and seven sites designated by the Karnataka Department of Archaeology, Museums and Heritage (DAMH). In addition, many other relics and buildings of high cultural value are protected and managed by relevant organizations. All listed sites lie more than 1 km from the proposed alignment and depot sites; no significant impacts are anticipated.

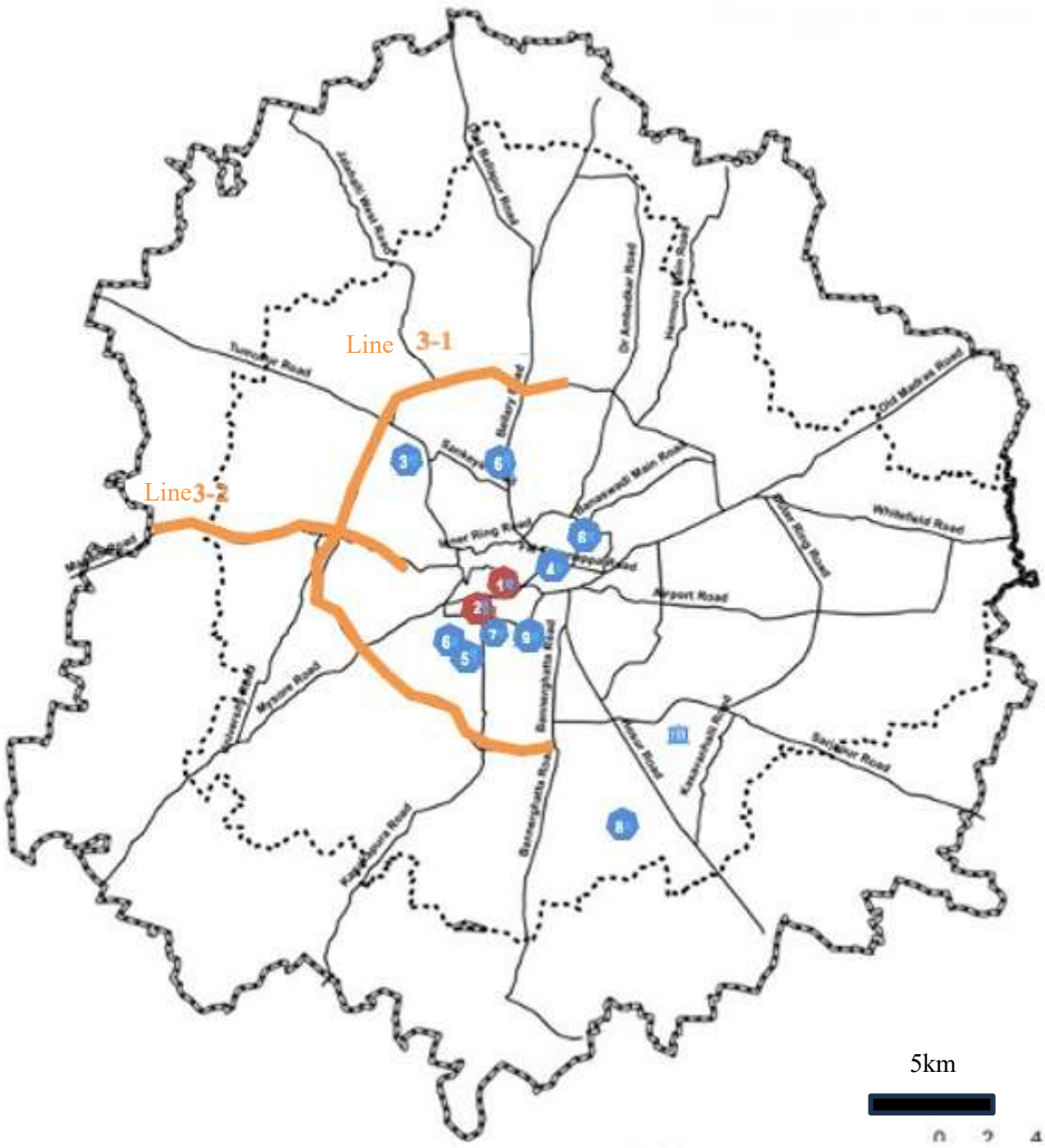
Table2-31: Cultural heritage Sites within the BMA

	name	Registration Number	Designated Agency	Description
1	Banaglore Old Dungeon, Fort and Gate	N-KA-B1	ASI	It is a fortress built in the 16th century and strengthened during the reign of Tipu Sultan
2	Tip Sultan's Summer Palace	N-KA-B2	ASI	Built in the late 18th century, it is the summer palace of Tipu Sultan, the monarch of the Kingdom of Mysore, and features elaborate architecture using teak wood
3	Basavesvara Temple	-	DAMH	A temple dedicated to the 18th-century Lingayat religious teacher and philosopher Sri Sharana Vasaveshwara
4	Bowring Institute	-	DAMH	Founded in 1858, this is a members-only club.
5	Gavi -Gangadhareswara Temple at Gavipuram	-	DAMH	A temple built by Kempe Gouda, the founder of Bengaluru, in a natural cave in the 9th century.

	name	Registration Number	Designated Agency	Description
6	Four Kempe Gowda's Watch Towers (Lal Bagh, Gavi puram, along Bellary Road)	-	DAMH	Four towers built by Kempe Gouda II in 1597 to mark the boundaries of Bangalore and to guard them.
7	Mallikarjuna Temple and Boulder Inscription at Basavanagudi	-	DAMH	Megalithic inscription from 1669 AD. Show that the settlements of Bengaluru are ancient
8	Sri Nagareshwara Group of Temples at Begur	-	DAMH	Two shrines of the Nageshvara Swamy deity and the temple consecrated by Rishi during the reign of Nitimarga I and Elyappa Nitimarga II of the West Ganga dynasty.
9	Venkataramanaswamy Temple at V.V. Puram	-	DAMH	Built in the 1600s by Chikka Devaraja Wardeyar, the temple embodies the architectural styles of Dravida and Vijayanagara.

DAMH = Department of Archaeology, Museums and Heritage

Source: BDA, Revised Master Plan for Bengaluru - 2031 (Draft): Volume-3



Source：JST, based on BDA, Revised Master Plan for Bengaluru - 2031 (Draft): Volume-3

Figure2-15: Location map of registered cultural heritage in BMA

3. Environmental-social consideration systems and organizations

3.1 Laws and Regulations on Environmental and Social Considerations

3.1.1 Environmental Policy, Strategy and Legal System

India has enacted environmental laws, and the Environment (Protection) Act 1986, which established the basic framework for environmental protection, came into effect in May 1986. In May 2006, the "National Environment policy" was issued, and in September 2006, the “Environmental Impact Assessment (EIA) Notification, 2006,” which sets out screening, scoping, public consultation and appraisal procedures for prior Environmental Clearance (EC). These procedures are administered by the Impact Assessment

Division under the Ministry of Environment, Forest and Climate Change (MoEFCC).

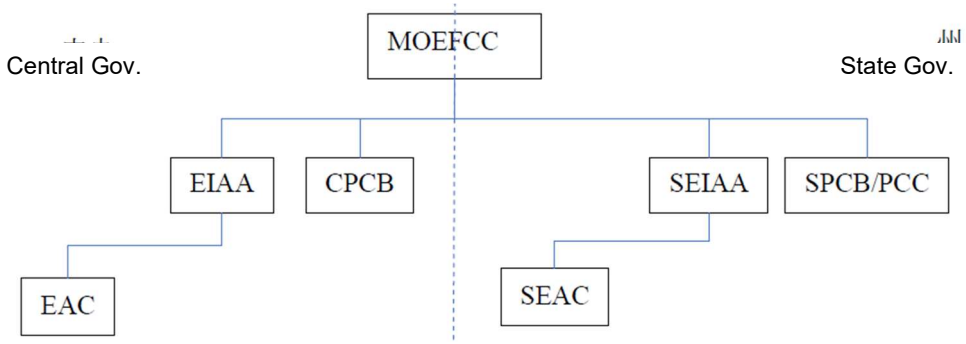
3.1.2 EIA-related organizational system

EIA-related organizations include the MoEFCC, which develops EIA-related legislation, the Expert Appraisal Committee (EAC), which supervises Category A projects, and the Expert Evaluation Committee (EAC), which reviews Category A projects. The names, abbreviations, and roles of these organizations are shown in the table below, and the organizational charts of the MoEFCC and related departments are shown in the figure below.

Table3-1: EIA-related organizations and roles

Organization Name	role
Ministry of Environment Forest and Climate Change (MoEFCC)	A national organization that has jurisdiction over environment-related matters. EIAA, SEIAA parent agency. Regulatory authority for Category A projects; issues Terms of Reference (ToR) and Environmental Clearance (EC) based on EAC appraisal.
Expert Appraisal Committee (EAC)	The Central Expert Committee conducts EIA reviews. Commissioners are appointed by the MoEFCC. For Category A projects, the MoEFCC will issue an EC on the advice of the EAC.
State environment Impact assessment authority (SEIAA)	State organization with jurisdiction over EIA procedures. SEIAA supervises Category B1 projects and certain Category B2 projects, while some B2 projects are exempt from EC.
Central Pollution control board (CPCB)	A central statutory organization under MoEFCC that has jurisdiction over pollution relations. National pollution regulator under MoEFCC; issues standards/guidelines and coordinates SPCBs/PCCs. It does not conduct project public hearings. It has the obligation to monitor the pollution situation after the issuance of the EC.
State Expert Appraisal Committee (SEAC)	A state-level expert committee conducting EIA reviews. Members are constituted as per MoEFCC notification; appraises Category B proposals and recommends to SEIAA.
State Pollution control board/ Pollution Control Committee (SPCB/PCC)	The state government organization that has jurisdiction over pollution relations. Publicly announces and conducts public hearings in the project area (as applicable) and forwards the proceedings/recommendations to the regulatory authority (SEIAA or MoEFCC, as applicable). It has the obligation to monitor the pollution situation after the issuance of the EC.
Cabinet Committee on Investment (CCI)	It was established in January 2013 under the chairmanship of the Prime Minister to facilitate and accelerate decision-making on major investment projects exceeding Rs. 10 billion in sectors such as infrastructure and manufacturing. The CCI coordinates across ministries and sets deadlines for approvals, and has the authority to review procedures of concerned departments. However, the legal authority to grant Environmental Clearances (ECs) remains with the competent environmental authorities (MoEFCC/SEIAA). CCI/PMG facilitates inter-ministerial clearances but has no authority to grant ECs.
National Green Tribunal (NGT)	Specialized environmental court established under the National Green Tribunal Act, 2010. It hears appeals against Environmental Clearances (ECs) and other environmental decisions, and adjudicates cases related to environmental protection, forest conservation, and compensation for damages caused by violations of environmental laws or EC conditions.
Regional Offices of MoEFCC	Conduct monitoring/inspections and compliance verification; support appraisal/compliance processes at the regional level.
Public/ NGO	Members of the public and NGOs who are directly or indirectly affected can view the EIA summary. In addition, during public hearings, you can make remarks and submit written comments on concerns about the project.

Source: Environment Impact Assessment Guidebook for Japanese Companies' Overseas Project development- India-, IGES



Source: IGES, "Environmental Impact Assessment Guidebook for Japanese Companies' Overseas Project Development – India"

Figure3-1: Organizational structure of the EIA-related departments of MoEFCC

3.1.3 Environmental Management Laws and Regulations

(1) The Environment (Protection) Act, 1986

It came into force in May 1986. The Act is positioned as the so-called Basic Environmental Law, which constitutes the basic framework of environmental protection and consists of a total of 4 chapters and 26 items. The Environment (Protection) Act, 1986 stipulates the responsibility of the central government for the prevention, control and reduction of environmental pollution. The central government is empowered to formulate appropriate regulations to achieve the objectives of the Environmental Protection Act. The term "environment" defined in the Environmental Protection Act is defined as "including the internal interconnectedness that exists between water, the atmosphere, and land, and humans, other life, plants, microorganisms, and their property." The authority to prevent, regulate, and reduce environmental pollution and damage in this definition is stipulated in the Environmental Protection Act. The central government is empowered to set rules for the areas that need to be prevented and regulated by the environment.

(2) Environmental Impact Assessment Notification, 2006 (EIA Notification 2006)

India's Environmental Impact Assessment (EIA) system is implemented under the Environment (Protection) Act, 1986, based on the Environmental Impact Assessment Notification, 2006 (EIA Notification 2006). The Notification specifies procedures for screening, scoping, appraisal, Environmental Clearance (EC) application, validity period, post-EC monitoring, and transfer of EC, along with prescribed formats. There is no EIA ordinance system at the local government level.

Projects are categorized into A, B1, and B2. Category A projects are regulated by the Central Government (MoEFCC), while Category B1 and B2 projects fall under the State-level authorities (SEIAA/SEAC). Formerly, District-level bodies (DEIAA/DEAC) handled certain B2 projects such as small-scale mining, but these were abolished in 2018, and their functions have since been integrated into SEIAA/SEAC.

Table3-2: Overview of Supervisory Bodies and Examination Bodies by Category in India

category	EIA Supervisory Body	Examination Body	EIA	Environmental Approvals (EC)	monitoring
A	MoEFCC	EAC	necessity	necessity	necessity
B1	SEIAA	SEAC	necessity	necessity	necessity
B2 (excluding mineral mining)	SEIAA	SEAC	unnecessary	Necessity (From SEIAA)	necessity
B2 (Mineral Mining)	DEIAA	DEAC	unnecessary	Necessity (From SEIAA)	necessity
Projects not requiring Environmental Clearance (Non-EC projects)	-	-	unnecessary	unnecessary	necessity

*MoEFCC: Department of Environment, Forests and Climate Change, SEIAA: State Environmental Impact Assessment Authority, SEAC: State Professional Assessment Board, DEIAA: Provincial Office of Environmental Impact Assessment, DEAC: Prefectural Expert Evaluation Committee

Source: Environment Impact Assessment Notification 2006

3.1.4 Environmental screening of this project

(1) Screening in the Environmental Impact Assessment Circular 2006

According to the MoEFCC Notification, urban rail and metro projects are exempt from the requirement of obtaining Environmental Clearance (EC). BMRCL confirmed that EC is not required for this metro project. However, for the road component of the double-deck viaduct, the necessity of EC from the State authority was confirmed with SEIAA-Karnataka in late July 2025. SEIAA responded that the project, including its road component, does not fall under any category requiring EC under the EIA Notification, 2006, as it does not qualify as a national or state highway project under Schedule of the Notification.

(2) Screening based on JICA Guidelines for Environmental and Social Considerations

This project is classified as Category A because it falls under the railway sector listed in the "Japan International Cooperation Agency Guidelines for Environmental and Social Considerations" (promulgated in January 2022) (JICA GL) and its characteristics that are prone to impact (large-scale involuntary resettlement).

3.1.5 Survey policy of this project

This project is classified as Category A in JICA GL. For this reason, the survey will be conducted in accordance with JICA GL.

Table3-3: Divergence between JICA GL and India's EIA regulations

Topic	JICA GL	Environmental Impact Assessment (EIA) Notification, 2006	Policy in this survey
Basic Matters	When implementing a project, it is necessary to investigate and examine the environmental and social impacts of the project as early as possible at the planning stage, consider alternatives and mitigation measures to avoid or minimize them, and reflect the results in the project plan.	A detailed review of alternatives shall be conducted, and the environmental management plan shall consist of all mitigation measures for each item.	JICA GL compliant. (BMRCL is currently implementing EIA and SIA for this project in line with the standards of the Indian country and international organizations at the start of this project in 2025.) In this preparatory survey, we plan to conduct a survey that complements the above in order to provide environmental and social considerations in line with JICA GL. Request BMRCL to reflect its findings to the EIA and SIA)
Information Disclosure	The environmental assessment report (which may be called differently depending on the system) must be written in the official or widely used language of the country where the project is being implemented. In addition, explanations must be written in a language and style that the local people can understand. The environmental assessment report is open to the public in the country where the project is being implemented, including local residents, and is required to be available to local residents and other stakeholders at any time, and that copies are permitted.	For public consultation, the SPCB/UTPCC publishes the notice and hosts the draft EIA at designated locations in the project-affected district(s) and on its website; Category A/B documents are also available on the PARIVESH portal (MoEFCC/SEIAA).	JICA GL compliant. (Encourage BMRCL to allow the preparation and presentation of the report in the official or widely used language, as well as the viewing and copying of the report.) We will also check the contents of the EIA report when it is updated by the BMRCL.)
Public Consultation and Public Hearing	In particular, for projects that are considered to have a significant impact on the environment, it is necessary that information is made public from an early stage, such as considering alternatives to the project plan, and the results are reflected in the project content after sufficient consultation with local residents and other stakeholders. When preparing an environmental assessment report, sufficient information must be disclosed in advance, consultations must be held with local residents and other stakeholders, and a record of the consultation must be prepared. Consultations with local residents and other stakeholders should be conducted as necessary throughout the preparation and implementation periods of the project, especially at the time of selecting environmental impact assessment items and preparing the final draft report (DFR).	After submission of the draft EIA report, the project proponent shall undertake public consultation, including a public hearing conducted at or near the project site. The public hearing shall be completed within 45 days of receipt of the request from the project proponent, and the State Pollution Control Board (SPCB) or Union Territory Pollution Control Committee (UTPCC) shall provide a minimum public notice of 30 days prior to the hearing. In addition, the SPCB/UTPCC shall make the draft EIA report available at designated public locations and on its official website for written comments from stakeholders. The project proponent shall incorporate the collected opinions and comments into the final EIA report and project design.	Follow the JICA guidelines. (Consultations are conducted by BMRCL when preparing the EIA Report and SIA Report.) In this preparatory survey, we will check whether residents' consultations are in line with JICA GL, and if necessary, additional residents' councils will be conducted. In addition, since all sections of the metro phase 3 have become "double-deck viaduct projects", the impact of additional private land acquisition and resident relocation is expected. Additional research in this study is planned. SHM and FGD will be conducted twice, at the time of scoping and at the time of drafting the EIA report.

Topic	JICA GL	Environmental Impact Assessment (EIA) Notification, 2006	Policy in this survey
Scope of Impact Assessment	The scope of impacts to be investigated and considered for environmental and social considerations includes impacts on human health and safety and the natural environment (including transnational or global environmental impacts) through air, water, soil, waste, accidents, water use, climate change, ecosystems and biota, etc., as well as social considerations for the following matters. Population movement such as involuntary resettlement, local economy such as employment and livelihoods, land use and local resource use, social organizations such as social capital and local decision-making bodies, existing social infrastructure and social services, socially vulnerable groups such as the poor and indigenous peoples, equity in the distribution of damage and benefits and development processes, gender, children's rights, cultural heritage, conflicts of interest in the region, HIV/ Infectious diseases such as AIDS, working environment (including occupational safety). The impacts to be investigated and considered include not only the direct and immediate impacts of the project, but also derivative and secondary effects, cumulative impacts, and impacts of associated facilities and linked activities, to the extent reasonably considered. It is also desirable to consider the impact over the life cycle of the project.	In addition to the direct and indirect impacts of the project, its derivative, secondary and cumulative impacts, as well as the impact of impacts of associated facilities and linked activities, should also be investigated and evaluated within a reasonable range.	JICA GL compliant. (If the impact items listed in the JICA GL are not sufficiently analyzed in the EIA report prepared by BMRCL, additional evaluation will be conducted in this preparatory study.) In addition, environmental impact assessments will be conducted to the extent possible for facilities related to this project, such as quarries, borrow areas, and construction yards.)
Monitoring, Complaint Handling	Efforts should be made public to the local stakeholders involved in the project. If a third party specifically points out that environmental and social considerations are insufficient, a forum for stakeholders involved in the project to participate in discussions and consideration of measures must be established under sufficient information disclosure, and efforts must be made to agree on procedures for solving the problem.	Project implementers are required to submit environmental management plans and programs. Project implementers are required to submit a six-monthly compliance report on Environmental Clearance (EC) conditions (to be submitted to the regulator and disclosed online).	Follow JICA GL. (Requests BMRCL to disclose monitoring results to stakeholders and conduct additional meetings as necessary during the project implementation period)
Ecosystem and biota	The project must not involve significant conversion or significant degradation of important natural habitats or important forests.	Discussions are held by each law, standard, and constraint.	Follow JICA GL. (The project does not involve significant conversion or significant degradation of critical natural habitats or important forests, but we request the BMRCL to conduct an ecosystem survey in this preparatory study, consider alternatives and mitigation measures, and reflect the results in the EIA)

Topic	JICA GL	Environmental Impact Assessment (EIA) Notification, 2006	Policy in this survey
Indigenous	The impact of the project on indigenous peoples must be considered and avoided in all possible ways. If avoidance is not possible after such considerations, effective measures for indigenous peoples must be taken to minimize the impact and compensate for losses.	Discussions are held by each law, standard, and constraint.	Follow JICA GL. (For indigenous peoples, review the SIA survey being conducted by the BMRCL, consider alternatives and mitigation measures if identified, and encourage the BMRCL to reflect the results in the IPP (Indigenous Peoples Plan))

Source: JST

3.1.6 Other environment-related permits and approvals required for this project

This project is not subject to India's Environmental Clearance (EC) procedures; however, as summarized in Table3-4, various permits and approvals from the Government of Karnataka and BBMP are required. Applications for these permits are generally made prior to construction, during construction, and during operation.

Table3-4: Main Environment-related Permits and Approvals

Licensing	Legal provisions	Responsible Agency	applicant	Timing of Application / Stage
Permission for cutting of trees and transportation	Karnataka Preservation of Trees Act, 1976	State Forest Department	BMRCL	Pre-Construction
Elevated Metro Corridor Crossing Indian railway lines		SWR, Indian Railways	BMRCL	Pre-construction
No Objection Certificate (NOC) for Construction camp, Labor camp, Crushers, Batching Plants, Wet Mix Macadam plants, Hot mix plants	Air (Prevention and Control of Pollution) Act, 1981; Water (Prevention and control of Pollution) Act, 1974 and Noise Pollution (Regulation and Control) Rules, 2000	KSPCB, Karnataka	Contractor/ Supplier	Pre-construction
Employing Labor/ Workers	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996; Central Rules, 1998 and Karnataka Rules, 2006	District Labor Commissioner	Contractor	Pre-construction
Rehabilitation & Resettlement of Displaced families	KIADB Act with compensation at par with RFCTLARRA 2013.	Government of Karnataka	BMRCL	Pre-construction
Permission for withdrawal of groundwater for construction	Environment (Protection) Act, 1986	Central Ground Water Board	Contractor	Pre-construction
Installation of Generators	Air (Prevention and Control of Pollution) Act, 1981, "Water (Prevention and Control of Pollution) Act, 1974, Noise Pollution (Regulation and Control) Amendment Rules, 2017	KSPCB	Contractor	Pre-construction
Storage, handling and transport of hazardous materials	Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, formulated under Environment (Protection) Act, 1986	KSPCB, Karnataka	Contractor	During Construction

Licensing	Legal provisions	Responsible Agency	applicant	Timing of Application / Stage
Traffic Management and Regulation during operation	Local Traffic Police instructions/Regulations	Bengaluru Traffic Police	Contractor	During Construction
License for storing Diesel/Fuel	Petroleum Rules, 2002 (as amended in the year 2011) of the Petroleum Act, 1934	Commissioner of Explosives	Contractor	During Construction
Location/ layout of workers camp, equipment and storage yards	Environment Protection Act, 1986 The Building and Other Constructions Workers' (Regulation of employment & Conditions of Service) Act, 1996.	KSPCB, District Health Officer	Contractor	During Construction
Disposal of Construction and Demolition wastes	Karnataka Municipal Corporation Act 1976 (Karnataka Act, 14 of 1977)	BBMP	Contractor	During Construction

Source: BMRCL (2020) EIA report for Bengaluru Metro Rail Project Phase 2A (Outer Road Ring Metro Line)

3.1.7 Other Environmental and Social Laws and Regulations

Other environmental and social laws of the central and state governments of India are listed below. Gender considerations and considerations for people with disabilities are organized below, including relevant policies and programs.

Table3-5: Other laws and regulations related to the environment

classification	Laws, Systems, Guidelines, etc.
Country level	
atmosphere	・ Air (Prevention and Control of Pollution) Act, 1981 and its amendments ・ Air (Prevention and Control of Pollution) Rules, 1982 ・ Revised National Ambient Air Quality Standards, Notification, 2009
water	・ Water (Prevention and Control of Pollution) Act, 1974 and its amendments ・ Water (Prevention and Control of Pollution) Rules, 1975 ・ IS 10500:2012 (Drinking Water Specification, 2nd Revision; as amended)
waste	・ Solid Waste Management Rules, 2016 ・ Hazardous and Other Wastes (Management and Trans-boundary Movement) Rules, 2016 and its amendment ・ Construction and Demolition Rules, 2016 ・ Bio-Medical Waste (Management and Handling) Rules, 1998, as amended to date, 2003 ・ Battery Waste Management Rules, 2022 ・ Plastic Waste Management Rules, 2016 (and subsequent Amendments incl. 2022) ・ E-Waste (Management) Rules, 2022 (as amended)
noise	・ Noise Pollution (Regulation and Control) Rules, 2000 and its amendment 2010
ecosystem	・ Wildlife (Protection) Act, 1972 (as amended incl. 2002/2022) ・ Biological Diversity Act, 2002 ・ Indian Forest Act, 1927 ・ Forest (Conservation) Act, 1980; Forest (Conservation) Rules, 2003 (as amended); Forest (Conservation) Amendment Act, 2023 ・ National forest policy, 1988 ・ Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (FRA)
Cultural and historical heritage	・ Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act 1958 and its Amendment, 2010
Working environment	・ Employees' Compensation Act, 1923 ・ The Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013 ・ Maternity Benefit Act, 1951 ・ Equal Remuneration Act, 1979 ・ Payment of Gratuity Act, 1972

classification	Laws, Systems, Guidelines, etc.
	・ Employees PF and Miscellaneous Provision Act, 1952 ・ Contract Labour (Regulation and Abolition) Act, 1970 ・ Minimum Wages Act, 1948 ・ Payment of Wages Act, 1936 ・ Child Labor (Prohibition and Regulation) Act; 1986 and as amended ・ Inter-State Migrant Workmen's (Regulation of Employment and Conditions of Service) Act, 1979 ・ The Code on Wages 2019 ・ The Code on Social Security, 2020 ・ The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Cess Act of 1996 ・ Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 ・ Public Liability Insurance Act, 1991
other	・ Electricity Act, 2003 and subsequent amendments ・ Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989 (as amended) ・ Petroleum Rules, 2002 (as Amended in the year 2011)
State level	
	・ Karnataka Ancient Monuments and Archaeological Sites and Remains Act, 1961 ・ Karnataka Ground Water (Regulation and Control of Development and Management) Act, 2011 and Rules 2012 ・ Karnataka Preservation of Trees Act, 1976 ・ Karnataka Tank Conservation and Development Authority Act, 2014 and amendment Act, 2018

Source: JST

(1) Laws and Regulations Related to

As of April 2025, the following table has identified gender-sensitive policies and policies in India. BMRCL is preparing Gender Equality and Social Inclusive Action Plan (GESIAP), which need to be incorporated to the gender consideration of the project once it is approved.

Table3-6: Gender-sensitive legal systems that are scheduled to be scrutinized in the future

item	Key Details
policy	・ 1993 Ratification of the Convention on the Elimination of All Forms of Discrimination against Women ・ 2001 "National Policy for Women's Empowerment" ・ Women's empowerment policy goals in the past central government's five-year plan (the five-year plan system was abolished in 2015) ・ Women's Empowerment Policy Goals in the National Institution for Transforming India (NITI Aayog) 3-Year Action Plan, 7-Year Strategy, and 15-Year Vision
law	・ Constitution (Article 15: Prohibition of Discrimination on the Basis of Sex) (Article 39: Citizens have the right to livelihood and provide for equal work and equal pay for men and women) ・ Domestic Violence Protection Act 2005 ・ Companies Act 2013 (Mandatory appointment of one or more female directors for public (limited liability) companies of a certain size or more) ・ Labor Law (Revised March 2017) (Expanding the period of maternity leave for women from 12 weeks to 26 weeks) ・ Transgender Rights Protection Act (2019) ・ Karnataka Marriage Act, 1976
system	・ Policies to promote the protection and education of girls and toddlers ("Betty Bachao Betty Padao (Hindi for 'Let's save girls, educate girls')" program implementation area

item	Key Details
	・ Policies to promote women's entrepreneurship ("Stand Up India", "Deendayal Antyodaya Yojana National Rural Livelihoods Mission", etc.) Total loans ・ FICCI Women's Association (FLO) under the Federation of Indian Chambers of Commerce and Industry (FICCI) Activities ・ Areas where the comprehensive program for enhancing women's safety and security ("Mission Shakti") is implemented ・ Karnataka Women's Welfare Program Implementation Status ・ Karnataka Transgender Policy ・ Karnataka Udyogini Scheme, training programs, marketing assistance programs, etc.
Design Criteria	・ Design and operation standards for gender-sensitive railway projects set forth by MoHUA, DMRC, etc. (mandatory installation of women-only vehicles, related guidelines, etc.)
Implementing Organization	・ Ministry of Women and Child Development Policies and Budgets ・ National Commission for Women Policy ・ Karnataka State Institutions Policies and Budgets (Women Development Corporation, etc.) ・ Activities and support targets of NGOs in related fields in Karnataka and Bengaluru
Investigation Report	・ Women & Men in Karnataka 2019-2020

Source: JST

(2) Laws and Regulations Related to Consideration for Persons with Disabilities

As of February 2025, the following table has confirmed the following policies and policies for considering people with disabilities in India. This section has been updated in alignment with the completed GESIAP.

Relevant national and state laws on accessibility and disability inclusion have already been identified and incorporated into the project's design and mitigation measures.

Table3-7: Legal systems related to consideration for people with disabilities

item	Key Details
policy	・ Ratification of the 2007 United Nations Convention on the Rights of Persons with Disabilities ・ Ratification of the 2014 Marrakesh Convention (Consideration for the Blind and Visually Impaired)
law	・ Constitution (Article 15: Prohibition of any discrimination) (Article 39: Citizens have the right to livelihood and provide for equal work and equal pay for men and women) ・ The Rights of Persons with Disabilities Act (2016) ・ Harmonised Guidelines & Standards for Universal Accessibility in India, 2021 (accessibility standards for buildings and public spaces); sectoral codes for rail/airports apply. ・ Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act, 1995 (repealed and replaced by the RPwD Act, 2016). ・ Mahatma Gandhi National Rural Employment Guarantee Act, 2005 (MGNREGA) (includes persons with disabilities).
system	・ 12th Plan (2012-2017) (Implement various measures to provide appropriate spaces and facilities for people with disabilities in all modes of transportation, including railways, buses, and airplanes) ・ 2013 National Policy on Universal Electronic Accessibility ・ 2006 National Policy for Persons with Disabilities (specifies specific measures to make all schools a disability-friendly environment by 2020)

item	Key Details
	・ 2023 National Technology Development Plan for Persons with Disabilities ・ Financial support through the Karnataka State National Disability Fund ・ Karnataka Disability Rights Implementation Scheme: Barrier-free
Implementing Organization	・ Department of Empowerment of Persons with Disabilities (DEPwD), Ministry of Social Justice & Empowerment (issues UDID). ・ Ministry of Social Justice and Empowerment Scheduled Caste Central Special Support Project (Financial Support for Students with Disabilities) ・ Ministries implementing disability-related measures: Ministry of Home Affairs, Ministry of Minorities, Ministry of Consumer Affairs, Ministry of Food and Public Distribution, Ministry of Health and Family Welfare, Ministry of Housing and Urban Affairs (MoHUA), Ministry of Human Development, Ministry of Labour and Employment, Ministry of Justice, Ministry of Panchayati Raj, Ministry of Rural Development, Ministry of Statistics and Project Implementation, Ministry of Tribal Relations, Ministry of Women and Child Development, National Human Rights Commission ・ National Financial Development Corporation for Persons with Disabilities (NHFDC) ・ Karnataka State Agency Policies and Budgets (State Department of Welfare for Persons with Disabilities, State Department of Social Justice Special Assistance, etc.) ・ State Disability Welfare Committee ・ Karnataka State Disability Commission ・ State Handicapped Finance and Development Corporation ・ State Rehabilitation Centre for Persons with Disabilities ・ NGOs: Sightsavers, Indian Network of Women with Disabilities, Daisy Forum India
References	・ Pathways to Access (PartIII) - Rights of Persons with Disabilities (Miscellaneous) 2025 ・ Harmonised Guidelines & Standards for Universal Accessibility in India 2021 ・ Access The PHOTO-DIGEST: Demystifying Accessibility in built infrastructure.

Source: Disability Information by Country Republic of India, Japan International Cooperation Agency, JICA, February 2021

These legal and regulatory requirements are consistent with the GESIAP and have been fully reflected in the accessibility-related mitigation measures in the EMP.

3.2 Laws and Regulations on Land Acquisition and Resident Relocation

3.2.1 Land acquisition laws and regulations

This project will be implemented in accordance with the relevant laws and regulations of the central and state governments of India, as well as in accordance with JICA's guidelines. The outline of the legal framework related to this project is as follows.

Table3-8: Legal framework related to this project

Relevant Laws and Regulations	Overview and application to this project
Land Acquisition Act 2013 Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR2013)	・ The Act came into effect on January 1, 2014 and applies to land acquisition by the Government for public purpose, including public projects, PPPs and, in specified cases, private projects, as provided under Sections 2(1) and 2(2). ・ It stipulates the land acquisition process, compensation policy, compensation items and calculation methods.
Karnataka Industrial Areas Development Act (KIADA) 1966	・ Rules Concerning State Land Acquisition ・ If land is acquired under KIADA, compensation is determined in accordance with the provisions of KIADA.
Special Compensation System Compensation and Resettlement Package (CRP2019)	・ CRP2019 sets out compensation and assistance for BMRCL-affected persons, bridging gaps between LARR 2013/KIADA provisions and international safeguard policies.

Source: JST

(1) Land Acquisition Act, 2013

The fundamental law governing land acquisition and resettlement compensation in India is the *Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013* (hereinafter referred to as the "LARR Act, 2013"), which came into effect on 1 January 2014.

The LARR Act, 2013 aims to ensure a humane, participatory, informed and transparent process for land acquisition required for industrialization, infrastructure development, and urbanization, while minimizing the adverse impacts on landowners and other affected families. It provides for fair and equitable compensation, and lays down provisions for rehabilitation and resettlement (R&R) of those affected by land acquisition.

The following table summarizes the main procedures stipulated under the LARR Act, 2013.

Table3-9: Outline of procedures stipulated under the LARR Act, 2013

Part	Section	Key Provisions
Part I	Section 1	Short title, extent, commencement; the Act extends to the whole of India.
	Section 2	Application of the Act: governs acquisition for public purpose and certain private/PPP projects; also applies where private companies acquire land above prescribed thresholds by private negotiation.
	Section 3	Definitions, including "affected family" (those whose primary livelihood depended on the affected land in the preceding three years) and "cost of acquisition" (includes land price, housing construction, livelihood restoration, SIA costs, etc.).
Part II		Determination of social impact and public purpose
A		Initial confirmation of social impact and public purpose
	Section 4	Social Impact Assessment (SIA): appropriate Government to conduct SIA in consultation with local bodies; public notice; completion within six months; disclosure as prescribed.
	Section 5	Public hearing in affected areas; views of affected families to be recorded and included in the SIA report.
	Section 6	Disclosure: SIA report and Social Impact Management Plan to be made public in the prescribed manner; if EIA is undertaken, transmit SIA to the authorised appraisal agency.
B		SIA Review by Expert Group
	Section 7	Independent Expert Group appraisal of the SIA to verify public purpose and adequacy of mitigation.
	Section 8	Decision on public purpose: appropriate Government may approve acquisition after considering Expert Group and Collector's views and ensuring minimisation measures.
	Section 9	Exemption from SIA only in cases of urgency as provided in Section 40.
Part III		Special Measures for Food Security
	Section 10	Food security safeguards: no acquisition of irrigated multi-cropped land except as a demonstrable last resort and with equivalent cultivable area developed for food production.
Part IV		Notification and Acquisition
	Section 11	Preliminary notification of acquisition: publish in the Official Gazette, in two local daily newspapers (including one in the regional language), at relevant local offices/notice boards, and on the website; prohibits transactions until procedures conclude; summary to include public purpose and key SIA points.
	Section 12	Survey and demarcation of land to be acquired.
	Section 13	Compensation for damages caused during survey as determined by the Collector.
	Section 14	Lapse of SIA if preliminary notification under Section 11 is not issued within 12 months of Expert Group review; period may be extended by the appropriate Government.
	Section 15	Hearing of objections to acquisition; objections may be filed within 60 days of the preliminary notification.

Part	Section	Key Provisions
	Section 16	Preparation of Rehabilitation & Resettlement (R&R) Scheme: Administrator to conduct census/surveys and draft the Scheme with timelines; draft to be disclosed and heard in affected areas.
	Section 17	Collector to review the draft R&R Scheme and submit it with recommendations to the Commissioner for R&R.
	Section 18	Commissioner for R&R to review the Scheme and submit it to the appropriate Government for approval and publication.
	Section 19	Declaration of acquisition and publication of summary of the approved R&R Scheme; deposit of acquisition costs; declaration must be issued within 12 months of the Section 11 notification (extendable).
	Section 20	Collector to take order for acquisition and identify the specific land to be acquired.
	Section 21	Notice to persons interested; invite claims to compensation and R&R for not less than 30 days and not more than six months.
	Section 22	Power to call for information from persons interested.
	Section 23	Enquiry and Award by Collector: determine compensation and R&R entitlements as of the date of notification; issue award.
	Section 25	Time limit to make award; proceedings may lapse if timelines are not met unless extended per the Act.
	Section 26	Market value of land: highest of (i) market value as per Indian Stamp Act, 1899, (ii) average sale price of similar land in nearest vicinity, or (iii) consented amount in cases under Section 2(2).
	Section 27	Amount of compensation equals market value of land plus value of all attached assets.
	Section 28	Factors to be considered in determining compensation: crops, trees, attached movable/immovable assets or income therefrom, relocation and business shifting costs, loss of income, equity and justice to affected families.
	Section 29	Valuation of attached assets (buildings, trees, crops) with expert advice and prescribed methods.
	Section 30	Solatium of 100% on compensation; add 12% per annum on market value from the date of SIA notification under Section 4(2) until award or possession, whichever is earlier.
Part IV-A		Voluntary acquisition of land
	Section 30A	Power of State Government to acquire land by consent/negotiated settlement for public purpose notwithstanding anything contained in other laws.
Part V		Provision of livelihood recovery and relocation
	Section 31	R&R entitlements to all affected families per Second Schedule; provide the full set of benefits specified.
	Section 32	Resettlement areas to be provided with infrastructure and basic amenities as per Third Schedule.
	Section 37	Monitoring and disclosure of R&R implementation; maintain records and make summaries/details public as prescribed.
	Section 38	Taking possession after full payment of compensation and provision of R&R assistance; vesting of land free from encumbrances.
	Section 39	Avoidance of multiple displacement; prior displaced families to be protected from repeat displacement to the extent possible.
Part VI		Procedures and methods of livelihood recovery and resettlement
	Section 43	Appointment of Administrator for R&R where involuntary resettlement may occur.
	Section 44	Appointment of Commissioner for R&R; oversight of preparation and implementation of R&R plans.
	Section 45	Constitution of R&R Committee (for acquisitions ≥100 acres) chaired by the Collector; monitoring and social audit of implementation.
	Section 47	Where obligations are monetisable, requiring body to deposit funds; Administrator to manage and Collector to supervise utilisation.
Part VII	Sections 51–74	LARR Authority and appellate mechanisms; offences and penalties; procedures for dispute resolution.
Part VIII	Sections 75–114	Miscellaneous: rule-making powers, lapse/retrospective provisions, repeal of the Land Acquisition Act, 1894, and savings.

Source: Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (LARR) Act, 2013

The method of determining the price of land stipulated by the *Right to Fair Compensation and*

Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR Act 2013) is described in Chapter 4, Section 26.

Under this section, the market value of the land shall be determined as the higher of the following on the date of the preliminary notification under Chapter 4, Section 11:

(i) the market value as specified under the *Indian Stamp Act, 1899* for registration of sale deeds, or

(ii) the average sale price of similar land situated in the nearest village or vicinity of the land.

In addition, the value of attachments to the land—such as buildings—is calculated in accordance with Section 29, using the schedule of rates and the annually updated unit prices adopted by the State Public Works Department (PWD) for public construction works. This valuation is considered equivalent to the prevailing market price.

Furthermore, Section 30 provides that a *solatium* (100 percent of the total compensation) shall be added to both the land price and the value of attached assets. Consequently, as indicated in the First Schedule, the total amount payable to the landowner is:

[Land Market Value × 2] + [Value of Land Attachments × 2].

Therefore, compensation under the Land Acquisition Act 2013 is deemed to exceed the reacquisition cost of comparable land and buildings. BMRCL calculates the amount of land compensation in accordance with this Act.

Table3-10: Outline of compensation and support stipulated under the Land Acquisition Act, 2013

Item	Description
a. Establishment of public monitoring and dispute resolution bodies	・ Establish federal and state monitoring committees to oversee the land acquisition process (Section 48); ・ Establish a specialized authority (LARR Authority) to resolve disputes related to land acquisition, resettlement, and livelihood restoration (Section 51).
b. Scope of persons covered by the Act	・ Compensation applies to landowners; ・ Persons whose livelihoods are adversely affected by land acquisition are eligible for rehabilitation and resettlement (R&R) support.
c. Scope of covered asset loss	・ Land, buildings attached to land, and other appurtenances are also subject to compensation.
d. Consultation process	・ Except for cases of "emergency acquisition" (Section 9), all projects involving land acquisition by an administrative agency must undergo a multi-stage consultation process, including Social Impact Assessment (SIA), appraisal, and prior agreement with affected families (Section 4(1)).
e. Land price	・ The average registered sale price of land with similar characteristics in the neighborhood (as per the Indian Stamp Act, 1899) or the average sale price of comparable land in the surrounding area over the previous three years, whichever is higher (Section 26).
f. Building price	・ The State Public Works Department (PWD) applies standard valuation methods for public buildings using the annually updated schedule of rates and unit prices.
g. Total payment for land acquisition	・ Components included in the cost of acquisition: market value of land (Section 26), compensation for trees and crops on site, compensation for losses arising from acquisition, compensation for physical and economic displacement, and losses incurred after notification under Section 19; ・ [Land Price × 1.0 (urban area)] + [Compensation Cost (Land Price × 1.0, urban area)] + [Value of Land Attachments] + [Solatium (Value of Land Attachments × 1.0)]; In other words, [Land Market Value × 2.0] + [Value of Land Attachments × 2.0] is paid to the owner.
h. Contents of rehabilitation and resettlement	・ As listed in the Third Schedule, eleven types of benefits are specified, including: provision of residential houses, provision of alternative land, provision of employment, subsistence

Item	Description
	allowance for one year, provision of relocation expenses, reconstruction grants for livestock shelters, and provision of alternative fishing rights.

Source: Land Acquisition Act 1894、Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (LARR) Act, 2013

(2) Karnataka Industrial Areas Development Act (KIADA), 1966

As the State law operating alongside the LARR Act, the Karnataka Industrial Areas Development Act, 1966 (KIADA)provides the framework for acquisition of land for industrial infrastructure. (The Act dates to 1966 and has been amended multiple times, including in 2014.) BMRCL has applied KIADA procedures in past metro projects.

Under KIADA, the State Government may recognize land required for the metro as an *industrial area for the development of industrial infrastructure*. A preliminary notification (intention to acquire) is issued, inviting objections from landowners and other interested persons. Where objections are filed, a hearing by the Land Acquisition Officer is held, following which the Government takes a final decision on acquisition. Upon publication of the final declaration in the Official Gazette, the land vests absolutely in the State free from encumbrances. Assessment and payment of compensation are then undertaken.

KIADA also permits expedited acquisition by consent award—a preferred route in which the Land Acquisition Officer (with BMRCL's advice) presents the appraised value and the landowner gives free consent; compensation is mutually agreed between the acquirer and the landowner. If consent is not reached, compensation is determined under the statutory process. Section 28 sets out the notification/vesting procedure; Section 29 provides for compensation determination.

Compensation eligibility is subject to a cut-off date: for non-regular/encroacher households, the cut-off is the start date of the project census survey; for titleholders/regular affected persons, it is the date of the Section 28(1) notification.

Table3-11: KIADA (1966) — Outline of procedures and compensation

article	substance	
Article 28	Section 1	If, in the opinion of the State Government, any land is required for development by the Board or for any other purpose in furtherance of the objectives of this Act, the State Government may, by notification, declare its intention to acquire such land.
	Section 2	Upon publication of the notification under Section 1, the State Government shall serve notice on the owner of the land, the occupier if the owner is not in occupation, and all persons believed to have an interest in the land, inviting objections within thirty (30) days from the date of service of the notice and stating the reasons why the land should not be acquired.
	Section 3	After considering the reasons submitted by the landowner or any interested person and after giving such owner or person an opportunity of being heard, the State Government may pass such orders as it deems fit.
	Section 4	If, after considering the report under Section 3, the State Government is satisfied that the land is required for the purposes specified in the notification under Section 1, it shall make a declaration to that effect by notification in the Official Gazette.
	Section 5	Upon publication of the declaration in the Official Gazette, the land shall vest absolutely in the State Government free from all encumbrances.
	Section 6	After such vesting, the State Government may, by written notice, require the occupier of the land to surrender or deliver possession thereof to the State Government or to any person duly authorised by it within thirty (30) days from the date of service of the notice.

article	substance	
	Section 7	If any person refuses or fails to comply with an order issued under Section 6, the State Government or any officer authorised by it may take possession of the land and may, if necessary, use such force as may be required for the purpose.
	Section 8	Where any land has been acquired for the Board, the State Government may, after taking possession, transfer such land to the Board for the purpose for which it was acquired.
Article 29	Section 1	Where the State Government acquires any land under this Chapter, it shall pay compensation for such acquisition in accordance with the provisions of this Act.
	Section 2	If the amount of compensation is determined by agreement between the State Government and the person entitled to receive it, such compensation shall be paid in accordance with the terms of that agreement.
	Section 3	If no such agreement is reached, the State Government shall refer the matter to the Deputy Commissioner for determination of the amount of compensation payable and the person or persons entitled to receive it.
	Section 4	Upon such reference under Section 3, the Deputy Commissioner shall issue notices to the owner or occupier of the land and to all persons believed to be interested therein, requiring them to appear and state their respective interests in the land.

Source: KIADA 1966

(3) Special Compensation Package (CRP2019: Compensation and Resettlement Package)

The Compensation and Resettlement Package (CRP2019) details the compensation and assistance provided to affected residents as applicable to BMRCL's operations, and is supplementary to the Land Acquisition Act.

The compensation amount for land will be calculated based on the 2013 Act, and additional top-up measures will be implemented to bridge the gap between the KIADA compensation standards and the safeguard requirements of the International Financing Institutions (EIB, AIIB, ADB).

BMRCL adopted this Special Compensation Package in previous project phases in accordance with Government Order No. UDD 91 dated July 10, 2019, and will apply it to this project as well.

The main features of BMRCL's Special Compensation Package are as follows:

1. Affected communities shall be informed and consulted at each stage, including public hearings conducted as part of the Social Impact Assessment and the wide dissemination of information on planned surveys.
2. Affected households are entitled to financial assistance such as reconstruction and transportation costs for livestock sheds, shops, and work sheds.
3. Assistance for livelihood restoration and resettlement will be provided to affected households at INR 50,000 per relocation.
4. To ensure transparency, the disclosure of information on relocation, compensation, and resettlement—including the names of affected persons and details of compensation packages—is mandatory. Such information shall be made publicly available online by BMRCL and shared with local bodies (Gram Sabhas and Gram Panchayats in rural areas, or municipal administrations in urban areas).
5. No income tax or stamp duty shall be levied on affected individuals in accordance with the

applicable legal provisions.

3.2.2 Acquisition of Private Land related to this Project

Although it is legally required to acquire land for "private land" related to this project under the aforementioned Land Acquisition Act, the process is time-consuming, so there are many cases in which land acquisition is carried out under the agreement of both parties in the same way as general private transactions, as well as land acquisition systems established by each State or Special Administrative Zone that adds compensation and livelihood recovery support that exceeds the minimum compensation conditions of the Land Acquisition Act. BMRCL, the implementing agency of this project, has been proactive in past land acquisitions on a consensus basis and minimized delays in land acquisition.

According to the provisions of KIADA, the Government will publicize the land required for metro projects as industrial land and develop industrial infrastructure. Subsequently, a preliminary notice is issued informing the intention to acquire the site, and objections from landowners and interested parties are solicited for comment. If there is an objection, a formal hearing will be held by the land acquisition officer, after which the final decision on land acquisition by the government will be made. When the final notice of land acquisition is promulgated, the land belongs to the Government. The determination of compensation and its payment are made after the ownership belongs to the government. KIADA provides for expedited land acquisition by consent award. The consent award is a preferred method based on the assessed value presented by the land acquisition officer on the advice of the BMRCL and the free consent of the landowner. Through this process, the amount of compensation is mutually agreed between the acquirer and the landowner. If it is difficult to acquire on an agreement basis, the private land will be acquired through the procedures prescribed by KIADA based on KIADA's compensation standards applicable to the project. If a normal ruling is issued, the landowner can ask the court for an increase in compensation.

The transfer procedure for land acquisition related to public land is stipulated by the laws and regulations that govern each public land. In addition, even if the land is acquired on public land, asset compensation and livelihood recovery support for non-regular residents are required to follow the special compensation system.

3.2.3 Organizations related to land acquisition and involuntary resettlement

The land acquisition and relocation procedures will be carried out by the Karnataka government officials based on KIADA, but BMRCL, as the main body of the project, will pay compensation to the government, support affected people to receive compensation, and support livelihood recovery. The implementation system within BMRCL is organized entirely under its Land Department.

In addition, BWSSB will also be responsible for issuing necessary permits and providing technical approvals for well construction and water use at relocation sites, as described in the RAP. These procedures are essential to ensure water access for relocated households. Coordination between BMRCL and BWSSB shall be established to facilitate timely processing of these permits.

3.2.4 Gaps with JICA GL regarding land acquisition and involuntary resettlement and countermeasures

The following table summarizes discrepancies between the JICA Guidelines for Environmental and Social Considerations (2022) and the World Bank Environmental and Social Standard 5 (ESS5): Land Acquisition, Restrictions on Land Use and Involuntary Resettlement, and relevant Indian laws and regulations on land acquisition and resettlement. The gap analysis confirms no discrepancy with respect to the Land Acquisition Act, 2013 (LARR 2013), KIADA and the Compensation and Resettlement Policy (CRP 2019). Going forward, through consultations with BMRCL, we will confirm whether any gaps remain in compensation policy, etc., recommend measures to close such gaps, and seek agreement.

Table3-12: Comparison of JICAGL with Indian Law

No.	JICAGL (2022)・World Bank ESS5	Land Acquisition Act (LARR2013) / (KIADA) / (CRP2019)	Gap	Proposed Policy (draft) for this project
1	Involuntary resettlement and loss of livelihoods must be avoided by considering all means. (JICA Guideline 2022)	LARR2013 Article 4 and Article 8(1)(c) Acquire only the minimum amount of land necessary for the implementation of the project. Article 8(2) The administrative agency that supervises land acquisition and environmental impact shall confirm and supervise that the involuntary resettlement by the project is minimized, the impact on infrastructure and the natural environment is minimized, and the degree of negative impact on affected individuals is avoided or mitigated to a minimum.	None	Devise and consider alternatives that can be implemented through business planning and design, adopt evaluation methods that fully consider involuntary resettlement of residents and loss of livelihoods, and devise ways to select proposals with low impact.
2	If it is not feasible to avoid involuntary resettlement, effective measures shall be taken, in consultation with the affected persons, to minimize adverse impacts and to provide compensation for losses. (JICA Guidelines 2022)	LARR2013 Chapter II requires a Social Impact Assessment (SIA) to be conducted prior to land acquisition, disclosure of a draft compensation and assistance policy, and formulation of a final policy reflecting the opinions and suggestions of affected persons. Section 3(c) defines eligible persons for compensation and assistance as owners of land and assets and those whose primary livelihood depends on the land to be acquired.	None	Confirm that alternative alignments and design options are being considered to minimize involuntary resettlement and livelihood loss..
3	For persons affected by involuntary resettlement and loss of livelihood due to projects, adequate compensation and assistance must be provided in an appropriate manner by the partner country, etc. (JICAGL)	LARR2013 After the full amount of compensation in Chapter 5 Article 38 is paid and livelihood recovery and relocation assistance is implemented, the Land Department obtains the rights to the land. CRP2019 Compensation and other compensation for acquired land and structures, as well as resettlement allowances in the form of inconvenience allowances, transitional measures allowances, and compensation for economic losses, will be provided to all affected residents, including irregular residents.	None	Check the details of the compensation, the recipients, and the timing of compensation payment and support. Confirm the division of responsibilities among the employers of the project and confirm with BMRCL and BBMP that the above policy applies.

No.	JICAGL (2022) • World Bank ESS5	Land Acquisition Act (LARR2013) / (KIADA) / (CRP2019)	Gap	Proposed Policy (draft) for this project
4	Compensation shall, in principle, be provided at full replacement cost, and wherever possible, prior to relocation. (JICA Guidelines 2022)	**LARR 2013** Chapter IV stipulates additional payments based on market value — including a 100% solatium, and multipliers applied under Sections 26 to 30 and Schedule I. Section 26 defines market value as the higher of (i) the average registered sale price of comparable land in the vicinity (as per the Indian Stamp Act) or (ii) the average price of transactions over the past three years. Section 29 requires the assistance of experts to determine the market value of trees and crops. Section 30 provides for payment of a solatium equal to the total compensation amount. Section 46(4) stipulates that no physical alteration of land may take place until all compensation and assistance payments have been completed. **KIAD Act (Section 28)** Compensation for land acquisition is paid in accordance with Section 28 of the KIAD Act.	No explicit reference to the term "replacement cost."	The value of assets shall be assessed based on prevailing market rates without depreciation, and an additional 100% solatium shall be applied. For land prices, an additional solatium shall be added to the market value used on the left. Consequently, compensation in urban areas is expected to reach approximately two times the market value (1.0 × market value + 1.0 × solatium), and thus the total compensation for this project is anticipated to exceed the full replacement cost. Confirm with BMRCL and BBMP that the above policy is applied to this project. Ensure that a sufficient interval is secured between the completion of compensation and assistance payments for land and assets and the physical relocation of affected persons.
5	Efforts shall be made to improve the standard of living, income opportunities, and production levels of the affected persons, and at least to restore them to pre-project levels. (JICA Guidelines 2022)	**LARR 2013** Section 3(p), Section 27, and Section 29 stipulate that the scope of assets and losses subject to compensation covers land, buildings attached to the land, and structures appurtenant thereto. Section 26 defines land value as the higher of the average registered sale price of neighboring land or the officially published price. Section 28(5) includes in compensation the expenses necessary for changing a place of residence or business. Appendix II specifies eleven types of livelihood restoration support, including provision of residential housing, alternative land, employment, one-year living allowance, relocated housing, livestock reconstruction cost, and alternative fishing rights.	None	Regardless of legal ownership of land or assets, tenancy status, or length of residence, households compelled to relocate by the project shall receive a lump-sum livelihood support payment, a lump-sum moving allowance, and a relocation disturbance allowance (including compensation for lost income opportunities). Additional subsidies and skills training shall be discussed for vulnerable households. The Investigation Team formally requests the implementing agencies BMRCL and BBMP to implement the above policy.
6	Compensation standards shall be disclosed and applied consistently. Affected persons must be able to understand the compensation criteria. (JICA Guidelines 2022)	**LARR 2013** Section 19 stipulates that the competent administrative authority shall notify the public purpose for which land is to be acquired and the relocation site; at the same time, a summary of the related resettlement and livelihood restoration plan shall be disclosed. Section 37 requires that records of compensation, resettlement and livelihood restoration be kept by the Land Bureau and that both summaries and details be made public. **CRP 2019** To ensure transparency, information on resettlement and compensation — including the names of affected persons and details of compensation packages —	None	Confirm the organization of residents' meetings and the content of information sharing, and ensure that the implementing agency provides individual written explanations of compensation packages to project-affected persons (PAPs). In addition, verify whether the project entity has established a dedicated help center for this project.

No.	JICAGL (2022) • World Bank ESS5	Land Acquisition Act (LARR2013) / (KIADA) / (CRP2019)	Gap	Proposed Policy (draft) for this project
		must be disclosed to the public by the project proponent via the Internet and shared with relevant Gram Sabhas and Panchayats.		
7	In principle, compensation shall be documented in writing, including the agreed compensation, and such records shall be made available to affected persons for their confirmation. (JICA Guidelines 2022)	LARR 2013 Section 16 provides that the draft Resettlement and Rehabilitation (R&R) Plan shall be widely disclosed in the affected areas through public hearings and other means. The officer in charge shall submit the draft R&R Plan to the Collector together with a report summarizing opinions and objections expressed at the public hearing. Section 18 requires the Commissioner to publish the approved R&R Plan.	No explicit provision requiring individual written explanations of compensation to project-affected persons.	The implementing agency shall ensure that the details of compensation are explained to each project-affected person (PAP) in writing and that individual records of agreement are kept for confirmation.
8	In projects involving large-scale involuntary resettlement, a resettlement plan shall be prepared and made public. (JICA Guidelines 2022)	LARR 2013 Section 6(1) requires that the Social Impact Assessment (SIA) be widely disclosed by posting it at municipal offices and on official websites. Section 18 stipulates that the Resettlement and Rehabilitation (R&R) Plan shall also be widely disclosed at municipal offices and on official websites. CRP 2019 A baseline survey is to be conducted, based on which a Resettlement Action Plan (RAP) is developed. The CRP and RAP are made public, and affected persons are informed about the project and their rights. These documents are disclosed on the BMRCL website and at BMRCL offices.	None	The implementing agency is currently preparing a resettlement plan and a livelihood restoration plan in accordance with the law. It shall be confirmed that these plans will be prepared and disclosed in line with the JICA Guidelines.
9	Resettlement plans shall be prepared in consultation with affected persons, providing them with sufficient information and reflecting their opinions. (JICA Guidelines 2022)	LARR 2013 Section 4(2) requires that, at the initiation of a Social Impact Assessment (SIA), a notification be issued in the local language and published in the affected area, and also posted on the websites of the district, municipal, and relevant administrative offices. Section 5 stipulates that public hearings shall be held in the affected areas so that the opinions of affected households are duly recorded in the SIA report. Section 16(5)–(6) requires that public hearings on Resettlement and Rehabilitation (R&R) proposals be conducted after widely announcing the date, time, and place, and that the R&R report be submitted to the State Commissioner together with a summary of the affected households' opinions. KIAD Act Except for hearings provided under statutory requirements (Section 28(2)), there is no provision for residents' consultations.	None	For Lines 3-1 and 3-2, the first Stakeholder Meeting (SHM) has been conducted since February 2025. Ensure that sufficient information—such as specific project details, objectives, and implementation schedules—is provided at the outset of the SHM. Future SHMs to be conducted under subsequent surveys shall be implemented in accordance with the JICA Guidelines.
10	Consultations should take place at a time and place that is convenient for	LARR2013 Article 5 When a SIA survey is conducted, a public hearing shall be conducted to	None	In SHM, we will set up a place and time that is easy for affected residents to participate, and

No.	JICAGL (2022) • World Bank ESS5	Land Acquisition Act (LARR2013) / (KIADA) / (CRP2019)	Gap	Proposed Policy (draft) for this project
	affected people to participate. In addition, consultations must be conducted in a language and manner that is understandable to the affected person. (JICAGL)	ensure that the opinions of the households subject to the SIA survey are incorporated. Article 6 SIA shall be prepared and published in the language of the region where the project is implemented, and published on the websites of the prefectural and municipal offices and relevant administrative agencies.		confirm and discuss communication in the local language in addition to Hindi.
11	The appropriate participation of affected persons shall be promoted at each stage of the planning, implementation, and monitoring of the resettlement plan. (JICA Guidelines 2022)	LARR 2013 Section 5 provides that, when a Social Impact Assessment (SIA) is conducted, a public hearing shall be held to ensure that the opinions of affected households are incorporated. Section 50 requires the State Government to establish a committee to monitor the implementation of the Resettlement Action Plan (RAP). CRP 2019 Affected communities must be informed and consulted at each stage, including public hearings during social impact assessments and the wide dissemination of survey details to be carried out during planning.	None	Promote the participation of affected persons in both the implementation and monitoring phases of the RAP. Specifically, during the implementation stage, the NGO or consultant responsible for RAP implementation shall engage in individual meetings with each Project Affected Household (PAH). During the monitoring stage, it is proposed that the terms of reference include the participation of PAHs in participatory surveys, group monitoring, and sample surveys conducted by external monitoring experts.
12	Appropriate grievance redress mechanisms (GRMs) that are easily accessible to affected persons and their communities shall be established. (JICA Guidelines 2022)	LARR 2013 Section 7: SIA reviews are conducted by an expert group including representatives of the concerned local bodies. Section 15: The Collector receives objections regarding the acquisition area, purpose, and SIA results. Section 16: R&R proposals are disclosed at public hearings; opinions/objections are recorded and finalized by the Collector/Government. Section 50: The State establishes a committee to monitor R&R implementation. Section 64: Grievances regarding surveys, compensation amounts, payees, and entitlements to support/resettlement are submitted to the Project Implementing Officer (Authority) through the Collector. CRP 2019 Ch. 3 §3.2 provides for intermittent public consultation, internal monitoring, and grievance redress throughout the project.	None	Verify the actual implementation status of SIA review, grievance intake, recording, and resolution as required by law, and confirm ease of access as well as the smooth and prompt resolution of complaints.
13	It is desirable that resettlement plans include the contents stipulated in the World Bank's ESS5. ESS5 para.20 requires an early census to establish eligibility and deter influx for assistance.	**LARR 2013** Section 4: Where land is to be acquired for a public purpose, an SIA shall be conducted in consultation with the municipality.	The preliminary notification date is set as the cut-off date for titleholders/ regular residents; the baseline survey completion	The RAP survey for Lines 3-1 and 3-2 has been underway since January 2025; confirm that legal cut-off dates have been set. Also confirm, including in this study's supplementary RAP survey, the cut-off date settings; and with BMRCL/BBMP the measures to manage population influx and installation/expansion of structures at other industrial sites.

No.	JICAGL (2022) • World Bank ESS5	Land Acquisition Act (LARR2013) / (KIADA) / (CRP2019)	Gap	Proposed Policy (draft) for this project
			date is set as the cut-off date for non-titleholders.	
14	Compensation for those affected by involuntary resettlement and loss of livelihood shall, wherever possible, be provided in advance and at full replacement cost; efforts shall be made to improve, or at least restore, living standards, income opportunities and production to pre-project levels. (JICA GL 2022, Appx.1) ESS5 paras.10, 29–30 require compensation at replacement cost and livelihood restoration support for all eligible persons, regardless of legal title.	LARR 2013 Chapter II: Requires SIA, disclosure of draft compensation/assistance policy, and formulation reflecting affected persons' opinions. Section 3(c): Eligible persons include owners of land/assets and those whose primary livelihood depends on the land to be acquired; (ii) for non-owners, eligibility generally requires ≥3 years' tenancy/occupation. KIAD Act: Non-owners of land are included; non-owners on common land are not included. CRP 2019: Targets slum dwellers and commercial squatters for resettlement and related benefits.	Non-titleholders are eligible, but compensation/support typically requires ≥3 years' tenancy/occupation record.	Recognizing the scope limitations under the 2013 Act, also utilize CRP measures in this project to provide compensation and support; coordinate accordingly. If necessary, the Mission will formally request BMRCL to implement the above policy.
15	It is desirable that resettlement plans include ESS5 contents. ESS5 para.14: where livelihoods depend on land or land is jointly owned, the borrower shall offer the option of alternative land of at least equivalent productivity with secure tenure; provide additional livelihood restoration support as needed.	LARR 2013 Appendix II: Among the compensation options for loss of owned land is provision of alternative land.	No option for provision of alternative arable land to tenant farmers cultivating under contracts with landowners.	Propose and discuss inclusion of options such as provision of alternative arable land and facilitation/mediation support within assistance measures.
16	Necessary support shall be provided during the transition period until income is restored. (JICA GL 2022) ESS5 para.36: Provide transitional support to economically displaced persons for a reasonable period required to restore income-earning capacity, production levels, and living standards.	LARR 2013 Appendix II: Provides employment opportunities or a lump-sum payment (or a 20-year annuity), one-year livelihood support (monthly), relocation disturbance allowance, etc.	None	Households compelled to relocate by the project shall receive a lump-sum livelihood support payment, a lump-sum moving allowance, and a relocation disturbance allowance; discuss additional subsidies and skills training for vulnerable households.
17	Special consideration shall be given to vulnerable persons (e.g., the poor, women, children, minorities, etc.) to ensure they are not disadvantaged. (JICA GL 2022) ESS5 para.26: Pay particular attention to the needs of the poor and	LARR 2013 (Section 41): As far as possible, avoid land acquisition in Scheduled Areas predominantly inhabited by Scheduled Castes/Tribes; where unavoidable, provide additional protections/benefits per the Act. CRP 2019: No explicit provision; project authorities indicate special cases will be considered as needed.	Definition of vulnerable groups may be narrow.	Discuss provision of additional support to PAPs/PAHs meeting the following conditions: below-poverty-line income; belonging to designated tribes; women-headed households; persons with disabilities; and elderly (≥60) without family support.

No.	JICAGL (2022) • World Bank ESS5	Land Acquisition Act (LARR2013) / (KIADA) / (CRP2019)	Gap	Proposed Policy (draft) for this project
	vulnerable groups, including the poor, landless, elderly, women, children, Indigenous Peoples, ethnic minorities, and transferees not adequately protected by domestic law.			
18	Based on issues identified by the environmental and social impact assessment, a compensation and livelihood restoration plan commensurate with the risks and impacts shall be formulated. (JICA GL 2022) ESS5 para.21: Develop a plan including eligibility criteria, levels/standards of compensation, and measures to restore livelihoods and living standards, according to project nature.	Prepared based on survey results, including implementation deadlines.	None	In this project, clarify the division of responsibilities among the executing agencies within the RAP, and proceed with proposals and consultations accordingly.

Source: JST

3.2.5 Common Property Resources (CPRs) and treatment of religious facilities

In this project, community facilities such as parks, public toilets, religious facilities (temples, shrines, mosques, churches), and community halls that are owned by the State Government or local bodies but jointly used by local residents are classified as *Common Property Resources (CPRs)*. CPRs are assets over which no individual has exclusive ownership rights; rather, the community as a whole has rights and responsibilities regarding their use, operation and maintenance.

Religious facilities located within the proposed right-of-way are treated as CPRs under this definition. Where such CPRs are affected by land acquisition or construction activities, the Resettlement Action Plan (RAP) and Environmental Management Plan (EMP) will provide specific measures to (i) avoid impacts as far as practicable, and, where relocation is unavoidable, reconstruct or relocate the facilities in consultation with the concerned community and relevant local bodies so that their functions and accessibility are restored at least to pre-project levels; and (ii) during construction, ensure continued access for users, including, where necessary, the provision of temporary access routes and temporary facilities for worship or community use. The costs of reconstruction, relocation and temporary arrangements for CPRs will be included in the resettlement and compensation budget. These arrangements are consistent with the principles of the LARR Act, 2013 and the JICA Guidelines for Environmental and Social Considerations (2022), which require that adverse impacts on common property and cultural assets be avoided or minimised, and that, where impacts are unavoidable, affected community resources be restored or improved through appropriate compensation and livelihood restoration measures.

4. Consideration of alternatives (including the 'without-project' alternative)

4.1 Alternative Consideration Process

In this study, we examined the following step-by-step alternatives.

- Phase 1 (Initial Study)
- Compare with the "without-project" scenario, check the prerequisites such as physical constraints and connection to existing roads and lines, and select alignment and structural alternatives for further consideration.
- Phase 2 (comparison of alignment and structural alternatives)
- A comparative study of three structural alternatives in which the metro and road coexist for each of the two or three alignment alternatives.
- Phase 3 (Comparison of vehicle depot alternatives)
- We examined alternatives to the vehicle depot in the recommended alignment.

4.2 Initial consideration: Proposal not to implement the project

If the project is not carried out, the following risks are assumed.

- Traffic Congestion Risk:
  The increase in the urban population and the use of private cars and motorcycles will further aggravate traffic congestion and significantly reduce the efficiency of commuting and logistics.
- Risk of environmental degradation:
  The increase in emissions associated with a large number of vehicles will worsen air pollution and noise, and the impact on the health and living environment of urban populations in particular will increase.
- Risk of Financial Loss:
  Time loss due to traffic congestion, increased fuel costs, and logistics stagnation have a negative impact on the city's economic activity, leading to lost investment and employment opportunities in the long run.
- From the above, if the project is not implemented, the healthy growth of the city and the development of public transportation will be hindered, and sustainable urban development in terms of environment, economy, and society will not be realized. Therefore, it is deemed desirable to implement the project.

4.3 Initial Consideration: Assumptions, Confirmation of Possible Alternatives

In the initial study, based on the need for road and metro maintenance in the same section, several prerequisites were set for selecting alternatives that could be considered.

4.3.1 Prerequisite 1: The alignment proposal should be considered on an existing trunk road with a width of 30 m or more

Based on the project site width required for this project, it was decided to consider existing arterial roads with a width of 30 m or more, in line with JICA GL's principle of "avoiding and minimizing the impacts of land acquisition and resettlement." The reasons are as follows:

(1) Required project site width

According to the Indian Roads Congress (IRC) standards, the width of a four-lane road is about 20 m, including the median strip and curbs. For the metro, the Schedule of Dimensions of BMRCL (2015) stipulates inter-track and vehicle clearances, with a minimum requirement of 15 m. Therefore, a site width of at least 30 m is desirable to accommodate stations and ramps, maintenance works, easements, and other facilities.

(2) Scale of land acquisition and involuntary resettlement

It is assumed that some land acquisition and resident relocation will occur under any structural option—at-grade, viaduct, or underground. The project area is increasingly urbanized, and land available for development is limited. Since trunk roads are public land, no acquisition is required there. However, outside trunk roads, areas have become highly urbanized with dense residential and commercial development. Consequently, implementing the project on non-trunk roads would significantly increase the extent of land acquisition and resident relocation.

Table4-1: Initial Consideration and Selection of Structural Alternatives

item	Alternative 1. At-grade	Alternative 2. Elevated bridge	Alternative 3. Underground
Involuntary resettlement of residents and land acquisition	Large-scale land acquisition is required; involuntary resettlement will occur.	Land acquisition is required; involuntary resettlement will occur.	During construction, it is difficult to secure the space necessary for the installation of the shield machine.
Environmental Impacts	Long-term traffic restrictions due to construction, worsening congestion.	Long-term traffic restrictions due to construction, worsening congestion.	Excavation generates a large amount of sediment, significantly impacting the environment, including the selection of disposal sites.
Difficulty of construction	Relatively easy.	Relatively difficult viaduct construction.	High risk of interfering with foundation piles of medium- and high-rise buildings during underground station construction.
Construction costs	Relatively low.	High viaduct construction costs.	Deep underground tunnels are required, significantly increasing costs.

Source: JST

4.3.2 Prerequisite 2: Metro and road projects should be implemented on the same arterial road

According to the DPR, in Bengaluru, about 45% of existing roads have a width of 20 meters or less. Approximately 74% are two-lane roads, while only about 20% have four or more lanes. Therefore, existing wide roads are limited.

If a candidate arterial road exists in the project area, the following two alternatives were compared:

- **Alternative 1:** Metro and road projects implemented on different arterial roads
- **Alternative 2:** Metro and road projects implemented on the same arterial road

The comparative study found that under Alternative 1, if the project is implemented on different arterial roads, the scope of works (construction and land acquisition) would effectively double, proportionally increasing environmental and social impacts as well as construction costs. By contrast, under Alternative 2, implementing both projects on the same arterial road makes it possible to manage environmental and social impacts in an integrated manner, thereby minimizing both impacts and costs.

Accordingly, it is considered a prerequisite that the metro project and the road project be implemented on the **same arterial road**.

Table4-2: Initial Consideration and Selection of Linear Alternatives

item	Alternative 1: On different arterial roads	Alternative 2: On the same arterial road
Involuntary resettlement of residents and land acquisition	It is necessary to acquire land for two routes, and there is a risk of involuntary residents and opposition to the project.	It is necessary to acquire the site, but it is smaller than the first proposal.
Environmental Impact (Pollution Countermeasures)	Traffic restrictions due to construction have worsened traffic congestion, increased environmental impact such as air pollution and noise.	Smaller than Proposal 1.
Difficulty of construction	Construction traffic control in multiple sections is necessary	Smaller than Proposal 1.
Construction costs	Adjustment costs, land acquisition costs, and construction costs increased.	Smaller than Proposal 1.

Source: JST

4.3.3 Prerequisite 3: Vertical structure alternatives shall include three options: double-deck viaduct, parallel viaduct, and metro underground/road overpass

Metro and road projects can generally be implemented as at-grade, elevated, or underground structures, as summarized in the table below. However, since at-grade structures are expected to require large-scale land acquisition and resident relocation, they are not considered as viable alternatives for either the metro or road projects. In addition, underground structures for road projects are technically difficult and costly to construct. Therefore, underground structures are considered only for the metro project.

It should be noted that, in September 2025, the Urban Development Department (UDD) of the Government of Karnataka indicated to BMRCL its policy direction that all new metro projects within the Bengaluru Metropolitan Region should, in principle, adopt a double-deck structure. This policy was formally approved by the State Cabinet in the same month.

In this study, taking this policy direction into account, the double-deck was examined together with the other two structural alternatives (parallel viaduct and metro-underground/road-elevated) to confirm that the adoption of the double-deck structure is technically and socially justified and can be reasonably explained.

Table4-3: Initial Consideration and Selection of Structural Alternatives

Item	Alternative 1: On different main roads	Alternative 2: On the same trunk road
Elevated	Considerable	Considerable
At-grade	Both metro and road projects will have large-scale land acquisition and involuntary resettlement. Excluded from ⇒ alternatives	
underground	**Technical Aspects:** By using shield machines between stations, it is possible to construct without underground infrastructure. Since station construction requires excavation, the impact on transportation and other environmental and social aspects is significant. **Cost Aspect:** The construction of large-scale structures underground is very expensive compared to other structural alternatives. In addition, additional infrastructure such as drainage systems and ventilation systems are required, and life cycle costs are high. **Environmental and Social Considerations:** The cost of environmental and social consideration measures can be reduced. **Policy:** The upper transportation plan does not specify the maintenance of the underground metro. ⇒ can be considered as an alternative	**Technical Aspects:** It will be constructed using the excavation method. There are many existing underpasses and underground infrastructure (water and sewerage, electrical lines, gas pipes, etc.) in the city. In order to avoid them and build a new underground road, it is necessary to construct it at a very deep position. As a result, the construction method has become more complex, and the difficulty of excavation and shoring work has increased significantly. **Cost Aspect:** The construction of large-scale structures underground is very expensive compared to other structural alternatives. In addition, additional infrastructure such as drainage systems and ventilation systems are required, and life cycle costs are high. **Environmental and Social Considerations:** Because of the excavation method, the cost of environmental measures for noise, air quality, and traffic congestion is high. **Policy:** In the higher-level transportation plan, the development of underground roads is not explicitly recommended, but rather the expansion of the capacity of the main road on the premise of the viaduct structure is indicated as a priority measure Excluded from ⇒ alternatives

Source: JST

4.4 Comparative Examination Policy for Alignment and Structural Alternatives

According to the prerequisites confirmed in the initial review, the linear alternatives that could be considered were identified, and structural alternatives were confirmed for each linear alignment in each section.

4.4.1 Examination of Alternatives

The following policies were adopted for the consideration of alternatives:

- The target alignment was divided into five sections (Line 3-1: four sections, Line 3-2: one section), and both alignment and structural alternatives were examined for each section.
- Two or three linear alternatives were selected for each section.
- Three structural alternatives were selected: double-deck viaduct (vertical separation), parallel viaduct (lateral separation), and metro underground with road overpass (vertical separation).

4.4.2 Evaluation Criteria and Methodology

Each alternative was evaluated using scores (quantitative evaluation values) with assigned weights for each evaluation item. The overall score was calculated as a weighted sum, and the alternative with the highest overall score was identified as the “recommended alternative.”

(1) Setting of Evaluation Items

The evaluation items were adopted from the perspectives of *construction and design*, *social and economic efficiency*, and *environmental and social considerations*, as shown in Table4-4.

Each item was selected to quantitatively and comparably capture the key impacts of the alternatives. The specific impacts assessed under each item are as follows:

- **Construction and Design**
  - *Difficulty of construction method*: Evaluation of technical feasibility and safety margins during construction.
  - *Safety (construction and design)*: Evaluation of the effect of reducing accident risks during construction and operation.
  - *Construction costs*: Comparison of the financial burden and cost-effectiveness of the project.
  - *Construction period*: Assessment of social and traffic impacts and costs associated with the extension of the construction period.
  - *Impact on traffic during construction*: Evaluation of congestion and access restrictions caused by traffic control and occupation.
- **Social and Economic Efficiency**
  - *Number of stations*: Evaluation of convenience and attractiveness through improved accessibility.
  - *Passenger demand (metro)*: Evaluation of benefits such as increased transport capacity and reduced travel time.
  - *Congestion alleviation effect (road)*: Evaluation of connectivity and congestion mitigation in the wider road network.
  - *Number of ramps*: fewer = better, due to expected congestion reduction.
  - *Connectivity function*: Evaluation of ease of transfer to other transport modes and overall network integration.
  - *Seamless traffic movement*: Assessment of continuity of urban mobility (reduced barriers).
- **Environmental and Social Considerations**
  - *Scale of land acquisition*: Evaluation of impacts directly associated with the size of land acquisition and the difficulty of land rights adjustment.
  - *Impact on residential households*: Evaluation of direct impacts on housing and livelihoods.
  - *Impact on ecosystems (flora and fauna)*: Evaluation based on the number of trees felled, biodiversity, and habitat modification.
  - *Noise and vibration*: Evaluation of impacts on the acoustic environment and quality of life.
  - *Air pollution*: Assessment of health risks (concentration and exposure) from traffic-related emissions.
  - *Landscape*: Evaluation of visual impacts on urban landscape resources and view corridors.

In general, the “land acquisition area” and the “number of affected structures” are highly correlated, and

assessing them as separate items may result in overlapping evaluations.

However, for this route section, the correlation between the two was found to be low, and since they represent different types of impacts, they were treated as independent parameters and evaluated separately.

On the other hand, in the study of the vehicle depot, the two factors overlapped in their impact scope, and therefore they were integrated and the scoring was adjusted accordingly.

(2) Scoring Method for Each Alternative by Evaluation Item

For items that can be quantitatively evaluated, such as construction costs and the number of ramps, the value of each alternative was converted into a score on a six-point scale (with the most desirable alternative receiving 6 points) and rounded.

For items that can only be evaluated by ranking or relative superiority, the qualitative and quantitative assessments of each alternative for each evaluation item were converted into evaluation scores and rounded. In such cases, the most desirable alternative among all alternatives was given a full score of "6" and the least desirable alternative a score of "1." If all alternatives received the same rating, each was assigned a score of "3.5."

Where evaluations of alternatives were qualitative, they were converted into a relative scale based on professional judgment and scored accordingly.

(3) Weighting

When aggregating the scores of each alternative, higher weights were assigned to important evaluation items, and the total score was normalized so that the maximum overall score equaled 1.0. The weighting applied was as follows: *Construction and Design* – 0.2; *Social and Economic Efficiency* – 0.4; and *Environmental and Social Impacts* – 0.4.

Since environmental and social impacts are a critical factor in the selection of alternatives, a relatively high weight of 0.4 was assigned. Within *Construction and Design*, "Safety" was given twice the weight of other evaluation items in the same category due to its higher importance.

When calculating the overall score of each alternative, the subtotal for each category was standardized by dividing by the number of items within that category, and the standardized subtotals were then summed to produce the overall score.

Table4-4: Weighting by Classification in Alternative Consideration

No.	classification	item	Grading method	Specific gravity (total=1)	
				Per item	By classification
1	Construction and design	Difficulty of construction method	Experts from the survey team score 6 points as the maximum value based on ranking and relative superiority and inferiority	0.033	0.2
		Safety (weighted twice as much as other items in terms of	Experts from the survey team score 6 points as the maximum value based on ranking and relative superiority and inferiority	0.067	

No.	classification	item	Grading method	Specific gravity (total=1)	
				Per item	By classification
		construction and design)			
		Construction cost	Based on the estimated amount of construction costs, the lowest alternative is given a score of 6 out of 6, and other alternatives are scored by reflecting the excess of the estimated amount from there.	0.033	
		Construction period	The alternative with the shortest construction period is 6 points, and the experts of the investigation team score it based on the ranking and relative superiority and inferiority.	0.033	
		Impact on traffic during construction	The most desirable alternative is quantitatively scored by the experts of the investigation team on 6 points.	0.033	
2	Social and Economic	Passenger Demand: Number of Stations	The experts of the investigation team will quantitatively score (if the number of stations is large, the score will be high). If the number of stations in all alternatives is the same, all are scored 3.5 points.	0.067	0.4
		Passenger demand (metro)	Experts from the survey team will give a quantitative score (if passenger demand is large, a high score)	0.067	
		Traffic congestion alleviation effect (road)	Experts from the investigation team will give a quantitative score (high score if the traffic congestion alleviation effect is large)	0.067	
		Congestion alleviation effect (road): number of ramps	The alternative with the fewest number of ramps is given a perfect score of 6, and the other alternatives are scored according to the number of ramps. If the number of ramps in all alternatives is the same, all are rated 3.5 points.	0.067	
		Connecting routes	The experts of the investigation team will give a score quantitatively (if the connection route is large, the score will be higher). If all alternatives have the same number of connected lines, all will be rated 3.5 points.	0.067	
		Seamless Traffic Movement	Ratings are based on the vertical distance traveled by passengers. The alternative with the least distance traveled is given 6 points, and the other alternatives are scored according to the length of the distance traveled.	0.067	
3	Environmental and Social Impacts*	Scale of land acquisition	The alternative with the least land acquisition area is scored as 6 points, and the other alternatives are scored by reflecting the excess from there.	0.067	0.4
		Impact on residential households	The alternative with the lowest number of affected households calculated from the number of affected structures is scored as 6 points, and the other alternatives are scored by reflecting the excess from there.	0.067	
		Impact on ecosystems (flora and fauna) (assessed by the number of trees felled)	The alternative with the fewest number of felled trees for construction is scored on 6 points, and the other alternatives are scored by reflecting the excess from there.	0.067	
		Noise and vibration	- At the time of construction: The ratio of the impact of noise and vibration between alternatives from the product of the line length, site width, and metro underground is calculated, and the alternative with the lowest value is given 6 points, and the other alternatives are scored by reflecting the excess from there. - At the time of service: The ratio of the effect of noise and vibration between the alternatives from the product of the line length and the attenuation of the impact of the metro underground, the building area ratio is calculated, and the alternative with the lowest value is given 6 points, and the other alternatives are scored by reflecting the excess from there. - The above scores at the time of construction and service are integrated in a ratio of 3:7	0.067	

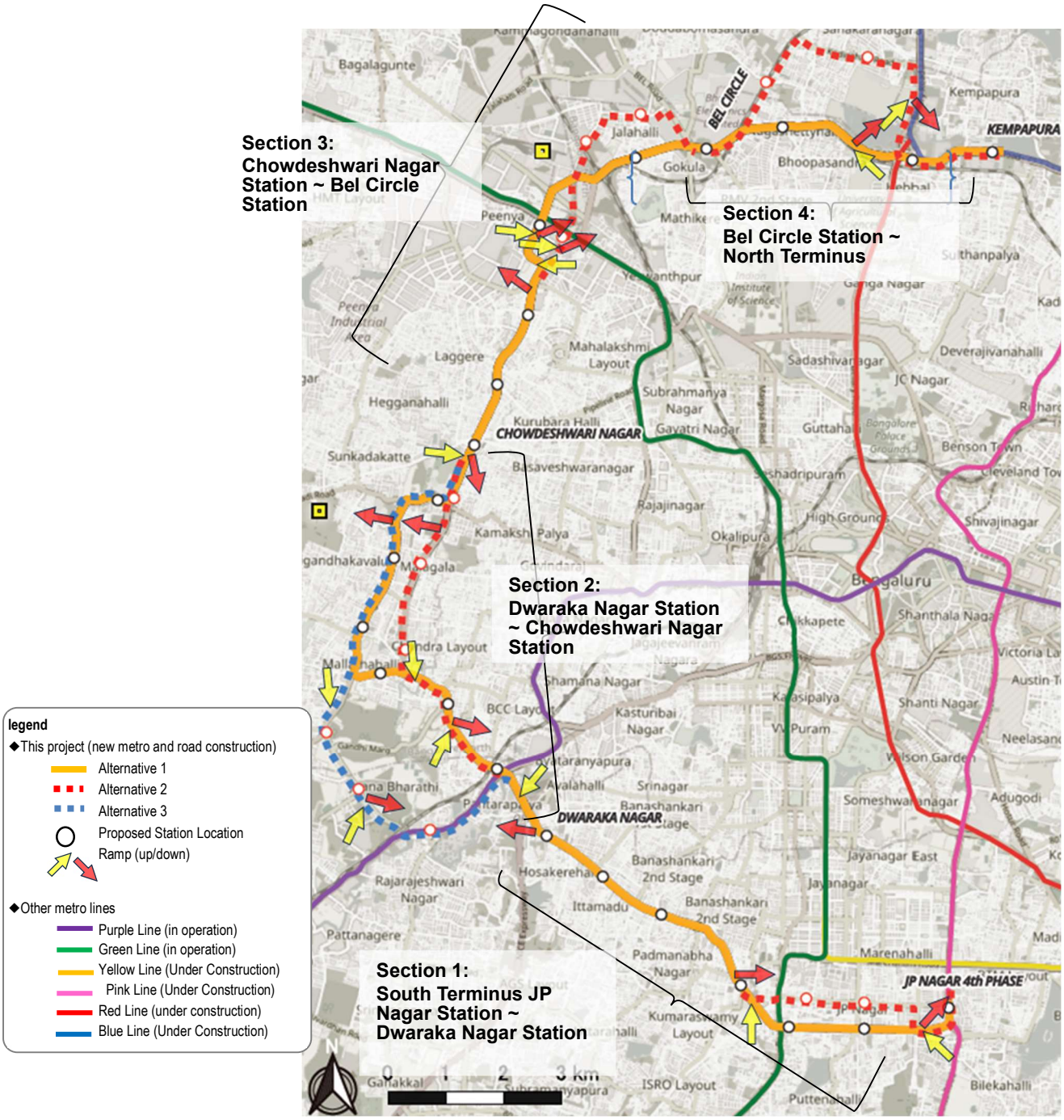
No.	classification	item	Grading method	Specific gravity (total=1)	
				Per item	By classification
		Air pollution	- At the time of construction: The ratio of the impact of air pollution between the alternatives from the product of the line length, site width, and aboveground construction and building area ratio is calculated, and the alternative with the lowest value is scored as 6 points, and the other alternatives are scored by reflecting the excess from there. - When in service: The ratio of air pollution effects between the alternatives is calculated from the product of the line length and building area ratio, and the alternative with the lowest value is given 6 points, and the other alternatives are scored by reflecting the excess from there. - The above score at the time of construction and service is scored according to the integration at a ratio of 3:7	0.067	
		Landscape	The ratio of the impact on the landscape between the alternatives from the product of the line length, the height of the viaduct, and the floor area ratio is calculated, and the alternative with the lowest value is given 6 points, and the other alternatives are scored by reflecting the excess from there.	0.067	
		Total		1.000	1.0

*: In comparing the structural alternatives, the height of the road carriageway is almost the same among the three alternatives, including the double-deck option; therefore, the dispersion characteristics of air pollutants emitted from road traffic during the operation phase are assessed as broadly equivalent across the alternatives. Regarding noise, in the double-deck option, the metro tracks are located at a higher elevation than in the other alternatives, providing greater distance attenuation for surrounding residential areas; this has been reflected in the evaluation.

Source: JST

4.4.3 Comparative study of alternatives for Line 3-1

For Line 3-1, the entire route was divided into four sections, and a comparative study of alternatives was conducted for each section, as shown in the figure below.



Source: Created by the investigation team based on OpenStreetMap (https://www.openstreetmap.org/copyright/ja)

Figure4-1: Sections for route-alternative examination for Line 3-1

(1) Section 1: Southern terminus (JP Nagar Station) – Dwaraka Nagar Station

This section connects JP Nagar Station in southern Bengaluru with Dwaraka Nagar Station, linking the city centre and suburban areas. Residential neighborhoods, commercial facilities, and educational

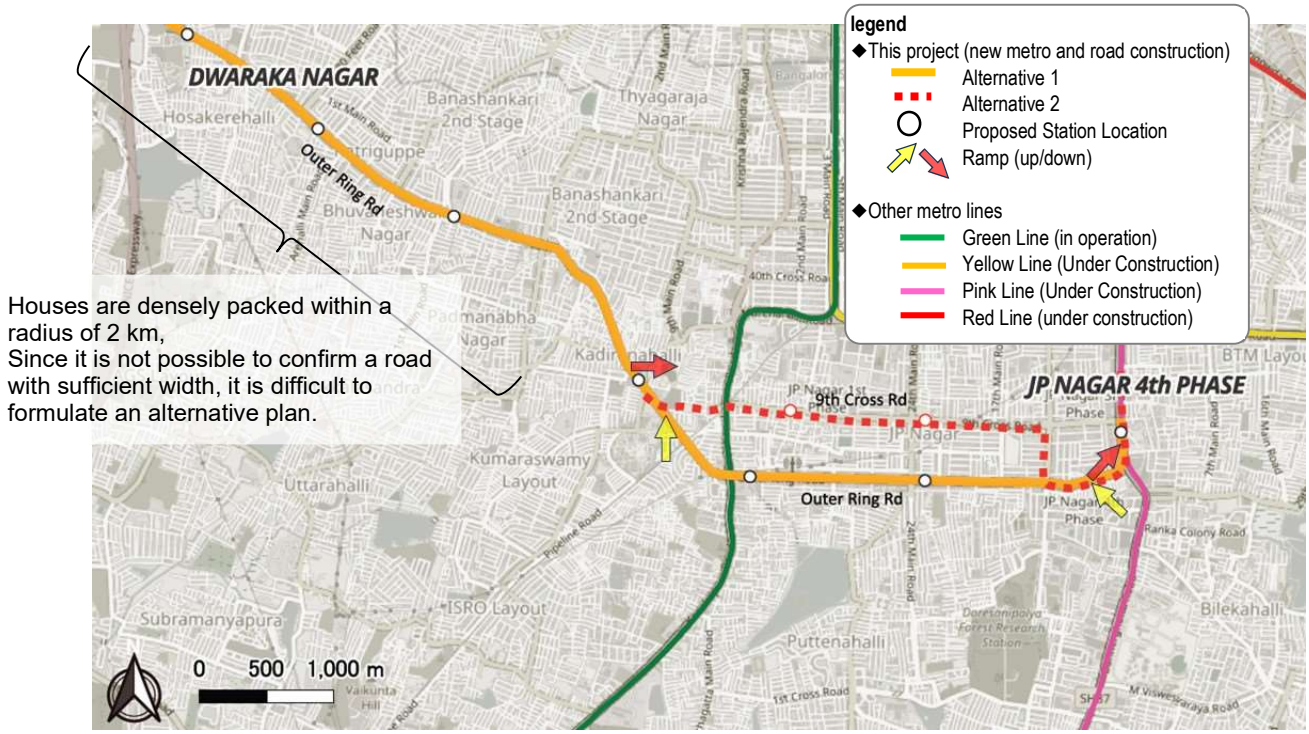
institutions are concentrated along the corridor. Two route alternatives were compared:

1) Alternative 1 (Orange): Route along the Outer Ring Road (ORR) to Dwaraka Nagar Station

- Covers commercial and residential areas in a well-balanced manner and can be constructed along existing roads.
- An elevated structure is readily applicable, with few intersections with major arterials.
- Land acquisition may be required near certain intersections.

2) Alternative 2 (Red dashed line): Route from JP Nagar via 9th Cross Rd and the ORR

- May pass through densely populated areas, potentially increasing station usage.
- Traffic control will be required at intersections with major roads during construction.
- Land acquisition may be required near certain intersections.



Source: Created by the Investigation Team based on OpenStreetMapOpenStreetMap (https://www.openstreetmap.org/copyright/ja)

Figure4-2: Section 1—alternative routes from JP Nagar Station to Dwaraka Nagar Station (southern terminus)

Table4-5: Section 1. Results of the comparative study of alternatives for Section 1 — from JP Nagar Station to Dwaraka Nagar Station (southern terminus)

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
Design		Length, Number of Stations and Ramps	9.10 km, 7 stations, 2 up-ramps and 2 down-ramps						9.25 km, 7 stations, 1 up-ramps and 2 down-ramps					
1	Design and Construction (Weight 0.2)	Construction Method Difficulty (Weight 0.033)	The structure will be taller than a typical elevated metro, with a height of about 5 m between stations and 10 m at stations. The superstructure design needs to be devised for special spans at grade-separated crossings, and the structure must withstand two-layer overturning moments.	3	The most versatile construction method among the alternatives. Two substructures are required.	6	Integration of underground and elevated structures is required at station areas. It is necessary to avoid the impact of underground works on the elevated structure, and advanced construction management is required.	1	Same as Alternative 1a.	3	A special structure type may be required to match the narrow road width.	4	Same as Alternative 1c.	1
2		Safety (Double the weighting of other design/construction items) (Weight 0.067)	Since the structure is higher, measures against falling and collapse accidents and countermeasures for bad weather (strong winds and lightning) are extremely important.	4	Construction is carried out in a spatially narrow area, so attention must be paid to contact accidents involving third parties.	6	The three-dimensional relationship between the two structures is complex, and countermeasures to avoid accidents in the tunnel section will require significant cost.	3	In addition to Alternative 1a, countermeasures against contact accidents become important.	3	Countermeasures against contact accidents become even more important.	4	In addition to Alternative 1c, countermeasures against contact accidents become important.	1

#	Item for Consideration	Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
3	Construction Cost (Weight 0.033)	The construction cost ratio is 1.00. A structure capable of withstanding excessive overturning moments with a single-leg double-deck design is required, but the substructure can be consolidated.	6	The construction cost ratio is 1.10. As the structures are parallel, it will be a standard structure, but two substructures are required.	6	The construction cost ratio is 1.78. It is necessary to consider the location and depth of piles that do not interfere with road substructures and tunnels.	3	The construction cost ratio is 1.02. A structure capable of withstanding excessive overturning moments with a single-leg double-deck design is required, but the substructure can be consolidated.	6	The construction cost ratio is 1.12. As the structures are parallel, it will be a standard structure, but two substructures are required.	6	The construction cost ratio is 1.81. It is necessary to consider the location and depth of piles that do not interfere with road substructures and tunnels.	3
4	Construction Period (Weight 0.033)	The construction period can be shortened compared to building each structure separately.	6	Since full road closure is not possible, one project must start after the other finishes, resulting in a longer construction period.	3	Simultaneous above-ground (including pile foundation) and underground construction is extremely difficult for safety reasons, so each must be constructed independently, resulting in a longer period. As access to tunnel work is limited, it is difficult to shorten the construction period by increasing work teams.	3	In addition to Alternative 1a, the narrow road width reduces workability for each structure, resulting in a longer construction period.	4	In addition to Alternative 1b, the narrow road width reduces workability for each structure, resulting in a longer construction period.	1	Same as Alternative 1c.	3

#		Item for Consideration	Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
5		Traffic Impact During Construction (Weight 0.033)	At least a two-lane restriction will continue for about four years.	5	At least a two-lane restriction will continue for six years.	4	Road restrictions during metro construction are limited to station areas; however, for the viaduct, at least a two-lane restriction will continue for about three years.	6	Due to the narrow road width, the impact will be greater compared to Alternative 1a.	4	Due to the narrow road width, the impact will be greater compared to Alternative 1b.	2	Due to the narrow road width, the impact will be greater compared to Alternative 1c.	5
		Total		28		31		19		23		21		14
6	Socio-Economic (Weight 0.4)	Passenger Demand (Metro): Number of Stations (Weight 0.067)	3 stations	3.5	Same as Alternative 1a	3.5	Same as Alternative 1a	3.5	3 stations	3.5	Same as Alternative 2a	3.5	Same as Alternative 2a	3.5
7		Passenger Demand (Metro) (Weight 0.067)	Covers densely populated residential areas in the southern ORR region, which is a railway-free zone, and is expected to generate commuting and school demand.	3	Same as Alternative 1a	3	Same as Alternative 1a	3	Covers densely populated residential and small commercial areas, expected to generate commuting and school demand; partially overlaps with the Yellow Line.	2	Same as Alternative 2a	2	Same as Alternative 2a	2
8		Traffic Congestion Alleviation Effect (Road) (Weight 0.067)	Partial congestion occurs.	3	Same as Alternative 1a	3	Same as Alternative 1a	3	Congestion occurs on narrow roads.	2	Same as Alternative 2a	2	Same as Alternative 2a	2
9		Traffic Congestion Alleviation Effect (Road): Number of Ramps (Weight 0.067)	Congestion occurs near four ramps.	4	Same as Alternative 1a	4	Same as Alternative 1a	4	Congestion occurs near three ramps.	6	Same as Alternative 2a	6	Same as Alternative 2a	6
10		Connecting Routes (Weight 0.067)	Two routes (Pink, Green)	6	Same as Alternative 1a	6	Same as Alternative 1a	6	One route (Pink)	4	Same as Alternative 2a	4	Same as Alternative 2a	4

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
11		Seamless Traffic Movement (Weight 0.067)	Two-level movement	4	One-level movement	6	One-level movement	6	Two-level movement	4	One-level movement	6	One-level movement	6
		Total		23.5		25.5		25.5		21.5		23.5		23.5
12	Environmental Impact (Weight 0.4)	Scale of Land Acquisition (Evaluation based on acquired area) (Weight 0.067)	48,059 m²	6	Ratio of route width to Alternative 1a (27m:40m)	4	Ratio of route width to Alternative 1a (27m:25m)	6	68,239 m²	4	Ratio of route width to Alternative 2a (27m:40m)	3	Ratio of route width to Alternative 2a (27m:25m)	5
13		Impact on Residential Households (Evaluated by Number of Affected Households) (Weight 0.067)	484 households	6	Ratio of route width to Alternative 1a (27m:40m)	4	Ratio of route width to Alternative 1a (27m:25m)	6	816 households	4	Ratio of route width to Alternative 2a (27m:40m)	3	Ratio of route width to Alternative 2a (27m:25m)	4
14		Impact on Ecosystems (Flora and Fauna) (Evaluated by Number of Trees Felled) (Weight 0.067)	770 trees	5	Ratio of route width to Alternative 1a (27m:40m)	3	Ratio of route width to Alternative 1a (27m:25m)	5	680 trees	6	Ratio of route width to Alternative 2a (27m:40m)	4	Ratio of route width to Alternative 2a (27m:25m)	6

#	Item for Consideration	Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
15	Noise and Vibration (Weight 0.067)	- - During construction: Scored from line length, site width, attenuation of impacts in the case of underground metro, and building coverage ratio (4.70) - In operation: Scored from line length, attenuation of impacts in the case of underground metro, and building coverage ratio (5) (Combined score of construction and operation periods in a 3:7 ratio)	5	- During construction (3.5) - In operation (5)	5	- During construction (6) - In operation (6)	6	- - During construction (4.64) - In operation (4.94)	5	- During construction (3.46) - In operation (4.94)	4	- -During construction (5.92) - In operation (5.92)	6
16	Air Pollution (Weight 0.067)	- During construction: Scored from line length, site width, attenuation of impacts in the case of underground metro, and building coverage ratio (4.76) - In operation: Scored from line length and building coverage ratio (6) / (Combined score of construction and operation periods in a 3:7 ratio)	6	- During construction (3.54) - In operation (6)	5	- During construction (5.07) - In operation (6)	6	- During construction (4.70) - In operation (5.92)	6	- During construction (3.5) - In operation (5.92)	5	- During construction (6) - In operation (5.92)	6

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
17		Landscape (Weight 0.067)	Scored from line length, viaduct height, and building coverage ratio	5		5		6		5		5		6
		Total		33		26		35		30		24		33

Evaluation Results		Alternative 1 (Orange)						Alternative 2 (Red Dashed Line)					
		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		b. Parallel Viaduct		a. Double-deck Viaduct		c. Metro Underground + Road Overpass	
Overall	Evaluation Category	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score
	Design and Construction	0.778	0.156	0.861	0.172	0.528	0.106	0.639	0.128	0.583	0.117	0.389	0.078
	Socio-economic	0.653	0.261	0.708	0.283	0.708	0.283	0.597	0.239	0.653	0.261	0.653	0.261
	Environmental Impact	0.917	0.367	0.722	0.289	0.972	0.389	0.833	0.333	0.667	0.267	0.917	0.367
Total		**Recommended**	**0.783**		**0.744**		**0.778**		**0.700**		**0.644**		**0.706**

Rating: Relative evaluation on a scale of 1 to 6. A higher score indicates a more favourable alternative.

Source: JST

(2) Section 2: Dwaraka Nagar Station to Chowdeshwari Nagar Station

This section links Dwaraka Nagar Station to Chowdeshwari Nagar Station, connecting southern Bengaluru to residential and commercial areas in the northwest. Major traffic corridors run along the Outer Ring Road (ORR) and Bangalore University Road. In the alignment planning for this section, the following three alternatives were compared.

1) Alternative 1 (Orange): Route via Mysore Road and along the ORR

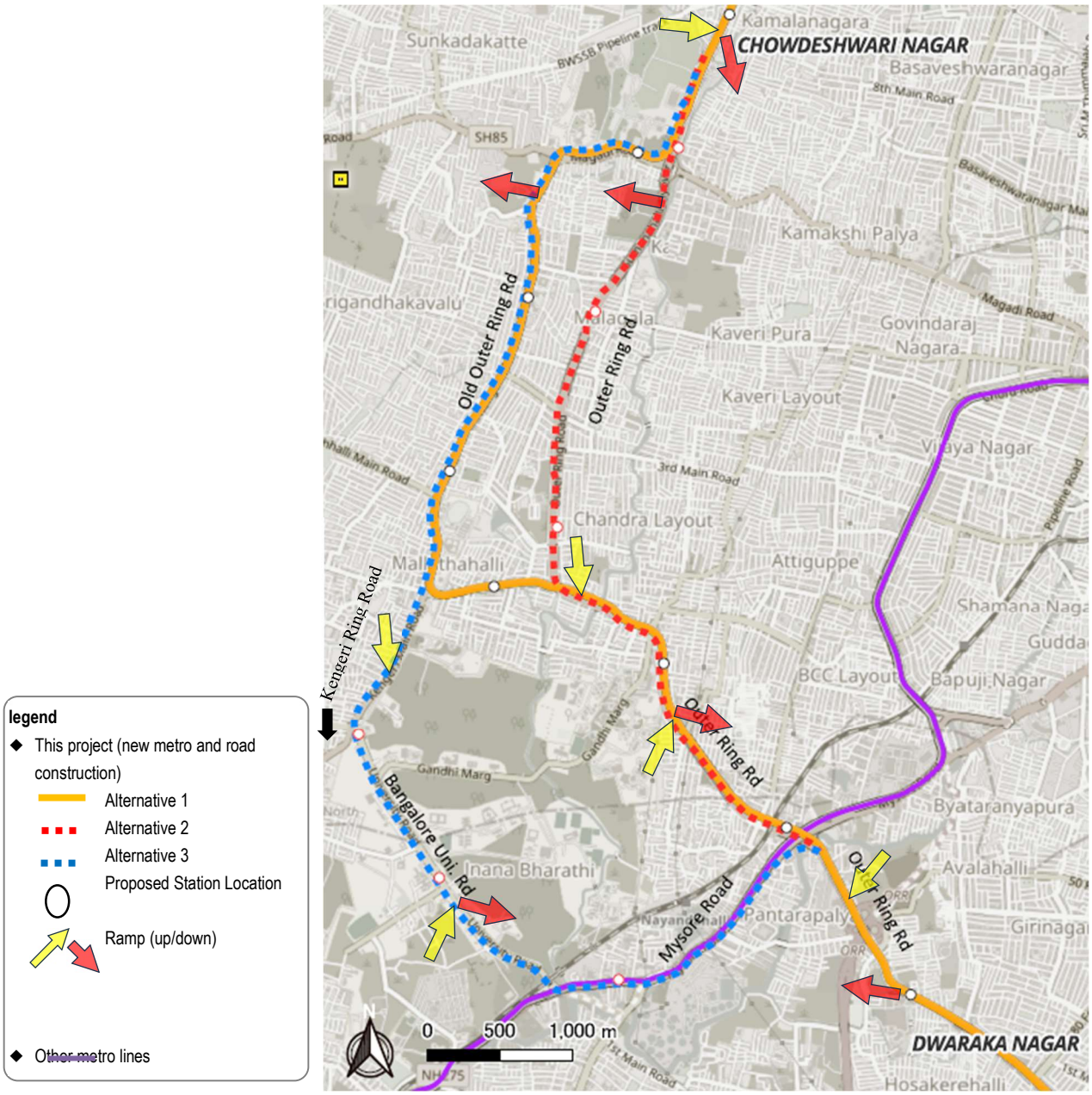
- It covers the main commercial area and can be built along the main road.
- The elevated structure is easy to apply and has relatively little impact on existing traffic.
- The need for land acquisition is low, and the constructability is excellent.

2) Alternative 2 (Red dashed line): Route from Dwaraka Nagar northbound on the ORR to Chowdeshwari Nagar Station

- Improves access to the city center by leveraging busy arterial roads.
- Some segments run parallel to the existing flyover, which may raise land acquisition issues.
- Potential for traffic congestion near intersections during construction.

3) Alternative 3 (Blue): Route via Bangalore University Road and the Old Outer Ring Road

- asses through the Bangalore University campus and green areas, with potential demand from surrounding residents.
- Some segments run parallel to the existing Purple Line, which may raise land acquisition issues.



Source: Created by the investigation team based on OpenStreetMap (https://www.openstreetmap.org/copyright/ja)

Figure4-3: Section 2. Route alternatives from Dwaraka Nagar Station to Chowdeshwari Nagar Station

Table4-6: Results of the comparative study of alternatives for Section 2 - from Dwaraka Nagar Station to Chowdeshwari Nagar Station

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)						Alternative 3 (Blue line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
Design		Length, Number of Stations and Ramps	9.91 km, 8 stations, 4 up-ramps and 4 down-ramps						8.18km, 7 stations, 4 up-ramps and 4 down-ramps						11.88 km, 8stations, 4 up-ramps and 4 down-ramps					
1	Design and Construction (Weight 0.2)	Construction Method Difficulty (Weight 0.033)	The structure will be taller than a typical elevated metro. The superstructure of the special section where the span crosses at grade separations requires special design considerations. A structure capable of resisting two-layer overturning moments is necessary.	3	The most general construction method among the alternatives. Two substructures are required.	5	Integration of underground and elevated structures is required at station sections; it is necessary to consider the influence of underground works on the elevated structure, as well as pile location and depth that do not interfere with the road substructure and tunnel. Advanced construction management is required.	2	Compared to Alternative 1a, construction on wider roads makes it relatively easier.	4	Compared to Alternative 1b, construction on wider roads makes it relatively easier.	6	Compared to Alternative 1c, construction on wider roads makes it relatively easier.	3	A larger construction yard can be secured near University Rd, making construction somewhat easier than in Alternative 1a.	4	A larger construction yard can be secured near University Rd, making construction somewhat easier than in Alternative 1b.	6	A larger construction yard can be secured near University Rd, making construction somewhat easier than in Alternative 1c.	3

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)						Alternative 3 (Blue line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
2		Safety (Double the weighting of other design/construction items) (Weight 0.067)	Since the structure will be taller, fall protection and countermeasures against severe weather (strong winds and lightning strikes) are extremely important.	4	Construction is carried out in narrow areas, requiring precautions against contact accidents involving third parties.	5	The three-dimensional relationship between structures is complex, and large costs are required for countermeasures to avoid accidents in tunnel sections.	2	In addition to Alternative 1a, measures against contact accidents will be important.	5	Compared with Alternative 1b, measures against contact accidents are even more important.	6	In addition to Alternative 1c, measures against contact accidents will be important.	4	The construction yard is larger, increasing safety compared with Alternative 1a.	5	The construction yard is larger, increasing safety compared with Alternative 1b.	6	The construction yard is larger, increasing safety compared with Alternative 1c.	4
3		Construction Cost (Weight 0.033)	Cost ratio: 1.00. A structure capable of resisting large overturning moments with a single-leg two-layer system is required, but the substructure can be concentrated.	6	Cost ratio: 1.10. As the structures are parallel, it will be a standard configuration, but two substructures are required.	5	Cost ratio: 1.78. It is necessary to consider pile location and depth that do not interfere with the road substructure and tunnel.	3	Cost ratio: 0.83. A structure capable of resisting large overturning moments with a single-leg two-layer system is required, but the substructure can be concentrated.	6	Cost ratio: 0.91. As the structures are parallel, it will be a standard configuration, but two substructures are required.	6	Cost ratio: 1.47. It is necessary to consider pile location and depth that do not interfere with the road substructure and tunnel.	4	Cost ratio: 1.20. A structure capable of resisting large overturning moments with a single-leg two-layer system is required, but the substructure can be concentrated.	5	Cost ratio: 1.32. As the structures are parallel, it will be a standard configuration, but two substructures are required.	5	Cost ratio: 2.13. It is necessary to consider pile location and depth that do not interfere with the road substructure and tunnel.	2

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)						Alternative 3 (Blue line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
4		Construction Period (Weight 0.033)	The construction period can be shortened compared with constructing each structure separately.	5	Since full road closure is not possible, one project must be completed before starting the other, resulting in a longer construction period.	2	Independent construction of above-ground (including pile foundation) and underground structures is required, making the construction period longer. Because access to tunneling work is limited, it is difficult to shorten the schedule by increasing work teams.	2	Compared to Alternative 1a, the construction period can be shortened by reducing work on narrow roads.	6	Compared to Alternative 1b, the construction period can be shortened by reducing work on narrow roads.	3	Compared to Alternative 1c, the construction period can be shortened by reducing work on narrow roads.	3	Since work on the critical, narrow Kengeri Ring Rd remains unchanged, the construction period is the same as Alternative 1a.	5	Since work on the critical Kengeri Ring Rd remains unchanged, the construction period is the same as Alternative 1b.	2	Since work on the critical Kengeri Ring Rd remains unchanged, the construction period is the same as Alternative 1c.	2

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)						Alternative 3 (Blue line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
5		Traffic Impact During Construction (Weight 0.033)	At least two-lane traffic restrictions will continue for about four years.	4	At least two-lane traffic restrictions will continue for six years.	3	Road restrictions during metro construction are limited to station areas, but due to elevated construction, two-lane restrictions will continue for about three years.	5	Less construction on narrow roads compared with Alternative 1a, reducing negative traffic impacts.	5	Less construction on narrow roads compared with Alternative 1b, reducing negative traffic impacts.	4	No construction on narrow roads compared with Alternative 1c, reducing negative traffic impacts.	6	Same as Alternative 1a.	4	Same as Alternative 1b.	3	Same as Alternative 1c.	5
		合計		26		25		16		31		31		24		28		28		20
6	Socio-Economic (Weight 0.4)	Passenger Demand (Metro): Number of Stations (Weight 0.067)	8 stations	5	8 stations	5	8 stations	5	7 stations	4	7 stations	4	7 stations	4	8 stations	6	8 stations	6	8 stations	6
7		Passenger Demand (Metro) (Weight 0.067)	Covers dense residential, commercial, and school areas.	3	Covers dense residential, commercial, and school areas.	3	Covers dense residential, commercial, and school areas.	3	Covers densely populated residential areas.	3	Covers densely populated residential areas.	3	Covers densely populated residential areas.	3	Covers part of the university area.	2	Covers part of the university area.	2	Covers part of the university area.	2
8		Traffic Congestion Alleviation Effect (Road) (Weight 0.067)	Contributes to alleviating congestion on the ORR.	3	Contributes to alleviating congestion on the ORR.	3	Contributes to alleviating congestion on the ORR.	3	Contributes to alleviating congestion on the ORR.	3	Contributes to alleviating congestion on the ORR.	3	Contributes to alleviating congestion on the ORR.	3	Partially contributes to alleviating congestion on the ORR.	2	Partially contributes to alleviating congestion on the ORR.	2	Partially contributes to alleviating congestion on the ORR.	2

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)						Alternative 3 (Blue line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
9		Traffic Congestion Alleviation Effect (Road): Number of Ramps (Weight 0.067)	Congestion near ramps.	3.5	Congestion near ramps.	3.5	Congestion near ramps.	3.5	Congestion near ramps.	3.5	Congestion near ramps.	3.5	Congestion near ramps.	3.5	Congestion near ramps.	3.5	Congestion near ramps.	3.5	Congestion near ramps.	3.5
10		Connecting Routes (Weight 0.067)	2 connecting routes (Purple, Phase 3-2)	3.5	2 connecting routes (Purple, Phase 3-2)	3.5	2 connecting routes (Purple, Phase 3-2)	3.5	2 connecting routes (Purple, Phase 3-2)	3.5	2 connecting routes (Purple, Phase 3-2)	3.5	2 connecting routes (Purple, Phase 3-2)	3.5	2 connecting routes (Purple, Phase 3-2)	3.5	2 connecting routes (Purple, Phase 3-2)	3.5		
11		Seamless Traffic Movement (Weight 0.067)	Two-level movement	5	One-level movement	6	One-level movement	6	Two-level movement	5	One-level movement	6	One-level movement	6	Two-level movement	5	One-level movement	6	One-level movement	6
		Total		23		24		24		22		23		23		22		23		23
12	Environmental Impact (Weight 0.4)	Scale of Land Acquisition (Evaluation based on acquired area) (Weight 0.067)	33,025 m²	5	Ratio of route width to Alternative 1a (27m:40m)	3	Ratio of route width to Alternative 1a (27m:25m)	6	59,009 m²	2	Ratio of route width to Alternative 2a (27m:40m)	1	Ratio of route width to Alternative 2a (27m:25m)	2	39,206 m²	4	Ratio of route width to Alternative 3a (27m:40m)	2	Ratio of route width to Alternative 3a (27m:25m)	5
13		Impact on Residential Households (Evaluated by Number of Affected Households) (Weight 0.067)	364 households	5	Ratio of route width to Alternative 1a (27m:40m)	4	Ratio of route width to Alternative 1a (27m:25m)	5	580 households	4	Ratio of route width to Alternative 2a (27m:40m)	4	Ratio of route width to Alternative 2a (27m:25m)	4	232 households	6	Ratio of route width to Alternative 3a (27m:40m)	5	Ratio of route width to Alternative 3a (27m:25m)	6

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)						Alternative 3 (Blue line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
14		Impact on Ecosystems (Flora and Fauna) (Evaluated by Number of Trees Felled) (Weight 0.067)	770 trees	5	Ratio of route width to Alternative 1a (27m:40m)	3	Ratio of route width to Alternative 1a (27m:25m)	5	680 trees	6	Ratio of route width to Alternative 2a (27m:40m)	3	Ratio of route width to Alternative 2a (27m:25m)	6	1,170 trees	3	Ratio of route width to Alternative 3a (27m:40m)	2	Ratio of route width to Alternative 3a (27m:25m)	3

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)						Alternative 3 (Blue line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
15		Noise and Vibration (Weight 0.067)	- Construction: Rated from line length, site width, degree of above-ground construction, and building coverage ratio (4.96) - In service: Rated from line length, attenuation of impact in case of metro undergrounding, and building coverage ratio (4.59) (Scores during construction and in service are integrated at a 3:7 ratio)	5	- Construction (4) - In service (4.59)	4	- Construction (6) - In service (5.23)	5	- Construction (3.93) - In service (5.2)	5	- Construction (3.30) - In service (5.2)	5	- Construction (4.60) - In service (6)	6	- Construction (5.11) - In service (4.71)	5	- Construction (4.10) - In service (4.71)	5	- Construction (4.33) - In service (5.39)	5

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)						Alternative 3 (Blue line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
16		Air Pollution (Weight 0.067)	- During construction: Rated from line length, site width, attenuation of impact in the case of metro undergrounding, and building coverage ratio (4.53) - In service: Rated from line length and building coverage ratio (4.89) (Scores during construction and in service are integrated at a 3:7 ratio)	5	- During construction (3.39) - In service (5.04)	5	- During construction (5.77) - In service (5.04)	6	- During construction (3.30) - In service (6)	6	- During construction (2.55) - In service (6)	5	- During construction (4.11) - In service (6)	6	- During construction (4.70) - In service (5.24)	6	- During construction (3.5) - In service (5.24)	5	- During construction (6) - In service (5.24)	6
17		Landscape (Weight 0.067)	Scored from line length, viaduct height, and building coverage ratio	5		5		5		5		5		6		5		5		5

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)						Alternative 3 (Blue line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
		Total	30		24		32		28		23		30		29		24		30	
Evaluation Results			**Alternative 1 (Orange)**						**Alternative 2 (Red Dashed Line)**						**Alternative 3 (Blue Line)**					
			a. Double-deck Viaduct		**b. Parallel Viaduct**		**c. Metro Underground + Road Overpass**		**a. Double-deck Viaduct**		**b. Parallel Viaduct**		**c. Metro Underground + Road Overpass**		**a. Double-deck Viaduct**		**b. Parallel Viaduct**		**c. Metro Underground + Road Overpass**	
Overall	Evaluation Category	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score
	Design and Construction	0.722	0.144	0.694	0.139	0.444	0.089	0.861	0.172	0.861	0.172	0.667	0.133	0.778	0.156	0.778	0.156	0.556	0.111
	Socio-economic	0.639	0.256	0.667	0.267	0.667	0.267	0.611	0.244	0.639	0.256	0.639	0.256	0.611	0.244	0.639	0.256	0.639	0.256
	Environmental Impact	0.833	0.333	0.667	0.267	0.889	0.356	0.778	0.311	0.639	0.256	0.833	0.333	0.806	0.322	0.667	0.267	0.833	0.333
Total		**Recommended**	**0.733**		**0.672**		**0.711**		**0.728**		**0.683**		**0.722**		**0.722**		**0.678**		**0.700**	

Rating: Relative evaluation on a scale of 1 to 6. A higher score indicates a more favourable alternative.

Source: JST

(3) Section 3: Chowdeshwari Nagar Station to Bel Circle Station

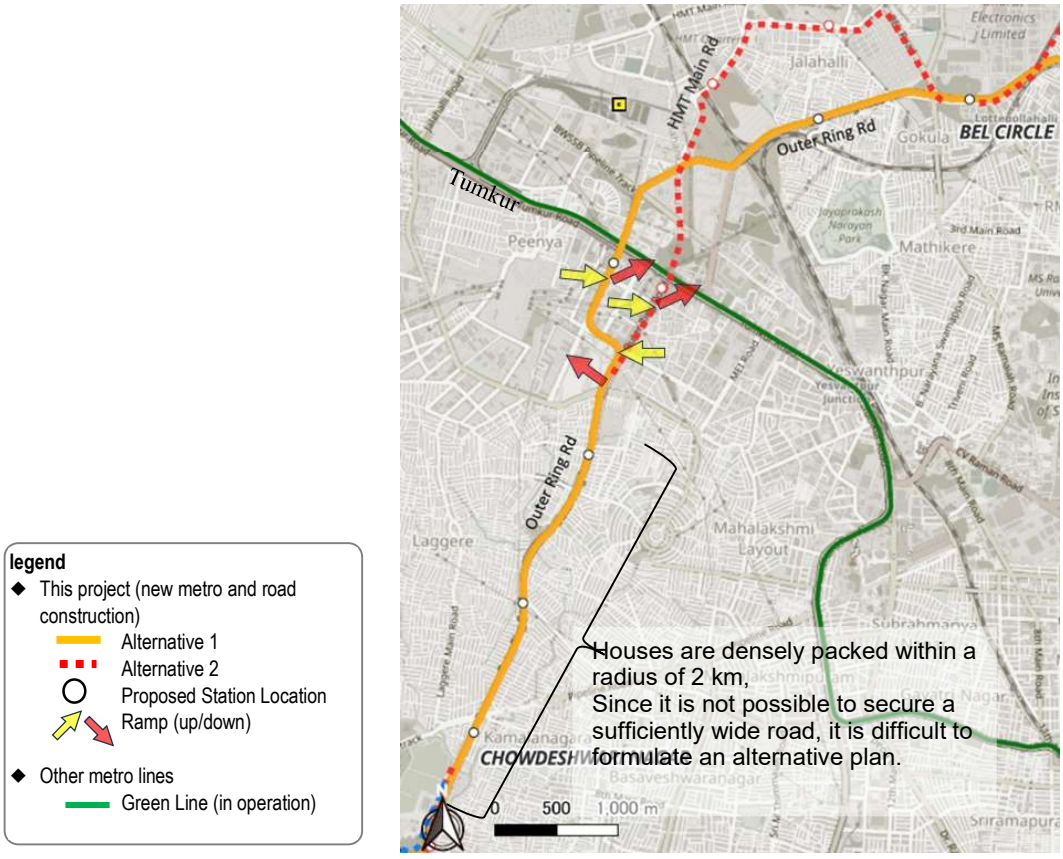
This section connects Chowdeshwari Nagar Station to Bel Circle Station, linking residential, commercial, and industrial areas in northwest Bengaluru. The corridor includes HMT Main Road and the Outer Ring Road, both major arterials. Considering compatibility with existing traffic operations and land use, the following two alternatives were compared.

1) Alternative 1: Outer Ring Road route (Orange): primarily along the Outer Ring Road to Bel Circle Station

- Covers major commercial and industrial areas and can be developed along the main road.
- An elevated structure is readily applicable with relatively limited impacts on existing traffic.
- Land acquisition may be required at certain intersections.

2) Alternative 2: HMT Main Road route (Red): via HMT Main Road to Bel Circle Station

- Expected to improve accessibility for HMT Industrial Park users.
- Some sections have narrow right-of-way; land acquisition may be required.
- Parts of the route traverse green spaces, making land acquisition a concern.



Source: Investigation Team, based on OpenStreetMap data (https://www.openstreetmap.org/copyright/ja)

Figure4-4: Section 3. Route alternatives from Chowdeshwari Nagar Station to Bel Circle Station

Table4-7: Results of the comparative study of alternatives for Section 3 – from Chowdeshwari Nagar Station and Bel Circle Station

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
Design		Length, Number of Stations and Ramps	7.72km, 6 stations, 2 up-ramps and 2 down-ramps						8.60km, 7 stations, 2 up-ramps and 2 down-ramps					
1	Design and Construction (Weight 0.2)	Construction Method Difficulty (Weight 0.033)	A difficult method to construct a tall structure that overtakes the Peenya station on the open Green Line on Tumkur Rd, a main road	6	Same as 1a	6	In the station part, it is necessary to integrate the design of the underground structure and the elevated structure. It is necessary to avoid the impact of underground construction on elevated structures, which requires advanced construction management.	4	The height is reduced because it intersects between Green Line stations, but the intersection between ORR and Tumkur Rd is the west ORR, which is the busiest place, including at night, and the construction of a station at the same point is extremely cumbersome	1	Same as 2a.	1	In addition to Alternative 1c, construction at the intersection of ORR and Tumkur Rd will be extremely cumbersome	1
2		Safety (Double the weighting of other design/construction items) (Weight 0.067)	As structures become taller, it is extremely important to take measures against falling and falling disasters and bad weather (strong winds and lightning)	4	It will be constructed in a narrow space, and it is necessary to pay attention to contact disasters, including against third parties	6	The three-dimensional relationship between the two structures is complex, and the cost of countermeasures to avoid accidents in the tunnel part increases	3	In addition to Alternative 1a, contact disaster countermeasures will be important	3	In addition to alternative 1b, contact disaster countermeasures will be important	4	In addition to Alternative 1c, contact disaster countermeasures will be important	1
3		Construction Cost (Weight 0.033)	The construction cost ratio is 1.00. It requires a structure that can withstand excessive tipping moments with a single leg of two layers, but it is possible to concentrate the undercarriage.	6	The construction cost ratio is 1.10. Since they are parallel, it will be a standard structure, but two undercarriages will be required.	6	The construction cost ratio was 1.78. It is necessary to consider the location and depth of piles that do not interfere with road subconstruction and tunnels.	3	The construction cost ratio was 1.11. It requires a structure that can withstand excessive tipping moments with a single leg of two layers, but it is possible to concentrate the undercarriage.	6	The construction cost ratio was 1.23. Since they are parallel, it will be a standard structure, but two undercarriages will be required.	5	The construction cost ratio is 1.98. It is necessary to consider the location and depth of the piles that do not interfere with the road substructure and the tunnel.	3

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
4		Construction Period (Weight 0.033)	The construction period can be shortened compared to building each structure	6	Since it is not possible to completely close the road, the other project will be started after one project is completed, which will take a long time.	3	It is extremely difficult to proceed with above-ground (including pile foundations) and underground construction at the same time for safety reasons, and each will be constructed independently, which will lengthen the construction period. Since tunnel construction has limited access to work, it is difficult to shorten the construction period by increasing the number of work teams.	3	In addition to Alternative 1a, due to the narrow width of the road, progress at the intersection of ORR and Tumkur Rd is likely to be a critical path and delay the entire process	3	In addition to Alternative 1b, progress at the intersection of ORR and Tumkur Rd is likely to be a critical path and delay the entire process	1	In addition to Alternative 1c, progress at the intersection between ORR and Tumkur Rd is likely to be a critical path and delay the entire process	1
5		Traffic Impact During Construction (Weight 0.033)	At least the two-lane regulation will continue for about 4 years.	5	The two-lane restriction will continue for at least six years.	4	Road regulations at the time of subway construction are limited to the station area, but due to the construction of the overpass, the two-lane regulation will continue for at least three years	6	The adverse traffic impact at the intersection of ORR and Tumkur Rd and in residential areas on the north side of ORR will be greater than Alternative 1a	4	The adverse traffic impact at the intersection of ORR and Tumkur Rd and in the residential area north of the ORR will be greater than that of Alternative 1b	2	The adverse traffic impact at the intersection of ORR and Tumkur Rd and in residential areas north of ORR will be greater than that of Alternative 1c	4
		sum		31		31		22		20		17		11
6	Socio-Economic (Weight 0.4)	Passenger Demand (Metro): Number of Stations (Weight 0.067)	6 stations	5	Same as Alternative 1a	5	Same as Alternative 1a	5	7 stations	6	Same as Alternative 2a	6	Same as Alternative 2a	6
7		Passenger Demand (Metro) (Weight 0.067)	It is well connected with other lines, and demand from industrial complexes and residential areas	4	Same as Alternative 1a	4	Same as Alternative 1a	4	Nodules are inferior to other lines, and access from residential areas is restricted	3	Same as Alternative 2a	3	Same as Alternative 2a	3
8		Traffic Congestion Alleviation Effect (Road) (Weight 0.067)	Contributing to ORR congestion alleviation	4	Same as Alternative 1a	4	Same as Alternative 1a	4	Partly contributed to ORR congestion alleviation	3	Same as Alternative 2a	3	Same as Alternative 2a	3

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
9		Traffic Congestion Alleviation Effect (Road): Number of Ramps (Weight 0.067)	4 Congested near ramp	3.5	Same as Alternative 1a	3.5	Same as Alternative 1a	3.5	4 Congested near ramp	3.5	Same as Alternative 2a	3.5	Same as Alternative 2a	3.5
10		Connecting Routes (Weight 0.067)	1 route (green)	4	Same as Alternative 1a	4	Same as Alternative 1a	4	0 routes	1	Same as Alternative 2a	1	Same as Alternative 2a	1
11		Seamless Traffic Movement (Weight 0.067)	2 level move	4	1 level move	6	1 level move	6	2 level move	4	1 level move	6	1 level move	6
		Total		24.5		26.5		26.5		20.5		22.5		22.5
12	Environmental Impact (Weight 0.4)	Scale of Land Acquisition (Evaluation based on acquired area) (Weight 0.067)	48,271 ㎡	4	Ratio of line width to alternative 1a (27m:40m)	3	Ratio of line width to alternative 1a (27m:25m)	4	32,977 ㎡	6	Ratio of line width to alternative 2a (27m:40m)	4	Ratio of line width to alternative 2a (27m:25m)	6
13		Impact on Residential Households (Evaluated by Number of Affected Households) (Weight 0.067)	408 households	6	Ratio of line width to alternative 1a (27m:40m)	4	Ratio of line width to alternative 1a (27m:25m)	6	744 households	4	Ratio of line width to alternative 2a (27m:40m)	3	Ratio of line width to alternative 2a (27m:25m)	4
14		Impact on Ecosystems (Flora and Fauna) (Evaluated by Number of Trees Felled) (Weight 0.067)	590 bottles	6	Ratio of line width to alternative 1a (27m:40m)	4	Ratio of line width to alternative 1a (27m:25m)	6	850 pieces	4	Ratio of line width to alternative 2a (27m:40m)	3	Ratio of line width to alternative 2a (27m:25m)	4

#	Item for Consideration	Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
15	Noise and Vibration (Weight 0.067)	- At the time of construction: Rating from line length, site width, attenuation of impact in the case of metro undergrounding, building area ratio (4.70) - When in service: Line length, attenuation of impact in the case of metro undergrounding, score from building area rate (5) (Combined scores at the time of construction and service at 3:7)	5	- Under construction (3.5) - In Service (5)	5	- During construction (6) - In Service (6)	6	- Under construction (4.55) - In Service (4.84)	5	- Under construction (3.40) - In Service (4.84)	4	- Under construction (5.79) - In service (5.79)	6
16	Air Pollution (Weight 0.067)	- At the time of construction: Rating from line length, site width, attenuation of impact in the case of metro undergrounding, building area ratio (4.70) - At the time of service: Score from line length and floor area ratio (6) (Combined scores at the time of construction and service at 3:7)	6	- Under construction (3.5) - In Service (6)	5	- During construction (6) - In Service (6)	6	- Under construction (4.55) - In service (5.79)	5	- Under construction (3.40) - In service (5.79)	5	- Under construction (5.79) - In service (5.79)	6
17	Landscape (Weight 0.067)	Scored from line length, viaduct height, and building coverage ratio	5		5		6		5		5		6
	Total		32		26		34		29		24		32

Evaluation results		Alternative 1 (Orange)						Alternative 2 (dashed red line)					
		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		b. Parallel Viaduct		a. Double-deck Viaduct		c. Metro Underground + Road Overpass	
Overall	Evaluation Category	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score	Standardized Score	Weighted Score

#	Item for Consideration	Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
	Design and Construction	0.861	0.172	0.861	0.172	0.611	0.122	0.556	0.111	0.472	0.094	0.306	0.061
	Socio-economic	0.681	0.272	0.736	0.294	0.736	0.294	0.569	0.228	0.625	0.250	0.625	0.250
	Environmental Impact	0.889	0.356	0.722	0.289	0.944	0.378	0.806	0.322	0.667	0.267	0.889	0.356
Total		**Recommended**	**0.800**		**0.756**		**0.794**		**0.661**		**0.611**		**0.667**

Rating: Relative evaluation on a scale of 1 to 6. A higher score indicates a more favourable alternative.

Source: JST

(4) Section 4: From Bel Circle Station to the north end section

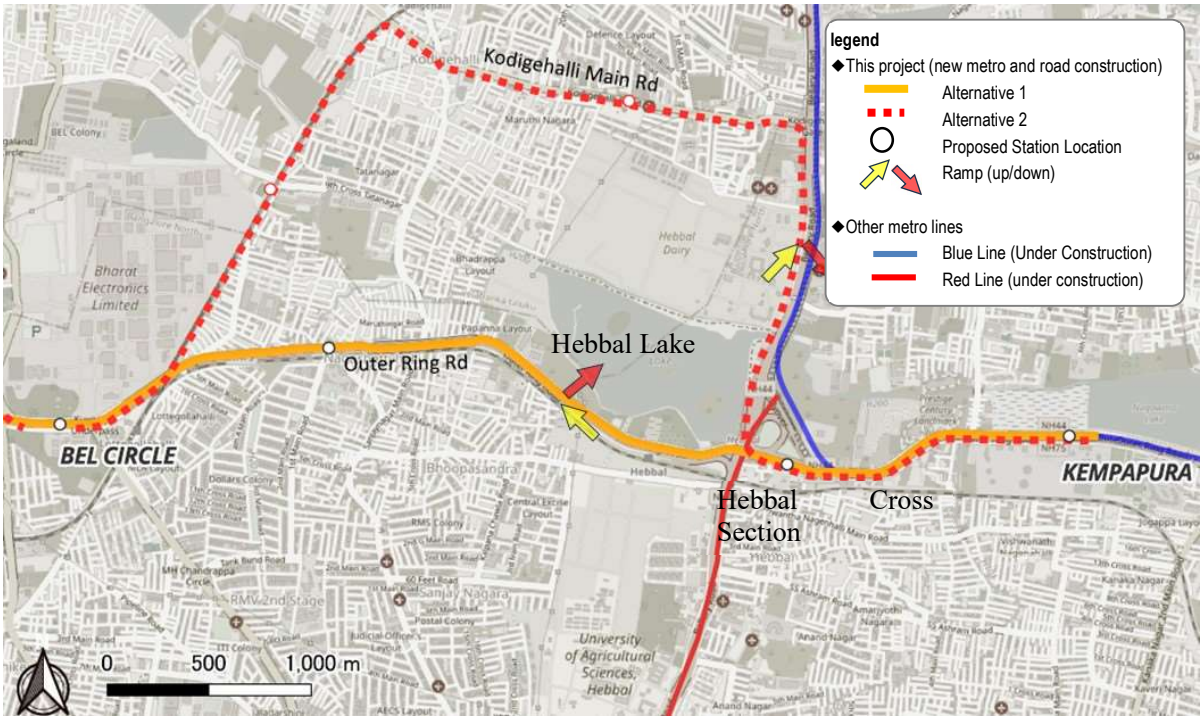
This section connects Bel Circle Station to the northern terminus of Line 3-1, enhancing access to the industrial and commercial areas of northern Bengaluru and surrounding residential zones.
The corridor includes major arterial roads such as the Outer Ring Road, the area around Kempapura, and Bellary Road.
Considering potential impacts on road traffic and the environment, the following two alternatives were compared..

1) Alternative 1 (orange): Route to the northern terminus, mainly following the Outer Ring Road and passing around Kempapura

- Passes through major commercial and industrial areas and can be constructed along existing main roads.
- The elevated structure is relatively easy to apply, with limited impacts on existing traffic.
- The required land acquisition area is small, and environmental impacts are low.

2) Alternative 2 (Red Dashed Line): Route northbound from BEL Circle via Main Road

- Passes through key residential and industrial areas, and the number of potential users is expected to increase.
- Requires a larger land acquisition area, with relatively higher environmental impacts.
- Some sections run parallel to the existing flyover, making land acquisition a potential issue.



Source: Investigation Team, based on OpenStreetMap data (https://www.openstreetmap.org/copyright/ja)

Figure4-5: Section 4. Alignment alternatives from Bel Circle Station to the northern terminus.

Table4-8: Results of the comparative study o alternative study of alternatives for Section 4 - from Bel Circle Station to the north terminus

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
Design		Length, Number of Stations and Ramps	5.40km, 4 stations, 1 up-ramp and 1 down-ramp						8.20km, 5 stations, 1 up-ramp, 1 down-ramp					
1	Design and Construction (Weight 0.2)	Construction Method Difficulty (Weight 0.033)	It will be a higher structure than a general viaduct structure. The superstructure of the special part where the span flies at the grade separation needs to be devised. Requires a structure that can withstand the tipping moment of two layers.	4	The most versatile construction method among the alternatives. 2 Underground work required	6	It is necessary to integrate underground and elevated structures at the station. It is necessary to avoid the impact of underground construction on the overpass. It is necessary to consider the location and depth of the pile that will not interfere with the road substructure and the tunnel. Advanced construction management required	2	In addition to Alternative 1a, the northeast section after Bel Circle Station will be constructed along the national highway, which will be limited by Aseth, and will require protective work on railway facilities. In addition, space-time on Bellary Rd is more difficult than Alternative 1a, which simply intersects.	2	In addition to Alternative 1b, the northeast section after Bel Circle Station will be constructed along the national highway, which will be limited by Asseth and will require protective work on railway facilities. In addition, space-time on Bellary Rd is more difficult than alternative 1b, which simply crosses.	4	In addition to Alternative 1c, the northeast section after Bel Circle Station will be constructed along the national highway, which will require protective work on railway facilities in addition to the constraints of Asseth. In addition, space-time on Bellary Rd is more difficult than alternative 1c, which simply crosses.	1
2		Safety (Double the weighting of other design/construction items) (Weight 0.067)	Since structures become taller, it is extremely important to take measures against falling and falling disasters and bad weather (strong winds and lightning)	4	It will be constructed in a narrow space, and it is necessary to pay attention to contact disasters, including against third parties	6	The three-dimensional relationship between the two structures is complex, and the cost of countermeasures to avoid accidents in the tunnel part increases	3	Compared to Alternative 1a, the more restrictions on construction methods, the more disaster risk will be increased.	3	Compared to Alternative 1b, the risk of disaster increases as restrictions on construction methods increase.	4	Compared to Alternative 1c, the risk of disaster increases as restrictions on construction methods increase.	1
3		Construction Cost (Weight 0.033)	The construction cost ratio is 1.00. It requires a structure that can withstand excessive tipping moments with a single leg of two layers, but it is possible to concentrate the undercarriage.	6	The construction cost ratio is 1.10. Since they are parallel, it will be a standard structure, but two undercarriages will be required.	6	The construction cost ratio was 1.78. It is necessary to consider the location and depth of the piles that do not interfere with the road substructure and the tunnel.	4	The construction cost ratio was 1.52. It requires a structure that can withstand excessive tipping moments with a single leg of two layers, but it is possible to concentrate the undercarriage.	5	The construction cost ratio was 1.67. Since they are parallel, it will be a standard structure, but two undercarriages will be required.	4	The construction cost ratio is 2.70. It is necessary to consider the location and depth of the piles that do not interfere with the road substructure and the tunnel.	2

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
4		Construction Period (Weight 0.033)	The construction period can be shortened compared to building each structure	6	Since it is not possible to completely close the road, the other thing is after the end of one business The project will start and the construction period will be longer.	3	It will be constructed independently, and the construction period will be longer. Since tunnel construction has limited access to work, it is difficult to shorten the construction period by increasing the number of work teams	3	Compared to Alternative 1a, the required process is longer due to construction constraints	4	Compared to Alternative 1b, the required process is longer due to construction constraints	1	Compared to Alternative 1c, the required process is longer due to construction constraints	1
5		Traffic Impact During Construction (Weight 0.033)	At least the two-lane regulation will last for about 4 years	5	The two-lane restriction will last for at least six years	4	Road regulations at the time of subway construction are limited to the station area, but due to the construction of the overpass, the two-lane regulation will continue for at least three years	6	Compared to Alternative 1a, more congestion at the intersection of ORR and Bellary Rd	4	Worse congestion at the intersection of ORR and Bellary Rd compared to Alternative 1b	2	Compared to Alternative 1c, congestion at the intersection of ORR and Bellary Rd will be worse	5
		Total		29		31		21		21		19		11
6	Socio-Economic (Weight 0.4)	Passenger Demand (Metro): Number of Stations (Weight 0.067)	4 stations	5	Same as Alternative 1a	5	Same as Alternative 1a	5	5 stations	6	Same as Alternative 2a	6	Same as Alternative 2a	6
7		Passenger Demand (Metro) (Weight 0.067)	Since the station area is a partial lake, the demand is inferior to that of alternative 2.	2	Same as Alternative 1a	2	Same as Alternative 1a	2	Housing covers dense areas, and demand is expected.	3	Same as Alternative 2a	3	Same as Alternative 2a	3
8		Traffic Congestion Alleviation Effect (Road) (Weight 0.067)	Traffic jam at the Hebbal intersection	1	Same as Alternative 1a	1	Same as Alternative 1a	1	Traffic congestion relief at Hebbal intersection.	2	Same as Alternative 2a	2	Same as Alternative 2a	2
9		Traffic Congestion Alleviation Effect (Road): Number of Ramps (Weight 0.067)	Traffic jam near the ramp	3.5	Same as Alternative 1a	3.5	Same as Alternative 1a	3.5	Traffic jam near the ramp	3.5	Same as Alternative 2a	3.5	Same as Alternative 2a	3.5
10		Connecting Routes (Weight 0.067)	Route 2 (blue red)	3.5	Same as Alternative 1a	3.5	Same as Alternative 1a	3.5	Route 2 (blue red)	3.5	Same as Alternative 2a	3.5	Same as Alternative 2a	3.5
11		Seamless Traffic Movement (Weight 0.067)	2 level move	5	1 level move	6	1 level move	6	2 level move	5	1 level move	6	1 level move	6
		Total		20		21		21		23		24		24

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
12	Environmental Impact (Weight 0.4)	Scale of Land Acquisition (Evaluation based on acquired area) (Weight 0.067)	1,548 ㎡	6	Ratio of line width to alternative 1a (27m:40m)	4	Ratio of line width to alternative 1a (27m:25m)	6	4,000 ㎡	3	Ratio of line width to alternative 2a (27m:40m)	2	Ratio of line width to alternative 2a (27m:25m)	3
13		Impact on Residential Households (Evaluated by Number of Affected Households) (Weight 0.067)	24 households	6	Ratio of line width to alternative 1a (27m:40m)	4	Ratio of line width to alternative 1a (27m:25m)	6	24 households	6	Ratio of line width to alternative 2a (27m:40m)	4	Ratio of line width to alternative 2a (27m:25m)	6
14		Impact on Ecosystems (Flora and Fauna) (Evaluated by Number of Trees Felled) (Weight 0.067)	480 bottles	5	Ratio of line width to alternative 1a (27m:40m)	3	Ratio of line width to alternative 1a (27m:25m)	5	380 bottles	6	Ratio of line width to alternative 2a (27m:40m)	4	Ratio of line width to alternative 2a (27m:25m)	6
15		Noise and Vibration (Weight 0.067)	- At the time of construction: Score from line length, site width, attenuation of impact in the case of metro undergrounding, building area ratio (4.70) - When in service: Line length, attenuation of impact in the case of metro undergrounding, score from building area ratio (5) (Scores during construction and in service are integrated at a 3:7 ratio)	5	- Under construction (3.5) - In Service (5)	5	- During construction (6) - In Service (6)	6	- Under construction (3.44) - In Service (3.63)	4	- Under construction (2.65) - In Service (3.63)	3	- During construction (4.29) - In Service (4.29)	4

#	Item for Consideration	Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
16	Air Pollution (Weight 0.067)	- At the time of construction: Score from line length, site width, attenuation of impact in the case of metro undergrounding, building area ratio (4.70) - When in service: Score from line length and floor area ratio (6) (Scores during construction and in service are integrated at a 3:7 ratio)	6	- Under construction (3.5) - In Service (6)	5	- During construction (6) - In Service (6)	6	- Under construction (3.44) - In Service (3.63)	4	- Under construction (2.65) - In Service (3.63)	3	- During construction (4.29) - In Service (4.29)	4
17	Landscape (Weight 0.067)	Scored from line length, viaduct height, and building coverage ratio	5		5		5		4		4		4
	Total		33		26		35		27		21		27

Evaluation results		Alternative 1 (Orange)						Alternative 2 (dashed red line)					
		a. Double deck viaduct		b. Parallel viaducts		c. Metro underground + road overpass		a. Double deck viaduct		b. Parallel viaducts		c. Metro underground + road overpass	
synthesis	Criterion Classification	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade
	Design and construction	0.806	0.161	0.861	0.172	0.583	0.117	0.583	0.117	0.528	0.106	0.306	0.061
	Socio-economic	0.556	0.222	0.583	0.233	0.583	0.233	0.639	0.256	0.667	0.267	0.667	0.267
	Environmental Impact	0.917	0.367	0.722	0.289	0.972	0.389	0.750	0.300	0.583	0.233	0.750	0.300
sum		**Recommendations**	**0.750**		**0.694**		**0.739**		**0.672**		**0.606**		**0.628**

Rating: Relative evaluation on a scale of 1 to 6. A higher score indicates a more favourable alternative.

Source: JST

4.4.4 Consideration of alternatives to Line 3-2

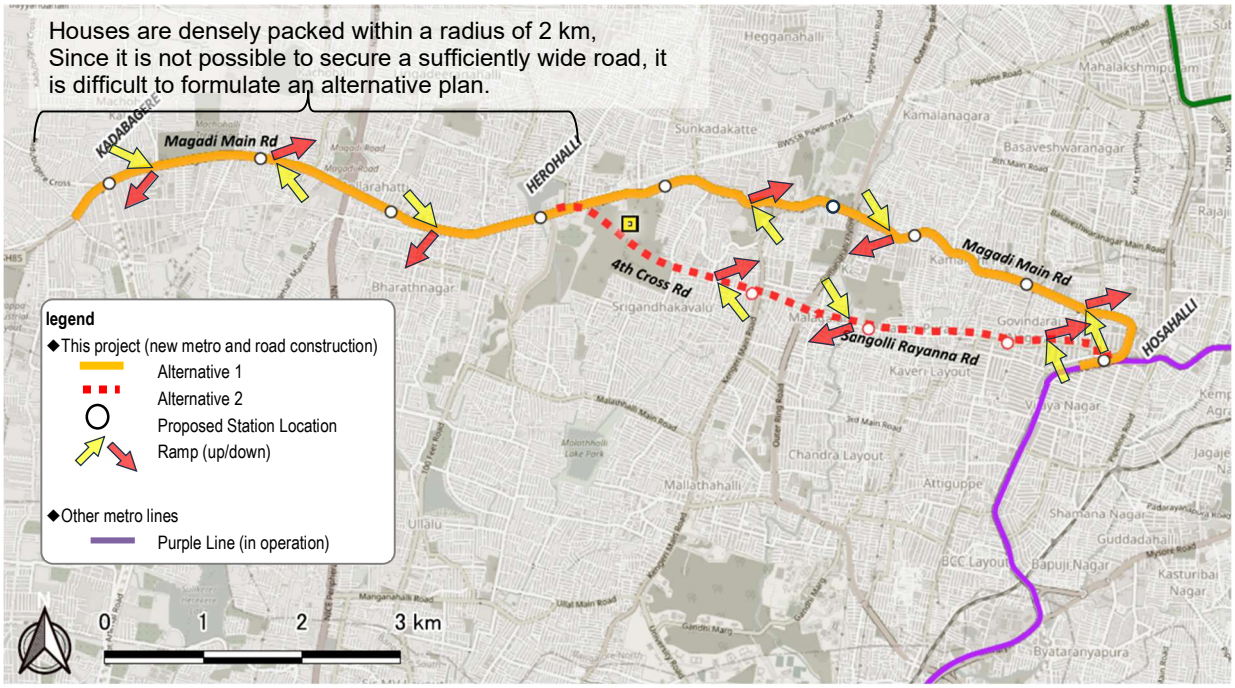
This section begins at Hosahalli and terminates near Kadabagere Cross. It passes through densely populated and congested areas such as southern Basaveshwaranagar, the northern parts of Vijayanagar, Sunkadakatte, and Tavarekere, proceeding to Seegehalli and onwards toward the Kadabagere Cross area. The route also crosses major arterials, including the Outer Ring Road and NICE Road. While taking into account the existing arterial road network and land use, the following two alternatives were compared.

1) Alternative 1 (Orange): Route via Magadi Road and 4th Cross Rd to the western terminus

- Construction is facilitated by utilizing existing major arterial roads.
- Road widening may be required in some sections.
- The route includes relatively many curves, and land acquisition may be necessary at curve points.

2) Alternative 2 (red dashed line): Route via Sangoli Rayanna Rd to the west terminus

- The route passes mainly through residential areas, implying significant land acquisition impacts.
- Some sections traverse dense built-up areas, requiring traffic restrictions during construction.



Source: Investigation Team, based on OpenStreetMap data (https://www.openstreetmap.org/copyright/ja)

Figure4-6: Line 3-2 (Hosahalli Station to Kadabagere Cross section)

Table4-9: 3-Results of the Alternative Proposal for Line 2

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro underground + road overpass		a. Double deck viaduct		a. Double-deck Viaduct		b. Parallel Viaduct	
Design		Length, Number of Stations and Ramps	12.50km, 9 stations, 6 up-ramps and 6 down-ramps						11.70km, 8 stations, 6 up-ramps and 6 down-ramps					
1	Design and Construction (Weight 0.2)	Construction Method Difficulty (Weight 0.033)	At a minimum, 5 m between stations and 10 m at the station area, it is a structure higher than a general viaduct structure. The span flies at the grade separation The superstructure of the special part needs to be devised. Requires a structure that can withstand the tipping moment of two layers.	4	The most versatile construction method among the alternatives. 2 Underground work required	6	It is necessary to integrate underground and elevated structures at the station. It is necessary to avoid the impact of underground construction on the overpass. It is necessary to consider the location and depth of the pile that will not interfere with the road substructure and the tunnel. Advanced construction management required	2	Sharp curves near Hosahalli station can be avoided, but construction will be on narrower roads compared to Alternative 1a. In addition to the need for planning coordination with Sunkadakatte Depot, the site of the depot is located on a hilly area, requiring preliminary development work	1	It will be constructed on a narrower road than Alternative 1b.	4	It will be constructed on a narrower road than alternative 1c.	1
2		Safety (Double the weighting of other design/construction items) (Weight 0.067)	Since structures become taller, it is extremely important to take measures against falling and falling disasters and bad weather (strong winds and lightning)	4	It will be constructed in a narrow space, and it is necessary to pay attention to contact disasters, including against third parties	6	The three-dimensional relationship between the two structures is complex, and the cost of countermeasures to avoid accidents in the tunnel part is large. It will be tight	3	Compared to Alternative 1a, the more restrictions on construction methods, the more disaster risk will be increased.	3	Compared to Alternative 1b, the risk of disaster increases as restrictions on construction methods increase.	4	Compared to Alternative 1c, the risk of disaster increases as restrictions on construction methods increase.	1
3		Construction Cost (Weight 0.033)	The construction cost ratio is 1.00. It requires a structure that can withstand excessive tipping moments with a single leg of two layers, but it is possible to concentrate the undercarriage.	6	The construction cost ratio is 1.10. Since they are parallel, it will be a standard structure, but two undercarriages will be required.	6	The construction cost ratio was 1.78. It is necessary to consider the location and depth of the piles that do not interfere with the road substructure and the tunnel.	3	The construction cost ratio was 0.94. It requires a structure that can withstand excessive tipping moments with a single leg of two layers, but it is possible to concentrate the undercarriage.	6	The construction cost ratio was 1.03. Since they are parallel, it will be a standard structure, but two undercarriages will be required.	6	The construction cost ratio was 1.67. It is necessary to consider the location and depth of the piles that do not interfere with the road substructure and the tunnel.	3

#		Item for Consideration	Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro underground + road overpass		a. Double deck viaduct		a. Double-deck Viaduct		b. Parallel Viaduct	
4		Construction Period (Weight 0.033)	The construction period can be shortened compared to building each structure	6	Since it is not possible to completely close the road, the other thing is after the end of one business The project will start and the construction period will be longer.	3	It will be constructed independently, and the construction period will be longer. Since tunnel construction has limited access to work, it is difficult to shorten the construction period by increasing the number of work teams	3	Compared to Alternative 1a, the required process is longer due to construction constraints	3	Compared to Alternative 1b, the required process is longer due to construction constraints	1	Compared to Alternative 1c, the required process is longer due to construction constraints	1
5		Traffic Impact During Construction (Weight 0.033)	At least the two-lane regulation will last for about 4 years	5	The two-lane restriction will last for at least six years	4	Road regulations at the time of subway construction are limited to the station area, but due to the construction of the overpass, the two-lane regulation will continue for at least three years	6	Compared to Alternative 1a, more congestion at the intersection of ORR and Bellary Rd	4	Worse congestion at the intersection of ORR and Bellary Rd compared to Alternative 1b	2	Compared to Alternative 1c, congestion at the intersection of ORR and Bellary Rd will be worse	5
		Total		29		31		20		20		21		12
6	Socio-Economic (Weight 0.4)	Passenger Demand (Metro): Number of Stations (Weight 0.067)	9 stations	6	Same as Alternative 1a	6	Same as Alternative 1a	6	8 stations	5	Same as Alternative 2a	5	Same as Alternative 2a	5
7		Passenger Demand (Metro) (Weight 0.067)	Some non-residential areas	2	Same as Alternative 1a	2	Same as Alternative 1a	2	Some Purple lines and overlapping and non-residential areas	2	Same as Alternative 2a	2	Same as Alternative 2a	2
8		Traffic Congestion Alleviation Effect (Road) (Weight 0.067)	Low congestion when merging into ORR	2	Same as Alternative 1a	2	Same as Alternative 1a	2	Large congestion when merging into ORR	1	Same as Alternative 2a	1	Same as Alternative 2a	1
9		Traffic Congestion Alleviation Effect (Road): Number of Ramps (Weight 0.067)	Traffic jam near the ramp	3.5	Same as Alternative 1a	3.5	Same as Alternative 1a	3.5	Traffic jam near the ramp	3.5	Same as Alternative 2a	3.5	Same as Alternative 2a	3.5
10		Connecting Routes (Weight 0.067)	Route 2 (purple, Phase 3)	3.5	Same as Alternative 1a	3.5	Same as Alternative 1a	3.5	Route 2 (purple, Phase 3)	3.5	Same as Alternative 2a	3.5	Same as Alternative 2a	3.5
11		Seamless Traffic Movement (Weight 0.067)	2 level move	5	1 level move	6	1 level move	6	2 level move	5	1 level move	6	1 level move	6

#	Item for Consideration		Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
			a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro underground + road overpass		a. Double deck viaduct		a. Double-deck Viaduct		b. Parallel Viaduct	
		Total		22		23		23		20		21		21
1 2	Environmental Impact (Weight 0.4)	Scale of Land Acquisition (Evaluation based on acquired area) (Weight 0.067)	19,777 ㎡	6	Ratio of line width to alternative 1a (27m:40m)	4	Ratio of line width to alternative 1a (27m:25m)	6	45,386 ㎡	3	Ratio of line width to alternative 2a (27m:40m)	2	Ratio of line width to alternative 2a (27m:25m)	3
13		Impact on Residential Households (Evaluated by Number of Affected Households) (Weight 0.067)	436 households	6	Ratio of line width to alternative 1a (27m:40m)	4	Ratio of line width to alternative 1a (27m:25m)	6	1,160 households	3	Ratio of line width to alternative 2a (27m:40m)	2	Ratio of line width to alternative 2a (27m:25m)	3
14		Impact on Ecosystems (Flora and Fauna) (Evaluated by Number of Trees Felled) (Weight 0.067)	1,220 copies	6	Ratio of line width to alternative 1a (27m:40m)	4	Ratio of line width to alternative 1a (27m:25m)	6	1,160 bottles	6	Ratio of line width to alternative 2a (27m:40m)	4	Ratio of line width to alternative 2a (27m:25m)	6
15		Noise and Vibration (Weight 0.067)	- At the time of construction: Score from line length, site width, attenuation of impact in the case of metro undergrounding, building area ratio (4.70) - When in service: Line length, attenuation of impact in the case of metro undergrounding, score from building area rate (5) (Combined score of construction and operation periods in a 3:7 ratio)	5	- Under construction (3.5) - In Service (5)	5	- During construction (6) - In Service (6)	6	- Under construction (4.62) - In Service (4.91)	5	- Under construction (3.44) - In Service (4.91)	4	- Under construction (5.89) - In service (5.89)	6

#	Item for Consideration	Alternative 1 (Orange)						Alternative 2 (Red dashed line)					
		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro underground + road overpass		a. Double deck viaduct		a. Double-deck Viaduct		b. Parallel Viaduct	
16	Air Pollution (Weight 0.067)	- At the time of construction: Score from line length, site width, attenuation of impact in the case of metro undergrounding, building area ratio (4.70) - At the time of service: Score from line length and floor area ratio (6) (Combined score of construction and operation periods in a 3:7 ratio)	6	- Under construction (3.5) - In Service (6)	5	- During construction (6) - In Service (6)	6	- Under construction (4.62) - In service (5.89)	6	- Under construction (3.44) - In service (5.89)	5	- Under construction (5,89) - In service (5.89)	6
17	Landscape (Weight 0.067)	Score from line length, viaduct height, and floor area ratio	5		5		6		5		5		6
	Total		34		27		36		28		22		30

Evaluation Results		Alternative 1 (Orange)						Alternative 2 (Red Dashed Line)					
		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass		a. Double-deck Viaduct		b. Parallel Viaduct		c. Metro Underground + Road Overpass	
synthesis	Criterion Classification	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade	Standardized grade	After aggravation grade
	Design and construction	0.806	0.161	0.861	0.172	0.556	0.111	0.556	0.111	0.583	0.117	0.333	0.067
	Socio-economic	0.611	0.244	0.639	0.256	0.639	0.256	0.556	0.222	0.583	0.233	0.583	0.233
	Environmental Impact	0.944	0.378	0.750	0.300	1.000	0.400	0.778	0.311	0.611	0.244	0.833	0.333
Total		**Recommendations**	**0.783**		**0.728**		**0.767**		**0.644**		**0.594**		**0.633**

Rating: Relative rating of 1-6. The higher the score, the better.

Source: JST

4.5 Comparative Study of Depot Alternatives

4.5.1 Evaluation method for vehicle depot

Alternatives for the vehicle depot and detention line were examined as part of the route recommendation study. The following facility and functional aspects, together with environmental and social considerations, were evaluated as the basic selection criteria.

Among these, "site area" and "efficiency of railway operation" were given greater weight as key parameters for assessing the facilities and functions of the depot, while "resident relocation" was weighted more heavily from the perspective of environmental and social considerations.

Table4-10: Selection criteria and weighting of vehicle depots.

Endpoints		weight	Evaluation content and method
Facilities and Functions	Site area	20	A depot requires a large site to accommodate and maintain railway vehicles and to install facilities for vehicle replacement and cleaning. The site area, the number of vehicles accommodated, and the length of the test run line were scored in proportion to their quantitative values, with the alternative having the largest values given full scores.
	Number of vehicles accommodated	5	
	Commissioning (test run) line length	5	
Connectivity to main line	Efficiency of railway operation (connectivity with main line)	20	To ensure smooth entry and exit of rolling stock between the main line and the depot, it is desirable to locate depots close to the primary routes of the railway network and near terminal stations. Alternatives were scored by experts of this study team, with the alternative judged to have the best connectivity assigned a full score and others rated relative to it.
Environmental and Social Considerations	Private land acquisition	10	Scored based on whether private land acquisition is required and its area. The alternative requiring the least area of private land acquisition was given a full score, and other alternatives were rated proportionally according to the excess area.
	Impact on local residents (based on number of affected structures)	20	Scored according to the number of structures within the candidate site. The alternative with the lowest number of affected structures was given a full score, and other alternatives were scored proportionally according to the excess number.
	Impact on ecosystems (flora and fauna) (based on affected forest land area)	20	nstallation in residential areas, protected zones, or green areas that may be affected by noise, vibration, or ecological disturbance was avoided. The alternative with the least affected forest area was given a full score, and other alternatives were scored proportionally according to the excess area.
sum		100	

* For all evaluation items, a higher score indicates a more favorable alternative.

Source: JST

4.5.2 Comparative study of alternatives for vehicle depots and stabling lines

Five alternative locations were identified as potential sites for vehicle depots under this project. Table4-11 and Figure4-7 show the position of the alternative and the results of the comparative evaluation.

Alternative 1 (Sumanahalli)	Public land near Unani Hospital along Magadi Road (along Routes 3-1 and 3-2)
Alternative 2 (Sunkadakatte)	Public land near Sunkadakatte station along Magadi Road (along Line 3-2)
Alternative 3 (Kachohalli)	Private property along Magadi Road and Highway 48 (along Routes 3-2)
Alternative 4 (Machohalli)	Forest Department public land along Magadi Road (along Routes 3-2)
Alternative 5 (Peenya)	Phase 1 Material yard (public land) near Peenya Depot (along Route 3-1)

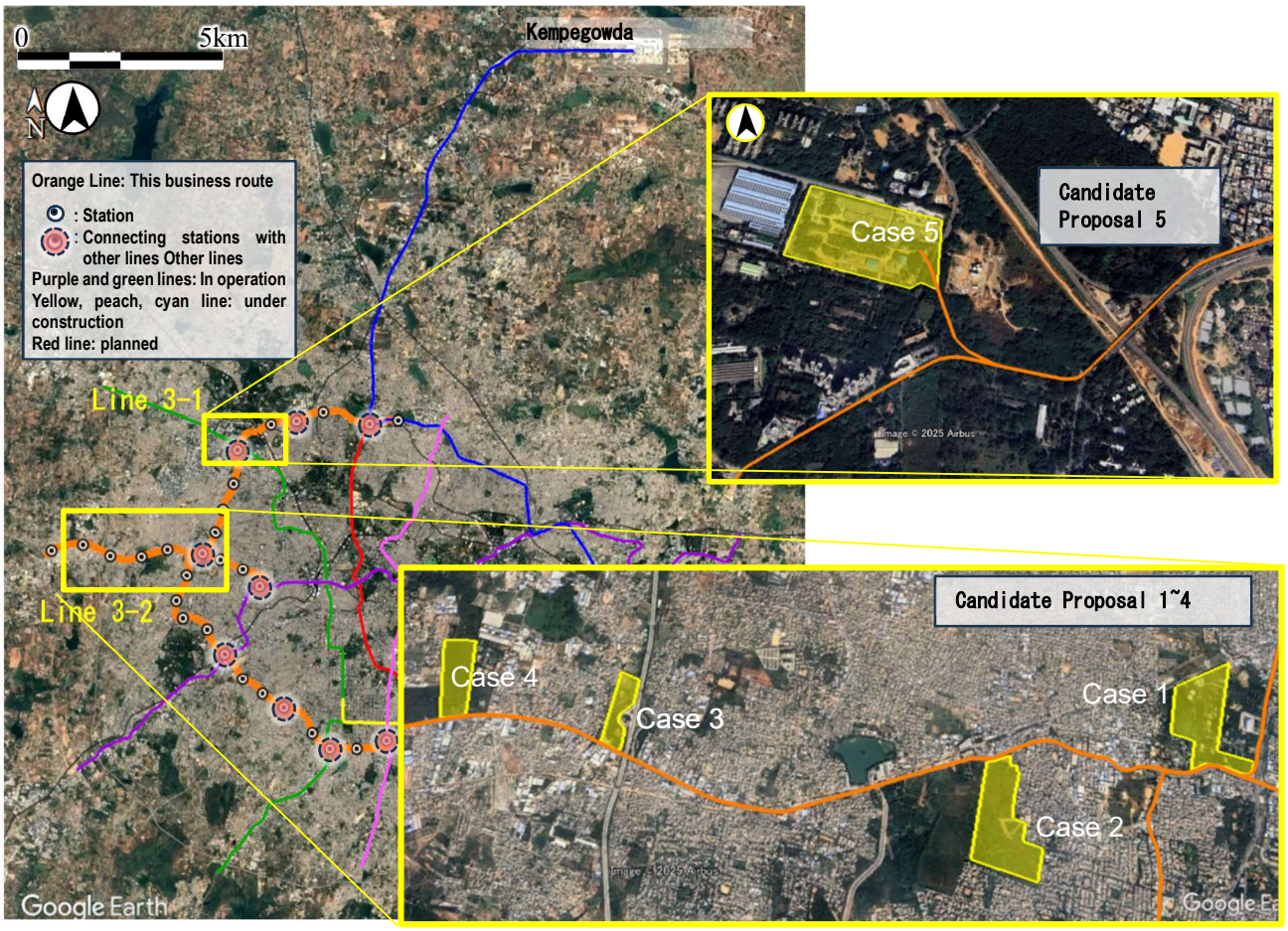
Regarding the “without-project” scenario (i.e., the option of not constructing a dedicated vehicle depot), railway cars would need to be stabled overnight at each station. This would interfere with the maintenance and management of trackside and ground facilities, and regular inspection or servicing of rolling stock could not be carried out properly. As this would significantly hinder the safe and efficient operation of the railway, this option was deemed undesirable and therefore excluded from the table below.

As a result of the comparative evaluation, Alternative 2—public land near Sunkadakatte Station—received the highest overall score in terms of facility functions and environmental and social considerations, and was therefore selected as the recommended alternative.

Table4-11: Results of the Comparative Study of Vehicle Depot Alternatives

No.	Considerations	Assignment	Alternative 1 Sumanahalli		Alternative 2 Sunkadakatte		Alternative 3 Kachohalli		Alternative 4 Machohalli		Alternative 5 Peenya	
Facilities and Functions												
1	Site area	20	Approx. 26.25 ha	17	Approx. 30.70 ha	20	Approx. 9.41 ha	6	Approx. 16.15 ha	11	Approximately 6.63ha	4
2	Number of vehicles accommodated	5	About 38 formations	5	About 38 formations	5	About 12 formations	2	About 16 formations	2	About 6 formations	1
3	Commissioning line length	5	Maximum length: approx. 780 m	5	Maximum length: approx. 800 m	5	Maximum length: approx. 550 m	3	Maximum length: approx. 550 m	3	Maximum length: approx. 300 m	2
Connectivity to the main line												
4	Connectivity to the main line	20	It is located adjacent to both Lines 3-1 and 3-2, but it is too close to the elevated Sumanahalli Cross station, so there is no gradient section connecting the depot and the main line	10	Although it is along Line 3-2, it is also close to Line 3-1, so it is suitable as a vehicle reception base for both lines because it is connected by providing a gradient section from the elevated Sumanahalli Cross station	20	It is far from Line 3-1 and is not suitable as a base to accommodate vehicles operating on Line 3-1.	1	It is far from Line 3-1 and is not suitable as a base to accommodate vehicles operating on Line 3-1	1	It is far from Line 3-2 and is not suitable as a base to accommodate vehicles operating on Line 3-2.	1
Environmental and Social Considerations												
5	Private land acquisition	10	There is no land acquisition because it is public land.	10	There is no land acquisition because it is public land.	10	Because it is private land, it is necessary to acquire about 9.41 ha of land.	1	There is no land acquisition because it is public land.	10	There is no land acquisition because it is public land.	10
6	Impact on local residents (scored from the number of affected structures)	20	About 19 items	5	About 5 items	20	About 8 cases	13	About 5 items	20	About 5 items	20
7	Impact on ecosystems (flora and fauna) (scored from affected forest land area)	20	Approx. 10.91 ha	3	Approx. 13.23 ha	3	Approx. 3.5 ha	9	Approx. 13.08 ha	3	Approx. 1.66 ha	20
sum		**100**		**55**	**Recommended**	**83**		**35**		**50**		**58**

Source: JST



Source: JST created based on OpenStreetMap (https://www.openstreetmap.org/copyright/ja) from information from DPR

Figure4-7: Location map of the depot alternative

5. Scoping

In this section, the screening and scoping proposals are summarized based on the information obtained from field surveys and existing literature, assuming positive and negative environmental and social impacts.

5.1 Scoping: types and scale of project impacts

The expected impact on the natural and social environment of the implementation of this project and the reasons for its evaluation are shown in the following table. The items were examined by adding items that were considered necessary based on the content and situation of the project to the "railway" and "road" items in the environmental checklist of the JICA guidelines. In the evaluation, the proposal recommended in the alternative consideration in the preceding paragraph was conducted.

Table5-1: Items expected to be affected by this project (including vehicle depots) and why.

SN	Impact Project (JICA Project)	Evaluation		Reasons for evaluation
		Before construction Under construction	During operation	
Pollution				
1.	Air pollution	✓	✓	**During construction**: The operation of construction-related vehicles and machinery on the construction site is expected to generate exhaust gases (nitrogen oxides (NOx) and particulate matter (PM)) and dust, which is expected to temporarily deteriorate air quality. In addition, temporary air pollution is expected due to the traffic of construction-related vehicles and the operation of heavy machinery along the access roads and at ancillary construction facilities such as the batching plant. **During operation:** Overall, the elimination of congestion around the project area is expected to have a positive impact on air quality, however, increased traffic volume around stations and expressway ramps (approach and exit roads) may have localized negative impacts on air quality.
2.	Water pollution	✓	✓	**During construction:** Surface and groundwater along the project route may be affected by the outflow of waste and untreated construction wastewater from the construction site, and by the generation of turbid water in the cut and cover sections. When a base camp or worker's accommodation is established, organically contaminated water may flow in, deteriorating the water quality. **During operation:** There is a possibility that untreated organic polluted water and general waste will flow into the toilets installed in stations and depots, and that chemical substances will leak, which may have a negative impact on water quality.
3.	Waste Management	✓	✓	**During construction:** It is expected that construction waste, such as construction soil and felled trees, as well as hazardous and dangerous waste, will be generated. There is a possibility that general waste and human waste will be generated from the base camp. **During operation:** There is a possibility that general waste and human waste will be generated from stations, depots, etc.
4.	Soil contamination	✓	✓	**During construction:** There is a possibility that the surrounding soil may be contaminated by oil leaks from heavy machinery and construction vehicles, leaks of chemicals, excavation, etc. The soil excavated at the construction site may be contaminated with heavy metals, etc., which may spread to the surrounding area. **During operation:** There is a possibility of soil contamination due to coating agents applied to vehicles during maintenance work at rail depots and along tracks and structures, or oil leaks from running vehicles.
5.	Noise and vibration	✓	✓	**During construction:** Noise and vibration will be generated due to the operation of construction vehicles/machinery, concrete pouring, and traffic congestion caused by traffic restrictions, which may affect sensitive areas in the surrounding area (residents, schools, hospitals, religious facilities, wildlife, etc.). **During operation:** The opening of the metro line under this project is expected to reduce traffic volume in the surrounding area, which is expected to reduce noise and vibration from road traffic. However, increased traffic volume around stations and on expressway ramps, as well as noise and vibration from metro operation, may have an impact on sensitive areas in the surrounding area.

SN	Impact Project (JICA Project)	Evaluation		Reasons for evaluation
		Before construction Under construction	During operation	
6.	Land subsidence	✓	✓	**During construction:** Because the entire line will be constructed using an elevated method, large-scale excavation work like that required for subways will not be required, and the risk of ground subsidence is relatively small. However, if the construction area has soft ground, there is a risk of ground subsidence due to the excavation work required for viaduct construction.
7.	Odor	✓	✓	**During operation:** If there is soft ground, there is a risk of ground subsidence due to the weight of the viaduct. **During construction:** There is a possibility of bad odors being generated due to improper management of general waste and human waste generated at the base camp.
Natural Environment				
8	Protected Areas			**During construction:** The nearest protected area (Bannerghattta National Park) is more than 7 km from the construction alignment. No impact on the protected area is expected due to construction. **During operation:** No impact on the protected area is expected from train or vehicle traffic.
9	Ecosystems	✓	✓	**During construction:** The construction of station buildings, structures, and depots will involve the alteration of vegetation through the filling and cutting of soil, tree felling, and other such activities, as well as pollution caused by construction activities, which may have an impact on the ecosystem, including endangered, endemic, and rare species and their habitats. **During operation:** Ecosystem values may continue to decline due to habitat loss, fragmentation, and edge effects.
10	Hydrology	✓	✓	**Under construction:** - Waste and soil generated during construction work may obstruct the flow of drainage water, and if no drainage facilities are available, this could cause localized flooding. Heavy rainfall due to monsoons or unusually heavy rains may exceed the drainage capacity of drainage facilities, causing localized flooding. This may damage construction activities and pose a threat to the safety of workers. **During operation:** There is a possibility of localized flooding due to insufficient drainage capacity caused by higher than expected rainfall.
11	Topography and Geology	✓		**Under Construction:** The terrain will be changed by raising the ground to standardize the elevation difference of the depot and install highway ramps. **During operation:** There will be no train operations or maintenance work that is expected to have an impact on the topography or geology.
Social Environment				
12	Land acquisition and resident relocation	✓		**Before construction:** According to the plan, approximately 248.698 m of land would need to be acquired for station intervals, stations, ramps, etc., resulting in the loss of approximately 1,592 structures, including homes and shops, and affecting approximately 3,009 households. **During operation:** No land acquisition is expected during operation.

SN	Impact Project (JICA Project)	Evaluation		Reasons for evaluation
		Before construction Under construction	During operation	
13	Livelihoods and Economic Activities	✓	✓	**Pre-construction and construction:** - Physical and economic relocation may adversely affect the current livelihoods and business income of affected individuals. Traffic restrictions caused by construction activities may temporarily adversely affect the income of businesses located along the route. - Meanwhile, the construction work is expected to have a positive impact on the local economy by providing employment opportunities and local demand. This could have a negative impact on unregulated development and the use of local resources. **During operation:** The metro project will create employment opportunities, stimulate economic activity around stations, reduce travel time within the city, and ease congestion, which is expected to have a positive impact on the local economy. On the other hand, the opening of the metro will reduce demand for buses and rickshaws, which are overlapping means of transportation, "Drivers could lose their jobs.
14	Socially Vulnerable Groups	✓	✓	**During construction:** There is a possibility that the People Affected by Projects (PAPs) may include socially vulnerable people, whose lives and livelihoods will deteriorate and it is expected that it will take time for them to recover to pre-project levels. In addition, the opinions and concerns of socially vulnerable people and women may not be reflected in the project plan, design, or construction plan, and they may be left out of opportunities to receive equal benefits from the project, such as compensation and assistance, employment opportunities, wages, and treatment. **During operation:** Lack of consideration for socially vulnerable people and gender mainstreaming as railway users1 may discourage metro users and create inequality.
15	Cultural Heritage	✓	✓	**Before/during construction:** No impacts are anticipated with the current alignment, but there is a possibility that vibration levels will temporarily increase around the access roads and ancillary facilities, which may affect cultural heritage sites. In addition, once the alignment and ancillary facilities that may newly identify cultural heritage sites within the project's impact area are finalized, we will reconfirm whether there will be any impacts. **During operation**: No new land acquisition will be required during operation, so no impact is expected. We will check whether there is any impact from vibrations caused by the metro and trains running.
16	Landscape and Visual Impact	✓	✓	**Construction Phase:** Poor site cleanliness and waste management may cause temporary negative impacts to local residents and visitors. **During operation:** The project area is planned to be constructed along existing roads in the city. The elevated tracks and station buildings will be constructed higher than the existing structures, which may alter the existing landscape characteristics and have a negative visual impact.
17.	Ethnic Minorities and Indigenous Peoples	✓	✓	**During construction:** There are no “Scheduled Areas” in Karnataka established under the Constitution of India to protect the habitation and livelihood rights of Scheduled Tribes (ST), and no affected residents corresponding to “Indigenous Peoples” as defined in the JICA Guidelines have been identified. The potential existence of Scheduled Tribe households and the risk of construction impacts will be assessed through social and RAP surveys. **During operation:** No activities that may affect Scheduled Tribes are envisaged.

SN	Impact Project (JICA Project)	Evaluation		Reasons for evaluation
		Before construction Under construction	During operation	
18.	Existing Social Infrastructure and Services	✓	✓	**During construction:** Land acquisition and traffic restrictions during construction may have adverse impacts on schools, hospitals, and religious facilities. Construction work is expected to result in temporary impacts due to the use of water and electricity in excess of the supply, as well as the relocation of infrastructure for daily life. **During operation:** The establishment of the station is expected to improve accessibility, which may have a positive impact on the use of social infrastructure such as schools and hospitals.
19.	Labor Conditions (incl. Occupational Safety)	✓	✓	**Under construction:** "Negative impacts on construction workers, such as occupational accidents and health and safety, are expected due to insufficient consideration for the working environment and non-compliance with laws and regulations. In addition, whether non-compliance with laws and regulations is anticipated will be assessed after confirming the local situation during on-site surveys. **During operation:** Negative impacts on employees are expected due to insufficient consideration of the working environment, such as occupational accidents and health and safety.
20.	Community Health, Safety, and Security	✓	✓	**During construction:** There is a possibility of increased traffic accidents between construction vehicles and pedestrians on major roads and at construction site entrances. Accidents caused by unauthorized entry of outsiders into construction sites or hazardous areas may also occur. The influx of construction workers may lead to the spread of infectious diseases such as STDs. Land alteration through cutting and filling may create new habitats for mosquitoes that can transmit malaria. In addition, the inflow and increase of workers may raise the risk of gender-based violence (GBV) and sexual exploitation and abuse (SEA) within local communities. **During operation:** Increased traffic volume around stations and expressway ramps may lead to more traffic accidents. A rise in settlers and tourists may also increase the spread of infectious diseases such as STDs. Elevated viaduct structures may pose risks of infringing on the privacy of nearby residents.
Others				
21.	Transboundary Impacts and Climate Change	✓	✓	**During construction:** Greenhouse gas absorption will be reduced due to tree cutting, and greenhouse gases will be generated due to the operation of construction machinery and vehicles, as well as the construction of structures. Once in **operation**, traffic volume will increase around stations and expressway ramps, electricity consumption due to metro train operations will increase, and there is a possibility that greenhouse gas emissions will increase locally. However, the opening of the metro covered by this project will reduce traffic volume on roads along the line and ease congestion, which is expected to result in a reduction in greenhouse gas emissions throughout the project area.

Note: ✓ Investigation required, blank: No investigation required (however ✓, items whose evaluation is unknown at this time are also included.) ）

Source: JST

6. TOR for Baseline Surveys

The TOR of the baseline survey conducted in this study is shown below.

6.1 ESIA Survey

As mentioned above, based on the survey already conducted by BMRCL, the baseline survey and its analysis method to be conducted as a complement to this preparatory study are shown below. For Routes 3-1 and 3-2, a dry season survey has already been conducted by BMRCL, so a supplementary survey was conducted to the rainy season survey of the unconducted environmental items. In addition, residents' councils were held at the scoping and DFR stages.

Table6-1: Baseline survey and impact assessment methods

No.	Impact Projects	Survey Items	Survey Methodology
Pollution Countermeasures			
1	air pollution	(1) On-site survey (1) Survey points: 27 points along the tracks of Bengaluru Metro Lines 3-1 and 3-2 (2) Items: SO_2, CO, NO_2, O_3, PM_{10}, $PM_{2.5}$ (3) Frequency: 24-hour survey once per rainy and dry season (except for rainy days) Note: BMRCL (commissioned by Monarch) has already conducted a similar atmospheric survey from January to April 2025 (dry season) and will use the results. (2) Impact assessment during construction and service	(1) Comparison of survey results with existing survey results and baseline values (2) Confirm the content, construction method, period, scope, type of construction machinery, operating position, operating engine, number of construction vehicles, duration, and travel route of the construction as much as possible.
2	water pollution	(1) On-site survey <u>Surface water</u> (1) Survey points: A total of 14 points, including drainage channels and rivers along the tracks of Bengaluru Metro Lines 3-1 and 3-2 (2) Items: Chromaticity, Odor, Turbidity, pH, Electrical Conductivity, Total Hardness, Chloride Compounds, Iron, Total Dissolved Solids, Sulfates, Nitrates, Lead, Copper, Manganese, Mercury, Cadmium, Zinc, Hexavalent Chromium, Total Alkalinity, Calcium, Magnesium, Sodium, Potassium, Dissolved Oxygen, BOD、COD (3) Frequency: Once per rainy season and dry season Note: BMRCL (commissioned by Monarch) has already conducted a similar water quality survey from January to April 2025 (dry season) and will use the results. In this survey, we will conduct rainy season surveys at all 14 locations. <u>groundwater</u> (1) Survey points: 27 points along the tracks of Bengaluru Metro Lines 3-1 and 3-2 (2) Items: Color, odor, taste, turbidity, pH, chloride compounds, iron, total dissolved solids, sulfates, nitrates, fluoride, lead, copper, manganese, phenolic compounds, mercury, cadmium, arsenic, cyanide, zinc, cleaning agents, hexavalent chromium, total alkalinity, aluminum, boron, coliform bacteria, Escherichia coli (3) Frequency: Once per rainy season and dry season Note: BMRCL (commissioned by Monarch) has conducted a similar water quality sample survey from January to April 2025 (dry season) and will use the results. (2) Effects during construction and service	(1) Comparison of survey results with existing survey results and baseline values (2) Confirm the content, construction method, period, scope, type of construction machinery, operating position, operating engine, number of construction vehicles, duration, and travel route of the construction as much as possible.
3	waste	How to dispose of construction waste Note: The construction waste disposal site currently in use has been identified.	Collect information on registered construction waste disposal sites around the project site or conduct on-site surveys in some cases. In

No.	Impact Projects	Survey Items	Survey Methodology
			addition, interviews and quantitative forecasts on waste disposal results to relevant ministries and agencies
4	soil pollution	(1) On-site survey (1) Survey points: 27 points along the line (2) Item: pH, electrical conductivity, lead, mercury, cadmium, arsenic, cyan, hexavalent chromium (3) Frequency: 1 time Note: BMRCL (commissioned by Monarch) has conducted a similar soil survey from January to April 2025 (dry season) and will use the results. (2) Impact assessment during construction and service	(1) Comparison of survey results with existing survey results and baseline values (2) Hearing with BMRCL
5	Noise and vibration	(1) On-site survey (1) Survey points: Noise: 27 points along the line Vibration: 27 points along the line (2) Item: Environmental noise (LAeq, 24 hours continuous/weekdays) Environmental vibration (24 hours/weekdays) *Scheduled to be held at 1-5 points in front of other susceptible target structures (villages, schools, hospitals, etc.) (3) Frequency: 1 time (dry season) (2) Noise and vibration levels during construction and service in representative sections (3) Impact assessment during construction and service	(1) Comparison of survey results with existing survey results and baseline values (2) Noise: Quantitative prediction (Traffic noise on road boundaries and points requiring consideration on typical elevated sections / LAeq dB(A)) Vibrations: Quantitative prediction (Traffic vibration on the road boundary of typical underground sections and at points that require consideration / Lv dB) (3) Confirm the content, construction method, period, scope, type of construction machinery, operating position, operating engine, number of construction vehicles, period, and travel route as much as possible.
6	Ground subsidence	Impact assessment during construction and service	Topographic survey at the time of design, analysis of ground survey results and hearing to BMRCL
7	stink	Effects during construction and service	Assessment of odor risk based on base camp and station and depot design.
Natural environment			
8	protected areas	Identification of critical habitats Identify critical habitats within a 10km radius of the project's planned route, clarify locations and boundaries. Eligible Regions: Internationally designated or recognized protected areas Important Biodiversity Areas (KBAs) Important Bird and Biodiversity Conservation Areas (IBAs) Ramsar Convention Wetlands World Natural Heritage Sites UNESCO Man and the Biosphere (MAB) Reserve Protected Areas by Indian National Law	Identification of protected areas (national law), Key Biodiversity Area, International Protected Areas (World Natural Heritage Sites, Ramsar Wetlands, UNESCO MAB Biosphere Reserve) and Important Bird Areas within 10 km of the project site (track and depot).
9	ecosystem	(1) Distribution of flora and fauna and inventory of endangered species List and inventory species in the study area, and check the distribution of flora and fauna. In particular, the endangered species that live in the Bengaluru metropolitan area listed below will be confirmed for their habitat, breeding, and nesting in the surveyed area. Regions surveyed: 100 meters range on both sides of the planned alignment	(1) Identification of important habitats Identification and mapping of geographic information using GIS analysis and map data. Comparative analysis with existing protected area databases (KBA, IBA, Ramsar wetlands, etc.). (2) Distribution of plants and animals and inventory of endangered species

No.	Impact Projects	Survey Items	Survey Methodology
		Planned depot and detention line (2 locations) (2) Project impact assessment Assess impacts on identified critical habitats. Assess the impact on flora and fauna identified in the affected area. *Endangered species living in the Bengaluru metropolitan area (see eBird, iNaturalist, etc.) mammal Bonnet Macaque (*Macaca radiata*) – VU (Critically Threatened) Indian leopard (*Panthera pardus*) – VU (Critically Threatened) Asian elephant (*Elephas maximus*) – EN (endangered species) birds Asian snake (*Anhinga melanogaster*) – NT (Near-Endangered) Cosibeni Pelican (*Pelecanus philippensis*) – NT (Near-Endangered) Kingswallow (*Sterna aurantia*) – VU (Critically Threatened) Asian woolly-necked stork (Ciconia episcopus) – VU (Critically endangered) Butterfly (*Phylloscopus tytleri*) – NT (Near-Endangered) Yellow-tailed hawk (*Aquila rapax*) – VU (Critically Threatened) Red-bellied (*Falco chicquera*) – NT (Near-Endangered) *Circus macrourus* – NT (Near-Endangered) Chabane kingfisher (*Pelargopsis amauroptera*) – NT (Near-Endangered) Blue-tailed hawk (*Clanga clanga*) – VU (Critically Threatened) reptile Numa crocodile (*Crocodylus palustris*) – VU (Critically Threatened) Indian python (*Python molurus*) – NT (Near-Endangered) Bengal monitor lizard (*Varanus bengalensis*) – NT (Near-Endangered) Indian soft-shelled turtle (*Lissemys punctata*) – NT (Near-Endangered) Indian tortoise (*Geochelone elegans*) – VU (Critically endangered) Anacondaboa (*Eryx conicus*) – NT (Near-Endangered) Trees and Plants Indian Sandalwood (*Santalum album*) – VU (Critically Endangered) Malabar Kino (*Pterocarpus marsupium*) – NT (Near-Endangered) White Meranti (*Shorea roxburghii*) – VU (Critically Threatened) Ceylon ironwood (*Mesua ferrea*) – NT (Near-Endangered) Akami (*Pterocarpus santalinus*) – EN (Endangered Species)	Field surveys (visual surveys, auditory surveys, camera trap surveys). Utilization of secondary data (including databases such as eBird and iNaturalist, academic papers, and interviews with experts). Habitat and population data collection (identification of breeding and nesting sites) For endangered species that are likely to live in the business site, we conducted interviews with residents around the business site after showing photos of the same species (3) Project impact assessment Quantitative and qualitative analysis. (4) Survey frequency: 2 field surveys (rainy season, dry season)
10	Survey of every tree	(1) On-site survey (1) Survey area: Confirmation of tree species and number of trees to be relocated or cut down due to construction work (construction of tracks, stations, and depots) (2) Item: Number of trees by tree species and IUCN category (3) Frequency: 1 time Note: Location information is also included for tree species with an IUCN category of NT or higher (including NT, VU, CR, EN) (see the list of endangered species above). Also, interview with experts if necessary	Utilization of existing survey data, on-site surveys, and interviews with BMRCL

No.	Impact Projects	Survey Items	Survey Methodology
	Water sign	Collection of existing rainfall data (e.g., Indian Meteorological Department (IMD)) Confirmation of existing drainage facilities (culverts, open drains, etc.) in the project area and understanding of drainage capacity (drawings and on-site surveys) Literature review on inundation history and past flood occurrence cases (including BBMP, KSPCB, etc.) Prediction of temporary runoff changes during construction and service using surface runoff models (using simple hydrologic models)	Utilization of existing survey data, on-site surveys, and interviews with BMRCL
12	Topography and geology	Impact during construction	Utilization of the results of the conducted topographic survey and underground ground survey, and interviews with the BMRCL
Social Environment			
13	Land acquisition and involuntary resettlement	(1) Scope of survey: Business site (ROW 27m), construction ancillary facilities, and local communities along the line (2) Items: Scope of affected land, number of affected structures, number of affected households and affected people, affected trees, grains, etc. (3) Frequency: 1 time	Results of census surveys, land and asset surveys, etc., results of the implementation of residents' councils
14	Life and livelihood	(1) Scope of survey: Project area (business site, local community where construction ancillary facilities are located, and local community along the line) (2) Item: Impact on the local economy, such as employment and livelihoods, impact on affected people, and impact on other modes of transportation (3) Frequency: 1 time	Existing data, interview survey results, socio-economic survey results, residents' councils and FGD implementation results
15	Socially vulnerable	(1) Scope of survey: Business site (ROW 27m), local community where construction facilities are located, and local community along the line (2) Items: Scope of affected land, number of affected structures, number of affected households and affected people, affected trees, grains, etc. (3) Frequency: 1 time	Utilization of interview survey results and social impact survey results, results of FGD implementation with residents' councils
16	cultural heritage	(1) Survey area: Radius of about 300m along the line (2) Location, distribution, and protection of cultural and historical heritage in the vicinity of the project target area (3) Frequency: 1 time	Utilization of existing data and results of interviews with relevant ministries and agencies
17	scenery	(1) Scope of survey: business area, nearby viewing points, etc. (2) Item: Current landscape components (3) Frequency: 1 time	Field surveys, results of residents' councils, etc.
18	Ethnic minorities and indigenous peoples	(1) Survey area: Radius of about 300m along the line (2) Location, distribution, and protection of cultural and historical heritage in the vicinity of the project target area (3) Frequency: 1 time	Literature Survey, Census Survey Results, If the existence of indigenous peoples is confirmed, we will support the preparation of indigenous peoples plans based on the "JICA Guidelines for Environmental and Social Considerations (2022)".
19	Existing social infrastructure and social services	(1) Survey area: Radius of about 200m along the line (2) Items: (1) Social infrastructure: location and distribution of hospitals, schools, religious sites, community centers, etc., (including interviews),	Utilization of existing data, interviews with service providers, on-site surveys, and interview survey results

No.	Impact Projects	Survey Items	Survey Methodology
		(2) Basic infrastructure: location and distribution of aboveground and underground buried objects, service providers, supply volume, etc. (3) Frequency: 1 time	
20	Working environment	(1) Scope of investigation: country, state, business (2) Items: Confirmation of relevant laws in India, confirmation of international standards, confirmation of occupational accidents, safety measures, and working environment at construction sites (3) Frequency: 1 time	Literature research, information gathering, site inspection and interview
21	Community Health, Safety and Security	(1) Scope of investigation: country, state, business (2) Items: Number of accidents along the railway line and the reason for the accident, the rate of infectious diseases in the vicinity of the project target area, and the risk of spreading infectious diseases such as STDs due to the influx of construction workers. (3) Frequency: 1 time	Survey of existing materials and field surveys. Where possible, interviews with police stations and local governments in the jurisdiction, and use existing data and interview survey results
Other			
28	The impact of cross-border and climate change	(1) Scope of survey: Business area (2) Item: Calculation of greenhouse gas generation and reduction from this project (3) Frequency: 1 time	Calculation of greenhouse gas reductions by collecting data, interviews with BMRCL, and application of JICA Climate FIT (mitigation measures)

Source: JST

7. Baseline Survey Results

The result of survey and analysis conducted for the environment impacts items identified as potentially affected by the Project is presented below. Some of items, which identified to have potential impacts based on scoping matrix such as waste, hydrology, topography/geology, traffic, climate change are recommended for further study.

The information presented in this chapter stems from various sources. Data on land environment has been collected and compiled from various reports and field surveys. The data on water quality, ground water hydrology, vegetation and fauna, air and noise quality and vibration were collected during field studies. Environment Baseline Monitoring and Data Collection for Ambient Air has conducted from 7th February 2025 to 6th May 2024, Ambient Noise has conducted at site from 15th March 2025 to 25th April 2025 and Vibration has conducted at site from 1st June 2025 completed by around 18th July 2025. Water (Surface and Ground Water) and Soil samples have been collected on 15th & 27th April 2025. We have also collected additional data for rainy season for air (5th June to 25th June 2025, of ground water and surface water and Biodiversity (7th July – 18th July 2025), which is compared with the CPCB data also for year 2024. Secondary data for ambient air has been obtained from Central Pollution Control Board for 2023.

7.1 Pollution

7.1.1 Ambient Air Quality

(1) Survey and Analysis Methodology

1) Selection of Sampling Sites

The design of monitoring network in the air quality surveillance program is based on the following considerations.

- Meteorological conditions on synoptic scale
- Topography of the study area
- Representation of project site
- Representation of cross-sectional distribution in the downward direction
- Influence of the existing sources if any, are to be kept at minimum

The sampling and analysis of the required parameters has been carried out as per IS: 5182 methodology entitled "Methods of Measurement of Air Pollution" and AWMA entitled "Methods of Air Sampling and Analysis."

There are twenty-seven (27) monitoring stations set up to assess the existing air quality of the study area. The stations are outside the proposed project alignment and stations.

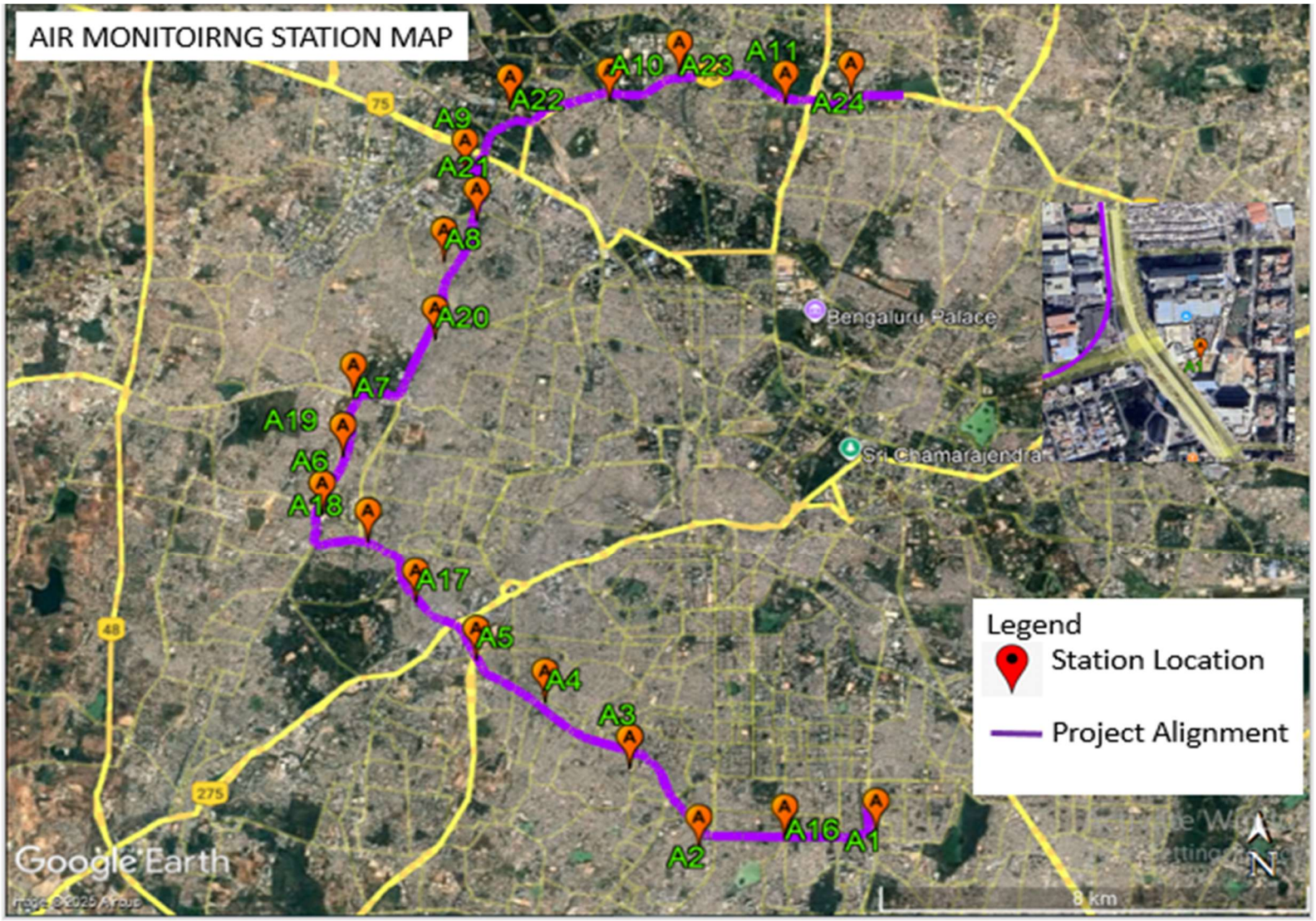
The locations of the monitoring stations are also based on the meteorological conditions of the study area like likeliness of pollution dispersion in areas located towards predominant wind directions, sensitive receptors in the study area like densely populated areas, forest area etc. Logistic considerations such as ready accessibility, security, availability of reliable power supply, etc. were also examined while finalizing the monitoring locations.

Table7-1: Ambient Air Quality Monitoring Stations and Justification

S. No.	Location Name	Latitude	Longitude	Distance (m) / (LHS/RHS)		Selection criteria
A1	Ranka Colony	12°54'24.57"N	77° 36' 4.26"E	0.13	LHS	Public area near Nexus Vega City Mall
A2	Ilyas Nagar	12°54'10.62"N	77° 34' 17.10"E	0.31	LHS	Residential Area south side of alignment.
A3	Padmanabhanagar	12° 55' 6.23"N	77° 33' 32.09"E	0.32	LHS	School on south side of alignment.
A4	Banashankari	12°55'52.88"N	77° 32' 41.21"E	0.12	RHS	Near open ground in residential area.
A5	Tollgate Hosakerehalli	12°56'15.92"N	77° 31' 57.05"E	0.05	LHS	Near Highway interchange
A6	PapreddyPalya	12°57'57.11"N	77° 30' 17.25"E	0.12	RHS	Sensitive location at playground near Dr. AIT college ground
A7	Kotiigepalya	12°59'17.40"N	77° 30' 40.74"E	0.08	LHS	Sparse trees area
A8	Lakshmi Devi Nagar	13° 0' 42.88"N	77° 31' 42.21"E	0.27	LHS	Near Industrial area
A9	Yeswanthpur	13° 1' 44.31"N	77° 31' 46.90"E	0.18	LHS	Sensitive location near playground
A10	Muthyala Nagar	13° 2' 33.23"N	77° 33' 18.32"E	0.20	RHS	Dense trees area
A11	Near Hebbal Railway Station	13° 2' 30.78"N	77° 35' 10.75"E	0.12	RHS	Near sensitive area beside Hebbal lake

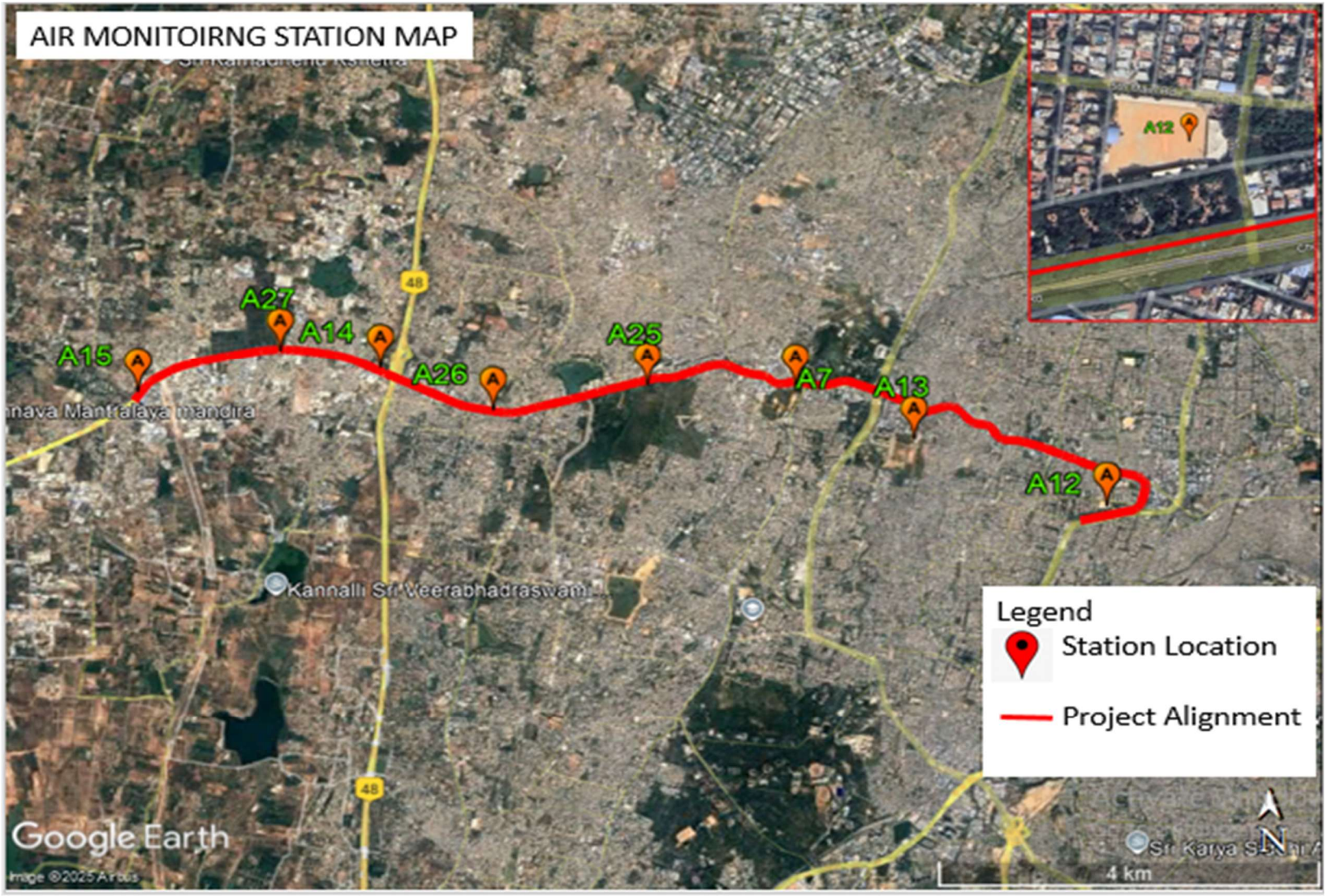
S. No.	Location Name	Latitude	Longitude	Distance (m) / (LHS/RHS)		Selection criteria
A12	Vijayanagar	12° 58'30.24"N	77° 32' 26.76"E	0.1	LHS	Near BBMP Playground
A13	Cauvery Nagar	12° 59' 4.84"N	77° 31' 25.54"E	0.35	LHS	In Open area
A14	Chikkagollarahatti	12° 59'10.16"N	77° 28' 13.93"E	0.10	RHS	Near Ring Road open area
A15	Kadabagere Cross	12° 59' 8.83"N	77° 26' 47.81"E	0.03	RHS	Open and dump area
A16	Near Corporation Grounds	12° 54'20.05"N	77° 35' 8.74"E	0.02	LHS	Densly populated area
A17	Metro Layout	12° 56'58.93"N	77° 31' 17.75"E	0.04	LHS	Near outer ring road
A18	Nagarabhaavi	12° 57'38.70"N	77° 30' 48.90"E	0.02	RHS	Open ground
A19	Near 6th crossroad Naagarabhaavi	12° 58'35.66"N	77° 30' 34.46"E	0.04	LHS	Near densly populated area.
A20	Kempegowda Layout, Laggere	12° 59'53.34"N	77° 31' 30.39"E	0.15	RHS	Open area near Nala.
A21	Nandini Layout	13° 1' 8.79"N	77° 31' 55.67"E	0.06	RHS	Near Industrial Shed
A22	Goraguntepalya, Nandini Layout	13° 2' 27.98"N	77° 32' 15.27"E	0.28	LHS	Near Industrial Area
A23	Tatanagar, Devinagar	13° 2' 51.47"N	77° 34' 3.26"E	0.08	LHS	Open Residential Area
A24	Vayunandana Layout, Yelahanka	13° 2' 41.21"N	77° 35' 57.36"E	0.14	LHS	Sensitive area near Religious place.
A25	Madeshwara Nagar, Sunkadakatte	12° 59'16.88"N	77° 29' 52.17"E	0.06	LHS	Senstive area near densly trees area
A26	Kempegowdanagar, Bedarahalli	12° 59' 6.23"N	77° 28' 52.99"E	0.01	RHS	Near Road area
A27	Chikkagollarahatti	12° 59'29.89"N	77°27'40.03"E	0.01	LHS	Near Populated area

Source: JST



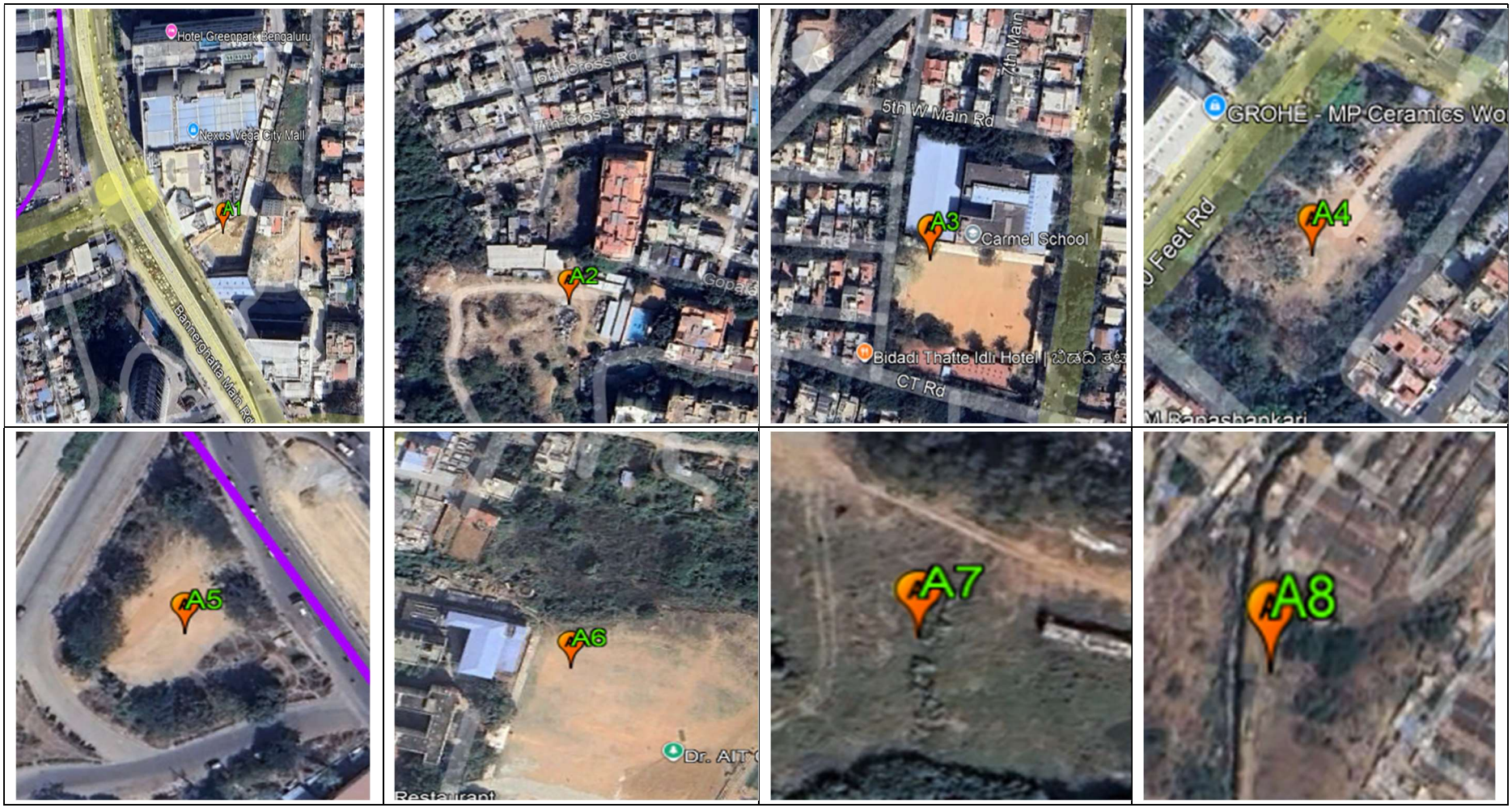
Source: JST

Figure7-1: Map showing Ambient Air Quality Monitoring Locations (Line 3-1)



Source: JST

Figure7-2: Map showing Ambient Air Quality Monitoring Locations (Line 3-2)


Hotel Greenpark Bengaluru
Nexus Vega City Mall
A1
Bannerghatta Main Rd
A2
5th W Main Rd
A3
Carmel School
Bidadi Thatte Idli Hotel
CT Rd
GROHE - MP Ceramics Wo
A4
A5
A6
Dr. AIT
Restaurant
A7
A8


A9
A10
A11
A12
A13
A14
A15
A16


A17
A18
A19
A20
A21
A22
A23
A24

Source: JST

Figure7-3: Map showing Ambient Air Quality Monitoring Locations (Zoomed-in)

2) Analytical Method for Air Quality Monitoring

Under the provisions of the Air (Prevention & Control of Pollution) Act, 1981, the CPCB has notified fourth version of National Ambient Air Quality Standards (NAAQS) in 2009. Ambient air is defined as any unconfined part of the Earth's atmosphere, that the surrounding outdoor air in which humans and other organisms live and breathe.

The "Respirable Dust Sampler has been used for air monitoring. The dust particulate matter is collected on glass micro fibre filter paper (size GF/A20.3x25.4 cm) and dust cup and the gaseous pollutants collected simultaneously by a known volume of air through a number of bubblers of different flow rate through appropriate solution for absorbing different gases. The collected samples are analysed according to standard method for different pollutants. The particulate matter was analysed by Gravimetric method (by weighing the mass of particles). The SO_2 was analysed by Colorimetric method by estimating absorbance of SO_2 from the exposed absorbing reagent at 540 nm using spectrophotometer. The NO_2 was analysed by Colorimetric method by reacting the nitrite ions with phosphorous acid sulphanilamide, and NEDA solution by measuring absorbance of NO_2 from the exposed absorbing reagent at 540 nm using spectrophotometer.

3) Sampling and analysis of Sulphur dioxide (Improved West and Geake method)

The sampling and analysis proposed to be carried out as per IS: 5182 methodology entitled "Methods of Measurement of Air Pollution" and AWMA entitled "Methods of Air Sampling and Analysis." Summary of the analytical techniques and their references are as given in Table7-2.

Table7-2: Techniques Adopted/Protocols for Ambient Air Quality Monitoring

S. No.	Parameters	Techniques	Technical Protocol
1	Sulphur Dioxide (SO_2)	West & Gaeke	IS:5182 (P2)
2	Nitrogen Dioxide (NO_2)	Jacob & Hochheiser	IS:5182 (P6)
3	Particulate Matter PM_{10}	Gravimetric	IS:5182 (P23)
4	Particulate Matter $PM_{2.5}$	Gravimetric	IS:5182 (P24)
5	Carbon-monoxide as CO	NDIR	IS: 5182 (P-10)
6	Ozone as O_3	UV Photometric	IS: 5182 (P-9)

Source: Baseline Monitoring Report, NAL LABS LLP

Sulphur dioxide from air is absorbed in a solution of potassium tetra chloro mercurate (TCM). A dichloro sulphito mercurate complex, which resists oxidation by the oxygen in the air, is formed. Once formed, this complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some time prior to analysis. The complex is made to react with para-rosaniline and formaldehyde to form the intensely coloured para rosaniline methyl sulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer.

4) Sampling and analysis of NOx (Modified Jacob and Hochheiser Method)

Ambient nitrogen dioxide (NO_2) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO_2) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulphanilamide, and N-(1-naphthyl)

ethylenediamine di-hydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540 nm.

5) Sampling and analysis of PM10 (Gravimetric Method)

Air is drawn through a size-selective inlet and through a 20.3 x 25.4 cm (8 x 10 in) filter at a flow rate, which is typically 1132 L/min. Particles with aerodynamic diameter less than the cut-point of the inlet are collected, by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM10 in the designated size range is calculated by dividing the weight gain of the filter by the volume of air sampled.

6) Sampling and analysis of $PM_{2.5}$ (Gravimetric Method)

An electrically powered air sampler draws ambient air at a constant volumetric flow rate (16.7 lpm) maintained by a mass flow / volumetric flow controller coupled to a microprocessor into specially designed inertial particle-size separator (i.e., cyclones or impactors) where the suspended particulate matter in the $PM_{2.5}$ size ranges is separated for collection on a 47 mm polytetrafluoroethylene (PTFE) filter over a specified sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter. The mass concentration in the ambient air is computed as the total mass of collected particles in the $PM_{2.5}$ size ranges divided by the actual volume of air sampled and is expressed in µg/m^3. The microprocessor reads averages and stores five-minute averages of ambient temperature, ambient pressure, filter temperature and volumetric flow rate. In addition, the microprocessor calculates the average temperatures and pressure, total volumetric flow for the entire sample run time and the coefficient of variation of the flow rate.

(2) Dry Season Survey Results

PM_{10} (Particulate Matter ≤ 10 µm):

The PM_{10} concentrations across the 27 locations range from a minimum of 66.8 µg/m³ in Metro Layout (A17) to a maximum of 81.8 µg/m³ in Kadabagere Cross (A15), with an average value of approximately 72.5 µg/m³. All recorded values exceed the WHO's annual air quality guideline of 15 µg/m³, indicating severe particulate pollution. The highest levels at Kadabagere Cross and Goraguntepalya (A22) suggest significant contributions from traffic, construction, or industrial dust, while the lowest levels in Metro Layout and Kotigepalya (A7) may reflect better urban planning or lower vehicular activity. Given that PM_{10} can cause respiratory and cardiovascular issues, urgent measures such as road dust suppression, green belt development, and stricter emission controls are essential to improve air quality across the region.

$PM_{2.5}$ (Particulate Matter ≤ 2.5 µm):

$PM_{2.5}$ levels vary from a minimum of 23.6 µg/m³ in Lakshmi Devi Nagar (A8) to a maximum of 38.2 µg/m³ in Goraguntepalya, Nandini Layout (A22), with an average of about 29.5 µg/m³—far above the WHO's recommended annual limit of 5 µg/m³. These elevated concentrations pose serious health risks, as fine particles can penetrate deep into the lungs and bloodstream. The peak in Goraguntepalya (A22)

likely results from dense traffic, industrial emissions, or localized burning activities, while the lowest values are observed in relatively cleaner residential zones. The consistently high $PM_{2.5}$ across most locations indicates a widespread problem, necessitating interventions such as promoting clean cooking fuels, regulating industrial emissions, and expanding public transportation to reduce vehicular pollution.

SO_2 (Sulfur Dioxide):

Sulfur dioxide concentrations range from a minimum of 10.9 µg/m³ in Vijayanagar (A12) to a maximum of 17.2 µg/m³ in Nandini Layout (A21), with an average of approximately 13.2 µg/m³. While these values are below the WHO 24-hour guideline of 20 µg/m³, they still indicate the presence of industrial or combustion-based pollution sources. The highest SO_2 levels in Nandini Layout and Kempegowda Layout (A20) may be linked to nearby industries, diesel generators, or fossil fuel-based heating. In contrast, lower values in Vijayanagar and Padmanabhanagar suggest limited industrial activity. Although SO_2 is not at critical levels, continued monitoring and a shift toward low-sulfur fuels and cleaner energy sources are recommended to prevent respiratory issues and environmental degradation like acid rain.

NO_2 (Nitrogen Dioxide):

Nitrogen dioxide levels span from a minimum of 22.2 µg/m³ in Kotigepalya (A7) to a maximum of 36.8 µg/m³ in Nandini Layout (A21), with an average concentration of around 26.5 µg/m³, significantly exceeding the WHO's annual guideline of 10 µg/m³. This strongly suggests traffic-related pollution, as NO_2 primarily originates from vehicle exhaust and combustion engines. The highest values are clustered in areas like Nandini Layout and Kempegowdanagar (A26), indicating high traffic density or proximity to major roads. The lowest levels in Kotigepalya and Lakshmi Devi Nagar reflect less congestion. To mitigate NO_2 pollution, strategies such as traffic decongestion, promotion of electric vehicles, and improved public transport infrastructure should be prioritized.

CO (Carbon Monoxide):

Carbon monoxide concentrations range from a minimum of 0.16 ppm in Metro Layout (A17) to a maximum of 0.36 ppm in Goraguntepalya, Nandini Layout (A22), with an average of approximately 0.24 ppm. While these levels are below the WHO 8-hour guideline of 9 ppm, they still reflect incomplete combustion from vehicles and industrial sources. The highest CO values are found in areas with heavy traffic and poor ventilation, such as Goraguntepalya (A22), while the lowest are in well-planned or low-traffic zones like Metro Layout. Although not immediately life-threatening, chronic exposure to CO can impair oxygen delivery in the body, particularly affecting individuals with heart conditions. Reducing vehicular emissions and improving urban airflow through green infrastructure can help lower CO levels.

O_3 (Ozone):

Ground-level ozone concentrations show the greatest variability, ranging from a minimum of 2.6 µg/m³ in Tatanagar, Devinagar (A23) to a maximum of 43.8 µg/m³ in Kempegowdanagar, Bedarahalli (A26), with an average of about 25.5 µg/m³. Unlike other pollutants, ozone is not directly emitted but forms through photochemical reactions between NO_x and volatile organic compounds (VOCs) under sunlight.

High ozone in Kempegowdanagar and Nagarabhavi (A18) suggests intense solar radiation combined with precursor emissions from traffic. In contrast, very low ozone in Tatanagar may be due to high NO levels that titrate ozone or limited sunlight exposure. Elevated ozone can trigger asthma and damage vegetation, so controlling NO_x and VOC emissions—especially during peak daylight hours—is critical for reducing ozone formation.

(3) Wet Season Survey Results

PM_{10} (Particulate Matter ≤ 10 µm):

The PM_{10} levels range from a minimum of 61.8 µg/m³ in Tollgate Hosakerehalli (A5) to a maximum of 78.0 µg/m³ in Vijayanagar (A12), Kadabagere Cross (A15), and Goraguntepalya (A22), with an average concentration of approximately 71.4 µg/m³. All values significantly exceed the WHO's annual guideline of 15 µg/m³, indicating persistent coarse particulate pollution across the region. The highest concentrations are clustered in urban and semi-industrial zones such as Vijayanagar and Kadabagere Cross, likely due to construction activity, road dust, and traffic congestion. The lowest level in Tollgate Hosakerehalli may reflect better ventilation or lower population density. Given the health risks associated with PM_{10}—including respiratory and cardiovascular diseases—dust control measures, green barriers, and improved road maintenance.

$PM_{2.5}$ (Particulate Matter ≤ 2.5 µm):

$PM_{2.5}$ concentrations vary from a minimum of 13.6 µg/m³ in Ilyas Nagar (A2) to a maximum of 36.6 µg/m³ in Vijayanagar (A12), Kadabagere Cross (A15), and Nandini Layout (A21), with an average of about 30.4 µg/m³—six times higher than the WHO's recommended annual limit of 5 µg/m³. This alarming level indicates widespread exposure to fine particles that can penetrate deep into the lungs and bloodstream. The unusually low value in Ilyas Nagar (A2) appears to be an outlier and may be due to data entry error or localized clean conditions. Most other locations show consistently high $PM_{2.5}$, particularly in traffic-heavy and industrial areas like Nandini Layout and Yeswanthpur. The primary sources likely include vehicle emissions, industrial combustion, and possibly domestic biomass burning. Transitioning to cleaner fuels and enhancing emission monitoring are critical for reducing health risks.

SO_2 (Sulfur Dioxide):

Sulfur dioxide levels range from a minimum of 12.6 µg/m³ in Tollgate Hosakerehalli (A5) and PapreddyPalya (A6) to a maximum of 17.2 µg/m³ in Nandini Layout (A21), with an average of approximately 15.0 µg/m³. While these values remain below the WHO 24-hour guideline of 20 µg/m³, they still indicate the presence of combustion sources such as diesel generators, industrial boilers, or fossil fuel-based heating. Elevated SO_2 in Nandini Layout, Lakshmi Devi Nagar, and Kadabagere Cross suggests localized industrial or energy-related emissions. The relatively uniform distribution across locations implies widespread but moderate SO_2 pollution. Although not at crisis levels, continued exposure can aggravate respiratory conditions, especially in vulnerable populations. Promoting low-sulfur fuels and transitioning to cleaner energy sources can help reduce SO_2 emissions over time.

NO_2 (Nitrogen Dioxide):

Nitrogen dioxide concentrations span from a minimum of 26.0 µg/m³ in Tollgate Hosakerehalli (A5), PapreddyPalya (A6), and Chikkagollarahatti (A27) to a maximum of 36.8 µg/m³ in Nandini Layout (A21), with an average of about 30.1 µg/m³—more than three times the WHO annual guideline of 10 µg/m³. This strongly indicates traffic-related pollution as the dominant source, since NO_2 is primarily emitted from vehicle exhaust. The highest levels are observed in densely populated and congested areas such as Nandini Layout, Hebbal Railway Station, and Cauvery Nagar. Even typically cleaner areas show elevated NO_2, pointing to city-wide vehicular pressure. Long-term exposure is linked to respiratory illnesses and reduced lung function. Mitigation strategies should include traffic decongestion, promotion of electric vehicles, expansion of public transport, and establishment of low-emission zones.

CO (Carbon Monoxide):

Carbon monoxide levels range from a minimum of 0.18 ppm in Chikkagollarahatti (A27) to a maximum of 0.34 ppm in Nandini Layout (A21), with an average of approximately 0.25 ppm. These values are well below the WHO 8-hour guideline of 9 ppm, suggesting that CO does not pose an immediate health threat. However, the higher levels in Nandini Layout, Yeswanthpur, and A10 reflect incomplete combustion from dense traffic, older vehicles, or poor ventilation. The lowest levels in Chikkagollarahatti and Metro Layout (A17) suggest better air circulation or fewer polluting sources. While current CO levels are safe, they still serve as an indicator of inefficient combustion processes. Encouraging vehicle maintenance, phasing out older engines, and improving urban airflow can further reduce CO emissions.

O_3 (Ozone):

Ground-level ozone concentrations vary widely, from a minimum of 9.6 µg/m³ in Ranka Colony (A1) to a maximum of 35.3 µg/m³ in Nandini Layout (A21), with an average of about 15.0 µg/m³. Ozone is a secondary pollutant formed when NO_x and volatile organic compounds (VOCs) react in sunlight, so high levels often occur in areas with strong sunlight and precursor emissions. The peak in Nandini Layout (A21) coincides with high NO_2 and $PM_{2.5}$, suggesting active photochemical smog formation. In contrast, lower ozone in Ranka Colony and Ilyas Nagar may be due to titration by NO or limited solar exposure. Although average ozone is moderate, elevated levels during peak hours can trigger asthma and harm vegetation. Controlling NO_x and VOC emissions—especially during sunny periods—is essential to prevent ozone buildup.

Table7-3: Baseline Results for the Ambient Air Quality Monitoring Locations

Parameters	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		NOx (µg/m³)		SO_2 (µg/m³)		O_3 (µg/m³)		CO (mg/m³)	
Location Code	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Location Code	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
A1	32.0	28.0	75.8	62.0	26.6	31.1	**A1**	32.0	28.0	75.8	62.0	26.6
A2	31.5	13.6	72.0	70.0	24.8	31.0	**A2**	31.5	13.6	72.0	70.0	24.8
A3	31.5	30.0	72.0	66.6	24.8	28.0	**A3**	31.5	30.0	72.0	66.6	24.8
A4	26.8	34.0	69.4	72.0	24.1	32.0	**A4**	26.8	34.0	69.4	72.0	24.1
A5	29.0	24.8	70.3	61.8	24.2	26.0	**A5**	29.0	24.8	70.3	61.8	24.2
A6	33.9	31.0	72.7	68.6	25.3	26.0	**A6**	33.9	31.0	72.7	68.6	25.3
A7	24.0	28.6	68.0	74.0	22.2	32.8	**A7**	24.0	28.6	68.0	74.0	22.2
A8	23.6	31.6	68.2	74.9	22.9	32.4	**A8**	23.6	31.6	68.2	74.9	22.9
A9	31.8	34.0	70.3	68.8	25.5	26.4	**A9**	31.8	34.0	70.3	68.8	25.5
A10	28.8	29.0	70.4	68.8	25.6	26.4	**A10**	28.8	29.0	70.4	68.8	25.6
A11	34.0	32.0	76.0	74.0	28.8	36.6	**A11**	34.0	32.0	76.0	74.0	28.8
A12	28.2	36.6	69.2	78.0	24.4	30.0	**A12**	28.2	36.6	69.2	78.0	24.4
A13	24.4	26.8	67.3	70.0	26.6	36.6	**A13**	24.4	26.8	67.3	70.0	26.6
A14	29.6	31.8	74.2	76.8	24.8	31.8	**A14**	29.6	31.8	74.2	76.8	24.8
A15	35.6	36.6	81.8	78.0	29.8	36.0	**A15**	35.6	36.6	81.8	78.0	29.8
A16	28.8	32.0	70.0	74.0	26.8	30.6	**A16**	28.8	32.0	70.0	74.0	26.8
A17	24.4	25.0	66.8	68.0	24.2	28.0	**A17**	24.4	25.0	66.8	68.0	24.2
A18	28.9	34.0	73.0	74.0	29.0	28.0	**A18**	28.9	34.0	73.0	74.0	29.0
A19	32.4	30.0	71.0	72.0	26.3	30.0	**A19**	32.4	30.0	71.0	72.0	26.3
A20	34.0	32.0	74.0	72.0	28.8	30.0	**A20**	34.0	32.0	74.0	72.0	28.8
A21	36.0	32.0	75.0	68.0	36.8	29.0	**A21**	36.0	32.0	75.0	68.0	36.8
A22	38.2	36.0	81.4	78.0	36.6	34.0	**A22**	38.2	36.0	81.4	78.0	36.6
A23	27.8	28.0	68.8	70.0	30.0	32.0	**A23**	27.8	28.0	68.8	70.0	30.0
A24	31.1	32.0	70.0	68.0	28.9	28.0	**A24**	31.1	32.0	70.0	68.0	28.9
A25	32.0	34.0	74.0	71.0	29.6	27.7	**A25**	32.0	34.0	74.0	71.0	29.6
A26	34.8	31.8	76.8	72.8	31.0	34.0	**A26**	34.8	31.8	76.8	72.8	31.0
A27	36.2	34.2	76.0	71.6	29.0	26.0	**A27**	36.2	34.2	76.0	71.6	29.0
National Ambient Air Quality Standards (NAAQS) 2009	60		100		80		80		180		2	
International Standards (WHO)	15		45		25		40		100		10	

Source: JST

(4) Secondary Data Survey results

The survey results of the secondary data of CPCB of Wet season in July and Dry season in March to provide the seasonal trend in the Project area. The table show the lowest and highest data recorded within the said month.

Table7-4: Secondary Monitoring data of July 2024

Parameters	Unit	BTM Layout, Bengaluru - CPCB		Bapuji Nagar, Bengaluru - KSPCB		Hebbal, Bengaluru - KSPCB		National Standards (NAAQS),	International Standards. (WHO)
		Min	Max	Min	Max	Min	Max		
PM_{10}	$\mu g/m^3$	41.18	56.81	25.79	79.37	14.76	48.71	100	45
$PM_{2.5}$	$\mu g/m^3$	17.05	20.15	10.31	31.76	2.78	8.22	60	15
SO_2	$\mu g/m^3$	15.48	22.59	1.89	4.47	5.93	10.54	80	25
NO_x	$\mu g/m^3$	24.18	36.20	1.11	2.04	-	-	80	40
O_3	$\mu g/m^3$	21.38	26.57	11.85	12.29	7.51	11.59	180	100
CO	mg/m^3	0.27	0.86	0.05	0.43	0.32	0.46	2	10

Note: Results exceeded national standard are highlighted in orange and results exceeded international standard are in red font.

The "Min" and "Max" values shown in this table represent the lowest and highest 24-hour average concentrations recorded during the monitoring period. These values are not hourly extremes but reflect the daily (24-hour) mean values measured across the seven-day monitoring campaign.

Source: JST

Table7-5: Secondary Monitoring data of April 2024

Parameters	Unit	BTM Layout, Bengaluru - CPCB		Bapuji Nagar, Bengaluru - KSPCB		Hebbal, Bengaluru - KSPCB		National Standards (NAAQS),	International Standards. (WHO)
		Min	Max	Min	Max	Min	Max		
PM_{10}	$\mu g/m^3$	56.47	108.49	53.22	110.49	39.96	108.13	100	45
$PM_{2.5}$	$\mu g/m^3$	18.49	32.94	21.24	44.32	14.18	65.81	60	15
SO_2	$\mu g/m^3$	5.93	9.34	12.80	36.12	2.17	10.49	80	25
NO_x	$\mu g/m^3$	31.06	36.86	3.09	5.84	-	-	80	40
O_3	$\mu g/m^3$	23.55	29.74	42.93	188.45	6.77	45.36	180	100
CO	mg/m^3	0.48	0.81	0.49	1.21	0.28	0.54	2	10

Note: Results exceeded national standard are highlighted in orange and results exceeded international standard are in red font.

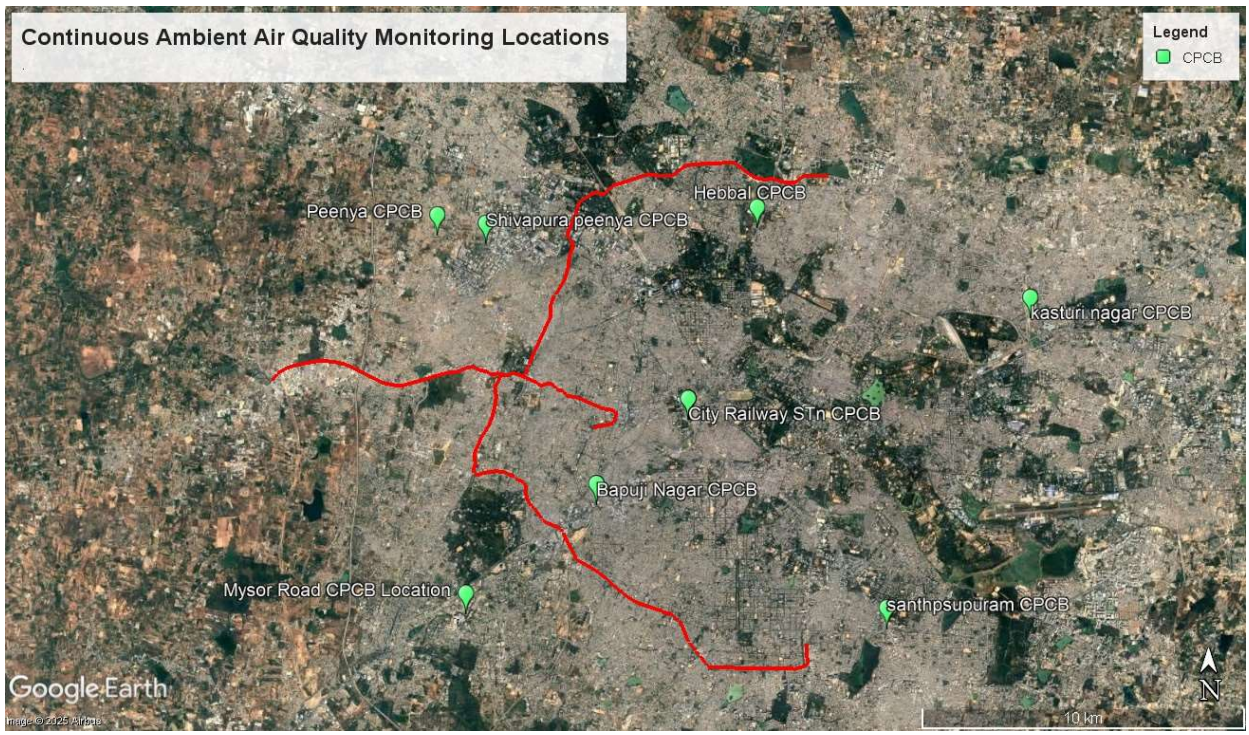
The "Min" and "Max" values shown in this table represent the lowest and highest 24-hour average concentrations recorded during the monitoring period. These values are not hourly extremes but reflect the daily (24-hour) mean values measured across the seven-day monitoring campaign.

Source: JST

These secondary monitoring results have been evaluated against both the National Ambient Air Quality Standards (NAAQS, 2009) and the World Health Organization (WHO) Global Air Quality Guidelines (2021) for daily average concentrations. The WHO guideline values relevant to the pollutants measured are as follows: PM2.5 – 15 µg/m³ (24-hour), PM10 – 45 µg/m³ (24-hour), NO_2 – 25 µg/m³ (24-hour), SO_2 – 40 µg/m³ (24-hour), O_3 – 100 µg/m³ (8-hour maximum), and CO – 10 mg/m³ (8-hour average).

As shown in Tables 7-4 and 7-5, most 24-hour values of $PM_{2.5}$ and PM_{10} at all three CAAQMS stations exceed the corresponding WHO 24-hour guideline values in both April and July, indicating that particulate matter is the key pollutant of concern in the project area. By contrast, SO_2, O_3 and CO remain below the relevant WHO short-term guideline values, while NO_2 exceeds the WHO 24-hour guideline

at several locations, particularly in traffic-dominated zones.



Source: JST based on Google Earth

Figure7-4: Map showing Continuous Ambient Air Quality Monitoring Stations (CAAQMS) of CPCB in Bengluru

7.1.2 Water Quality

(1) Primary Data Survey Results for Dry Season

1) Monitoring location selection

Identifying the ground water sampling locations has been done on the basis of the hydrogeological characteristics of the area and the potential sources of contamination. For assessment of baseline data of water quality status of one-time sampling was done.

The Groundwater and Surface Water quality has been collected and analysed as per the procedure specified in standard methods for examination of water and wastewater published by the American Public Health Association and Bureau of Indian Standards (APHA/BIS).

2) General Guidelines for Sampling

Grab samples were collected from a well-mixed section of the water body 30 cm below the water surface. DO was determined in a sample collected in a DO bottle using a DO sampler. The DO in the sample was fixed immediately after collection, using chemical reagents. Weighted sample bottle has been used to collect sample from an open well about 30 cm below the surface of the water.

Samples from the production tube wells/ Bore well was collected after running the well for about 5

minutes. Some parameters like pH, dissolved oxygen, temperature, conductivity and turbidity were analysed in situ.

3) Sample Preservation and Transport

Samples for BOD and bacteriological analyses were stored at a temperature below 4oC and in the dark as soon as possible after sampling by placing them in an insulated cool box together with ice or cold packs. Samples collected for chemical oxygen demand (COD) were preserved below pH 2 by addition of concentrated sulphuric acid. Samples which were to be analysed for the presence of heavy metals, were acidified to below pH 2 with concentrated nitric acid. Samples were transported to the concerned laboratory as soon as possible, preferably within 48 hours.

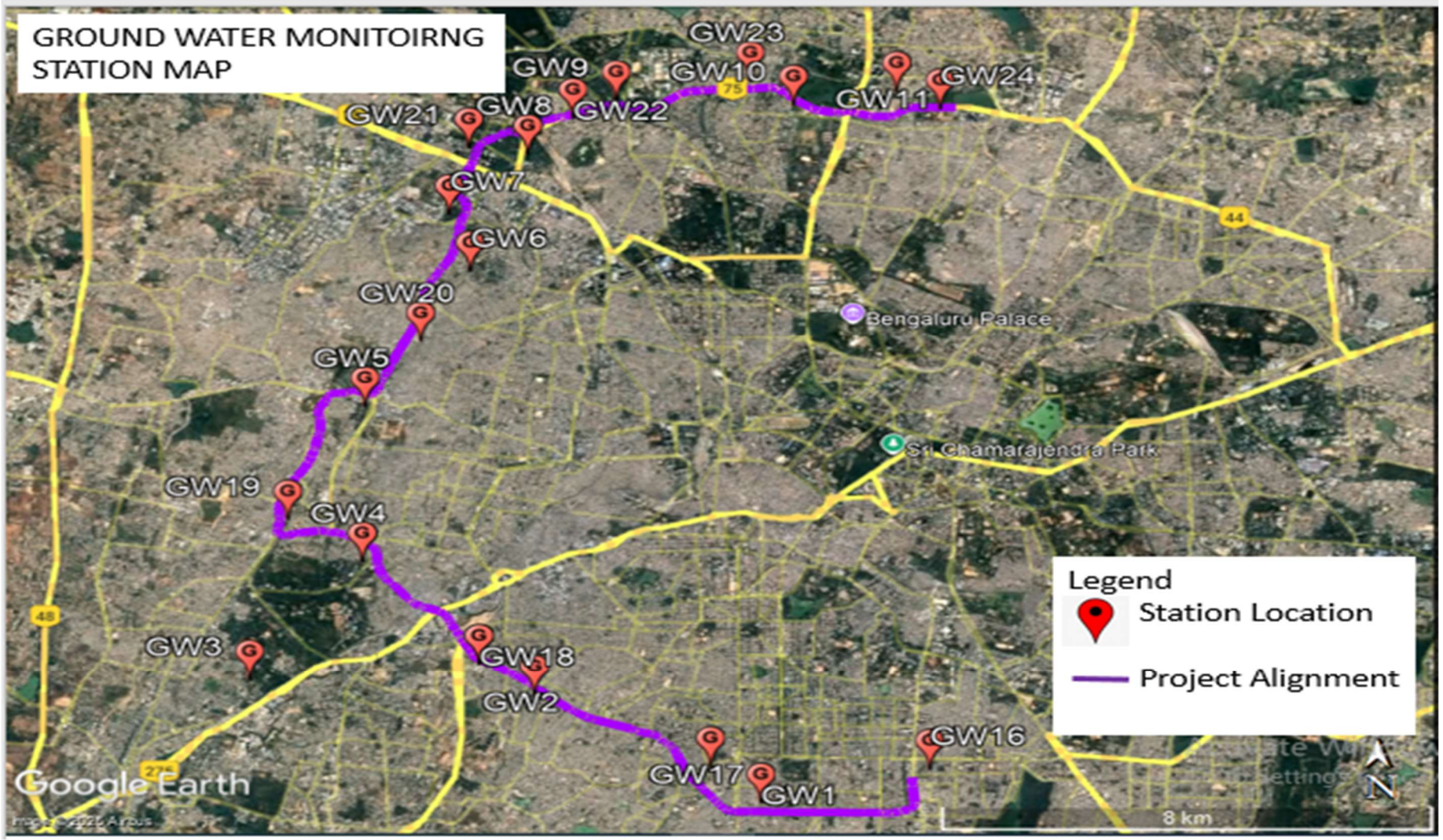
4) Water Quality Analysis

Samples were collected as per IS: 3025 (Part-1) methodology. Necessary precautions were taken while collecting, preserving and transporting. All the parameters were analysed as per "Methods of Sampling and Test (Physical and Chemical) for water and wastewater" IS: 3025 and "Standard Methods for the Examination of Water and Wastewater" APHA. The results were compared with the standards (IS: 10500 & IS: 2296) as per the quality of water. and surface water has compared with the CPCB standard.

Table7-6: Ground Water Sampling Stations

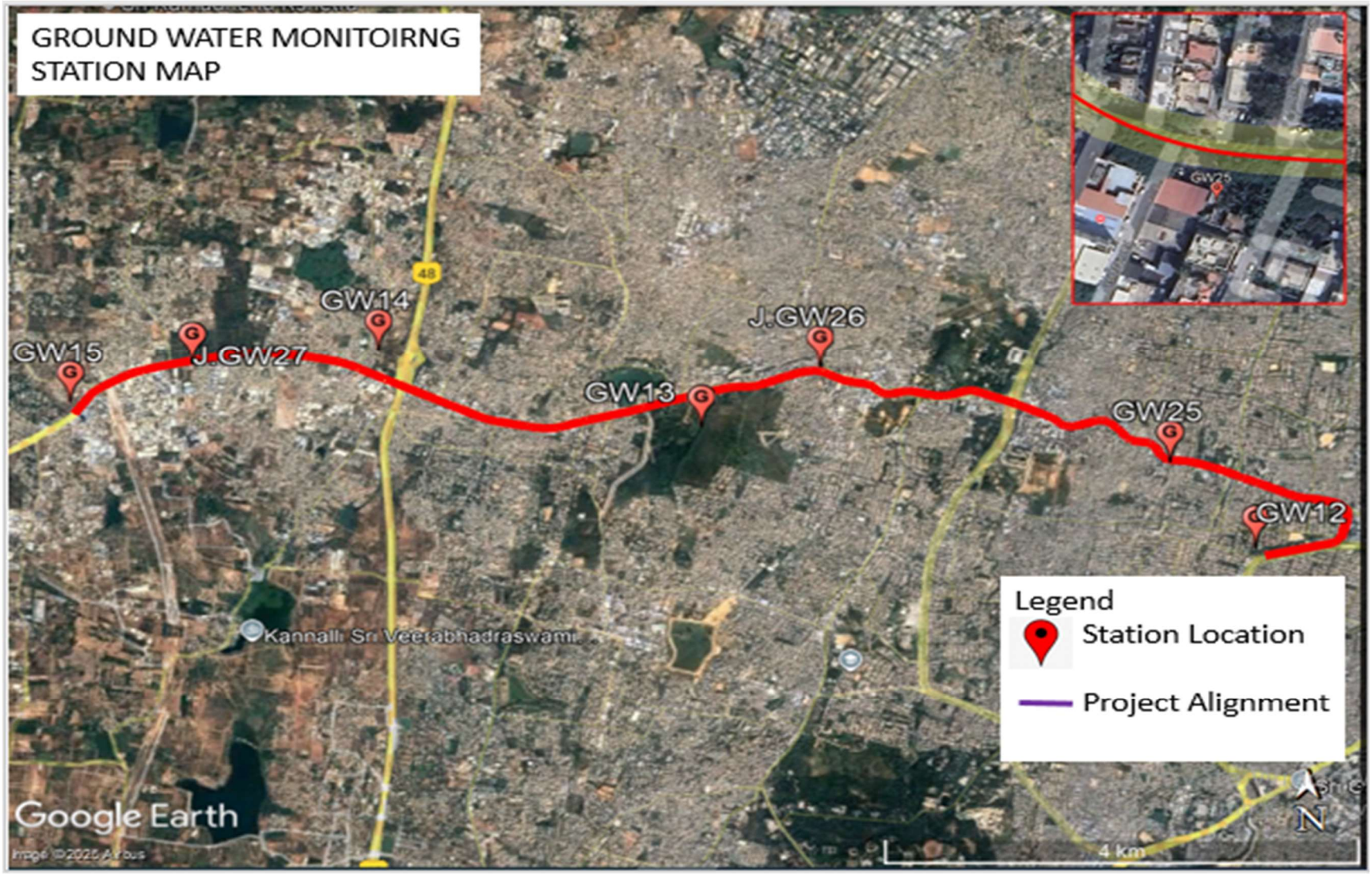
S. No.	Corridor	Location Name	Latitude	Longitude	Distance (m)	LHS/ RHS	Selection Criteria
GW1	Line 3-1	Sarakki Nagar	12° 54' 26.17"N	77° 34' 43.35"E	160	RHS	Borewell
GW2	Line 3-1	Banashankari 3rd Stage	12° 55' 52.92"N	77° 32' 41.19"E	130	LHS	Borewell
GW3	Line 3-1	Forest Layout	13° 2' 36.86"N	77° 35' 3.61"E	3235	LHS	Borewell
GW4	Line 3-1	Chandra Layout	12° 57' 26.18"N	77° 30' 58.74"E	240	LHS	Borewell
GW5	Line 3-2	Sajjepalya	12° 59' 9.48"N	77° 31' 6.67"E	277	RHS	Borewell
GW6	Line 3-1	Sreenivas Nagar	13° 0' 43.57"N	77° 32' 0.40"E	427	RHS	Borewell
GW7	Line 3-1	Surana PU College, Peenya	13° 1' 25.19"N	77° 31' 46.38"E	226	LHS	Borewell
GW8	Line 3-1	Muniswara Nagar	13° 1' 56.07"N	77° 32' 26.83"E	477	RHS	Drain
GW9	Line 3-1	Jalahalli	13° 2' 43.25"N	77° 33' 22.98"E	88	LHS	Drain
GW10	Line 3-1	Vijay Nagar	13° 2' 36.91"N	77° 35' 3.69"E	112	RHS	Drain
GW11	Line 3-1	Sanjeevini Nagar	13° 2' 48.24"N	77° 35' 54.88"E	390	LHS	Borewell
GW12	Line 3-2	Vijayanagar	12° 58' 28.37"N	77° 32' 18.19"E	125	LHS	Drain
GW13	Line 3-2	Anjana Nagar	12° 59' 10.45"N	77° 29' 34.94"E	328	LHS	Drain
GW14	Line 3-2	Hosahalli Gollarapalya	12° 59' 31.64"N	77° 28' 13.33"E	238	RHS	Drain
GW15	Line 3-2	Kadabagere Cross	12° 59' 9.06"N	77° 26' 50.65"E	94	RHS	Borewell
GW16	Line 3-1	Shantiniketan Educational Institutions	12° 54' 51.19"N	77° 36' 2.76"E	332	LHS	Borewell
GW17	Line 3-1	National Power Training Institute	12° 54' 49.02"N	77° 34' 1.65"E	380	RHS	Borewell
GW18	Line 3-1	PES University	12° 56' 6.32"N	77° 32' 11.14"E	97	LHS	Borewell
GW19	Line 3-1	PVP Polytechnic	12° 57' 45.55"N	77° 30' 17.42"E	112	RHS	Borewell
GW20	Line 3-1	Pipeline Road	12° 59' 53.14"N	77° 31' 30.67"E	227	RHS	Borewell
GW21	Line 3-1	Platinum City	13° 2' 8.46"N	77° 31' 59.47"E	150	LHS	Borewell
GW22	Line 3-1	Muthyalamma Temple Road	13° 2' 29.72"N	77° 32' 51.81"E	80	RHS	Borewell
GW23	Line 3-1	Shantiniketan School	13° 2' 52.87"N	77° 34' 33.50"E	160	LHS	Borewell
GW24	Line 3-1	BWSSB Water Treatment Plant	13° 2' 38.96"N	77° 36' 13.93"E	31	RHS	Borewell
GW25	Line 3-2	Kamakshipalya, Bengaluru	12° 58' 54.70"N	77° 31' 54.99"E	18	LHS	Borewell
GW26	Line 3-2	Near Muthuraya Swamy Temples	12° 59' 11.45"N	77° 30' 15.82"E	50	RHS	Borewell
GW27	Line 3-2	Near Shri Huliyuramma Devi Temple	12° 59' 11.76"N	77° 27' 12.95"E	30	LHS	Drain

Source: JST



Source: JST

Figure7-5: Map showing Ground Water Sampling Locations (Line 3-1)

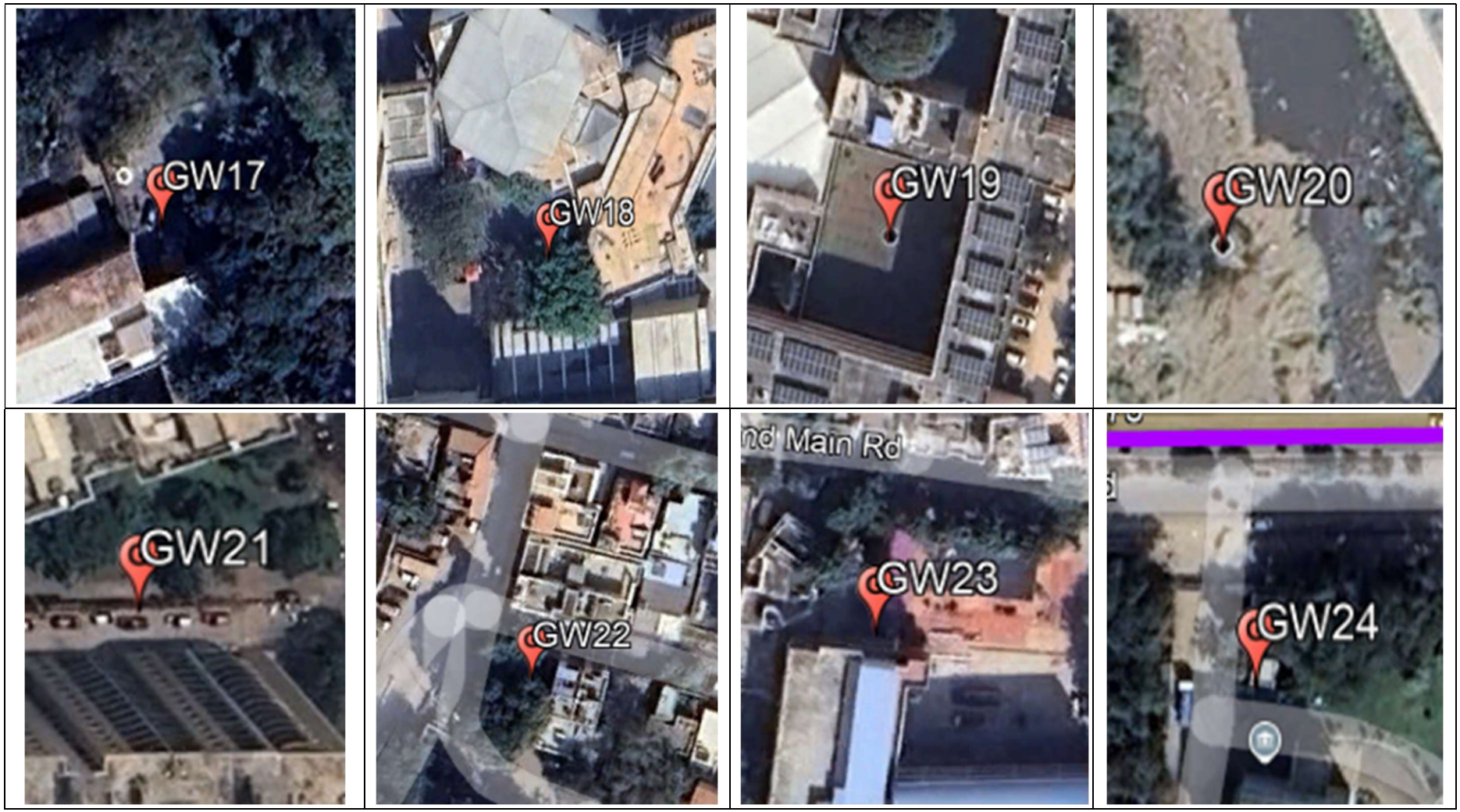


Source: JST based on Google Earth

Figure7-6: Map showing Ground Water Sampling Locations（Line 3-2）


GW1
GW2
GW3
GW4
GW5
GW6
GW7
GW8


u BEL
GW9
GW10
GW11
GW12
GW13
GW14
GW15
3rd Cross Rd
GW16


GW17
GW18
GW19
GW20
GW21
GW22
nd Main Rd
GW23
GW24

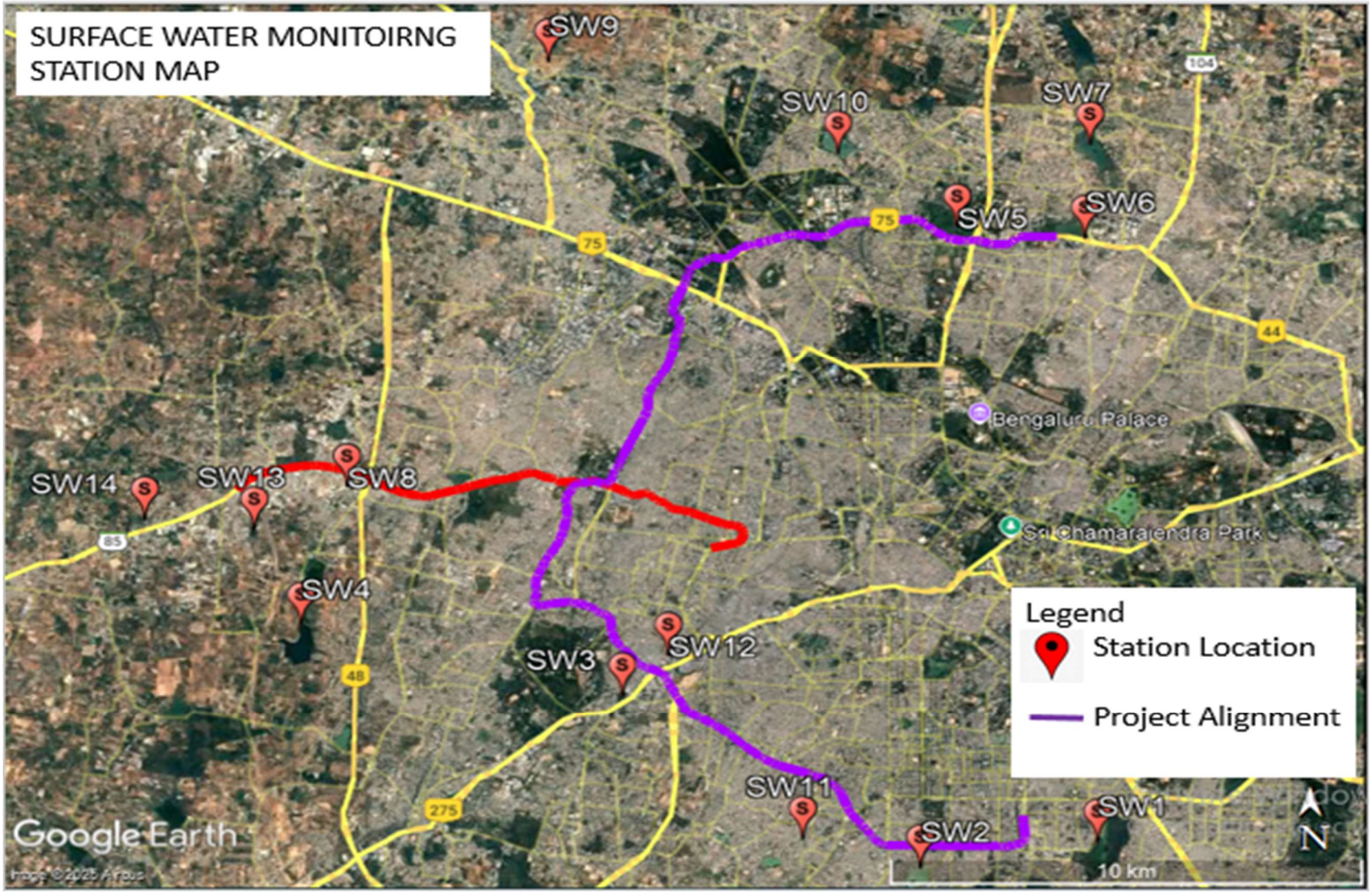
Source: JST based on Google Earth

Figure7-7: Ground Water Sampling Locations (Zoomed In)

Table7-7: Surface Water Sampling Stations

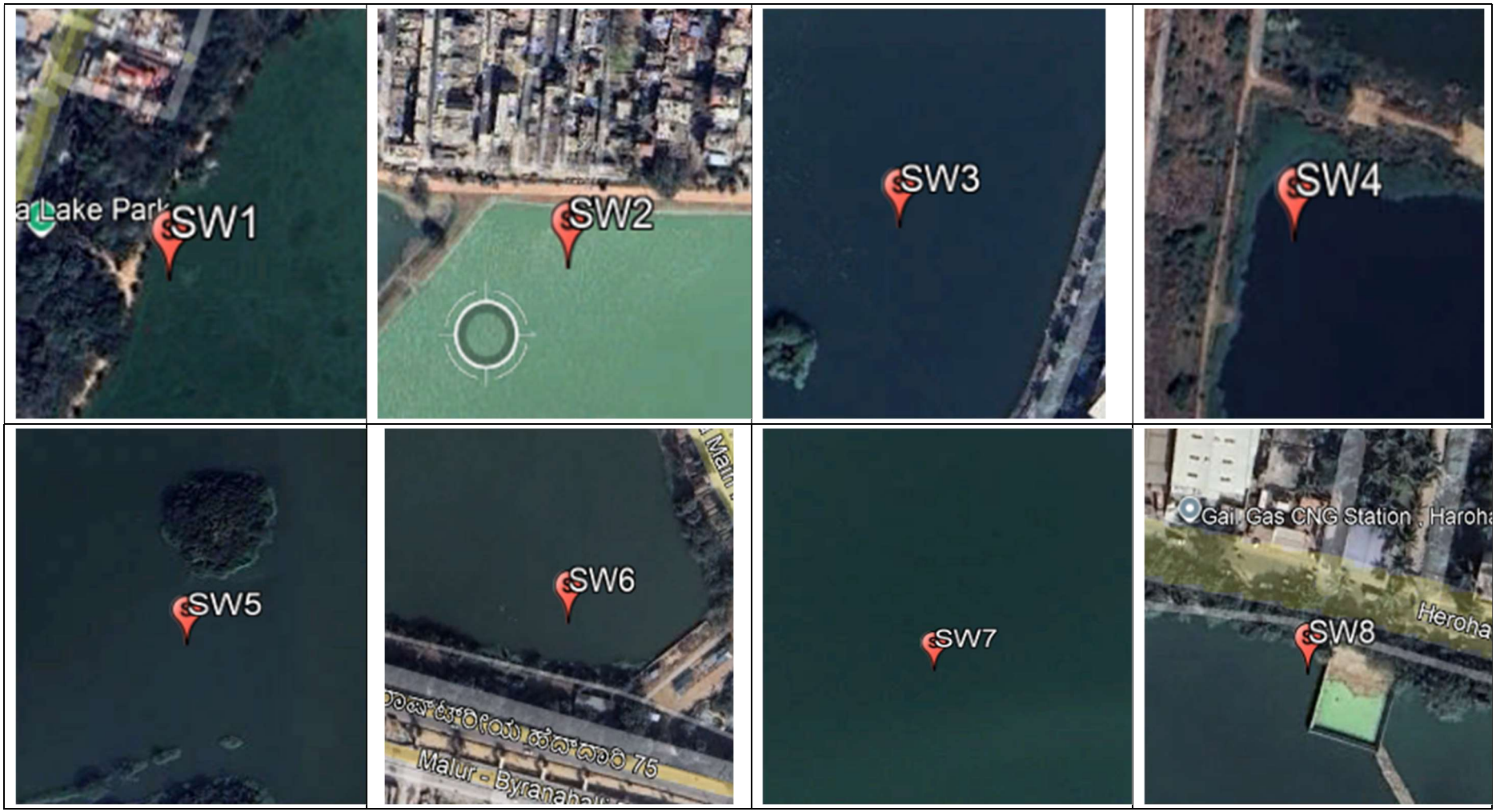
Corridor	S. No.	Location Name	Latitude	Longitude	Distance (m)	LHS/RHS	Selection criteria
SW1	Line 3-1	Madiwala Lake	12°54'21.20"N	77° 36' 47.50"E	1480	LHS	Lake
SW2	Line 3-1	Sarakki Lake	12° 54' 5.05"N	77° 34' 52.36"E	542	LHS	Lake
SW3	Line 3-1	ITI Layout 3rd Phase Lake	12° 56'19.58"N	77° 31' 14.63"E	840	LHS	Lake
SW4	Line 3-2	Sulikere	12° 56'51.76"N	77° 27' 40.05"E	3890	LHS	Lake
SW5	Line 3-1	Hebbal Lake	13° 2' 41.46"N	77° 35' 26.23"E	290	LHS	Lake
SW6	Line 3-1	Nagavara Lake	13° 2' 39.00"N	77° 36' 29.00"E	570	LHS	Lake
SW7	Line 3-1	Rachenahalli Lake	13° 3' 52.00"N	77° 36' 38.00"E	2398	LHS	Lake
SW8	Line 3-2	Herohalli	12° 59'24.71"N	77° 29' 28.82"E	363	LHS	Lake
SW9	Line 3-1	Chikkabanavara Lake	13° 5' 9.08"N	77° 30' 21.72"E	5907	LHS	Lake
SW10	Line 3-1	Doddabommasandra Lake	13° 3' 51.00"N	77° 33' 35.00"E	1725	LHS	Lake
SW11	Line 3-1	Goundana Lake	12° 54'25.22"N	77° 33' 23.97"E	1188	LHS	Lake
SW12	Line 3-1	DeepanjaliNagara Lake	12° 56'58.72"N	77° 31' 51.69"E	481	RHS	Lake
SW13	Line 3-2	Lake near Mayamma Devi's Temple	12° 58'36.75"N	77° 26' 57.72"E	1003	LHS	Lake
SW14	Line 3-2	Chenanahalli Lake	12° 58'46.08"N	77° 25' 44.37"E	2136	RHS	Lake

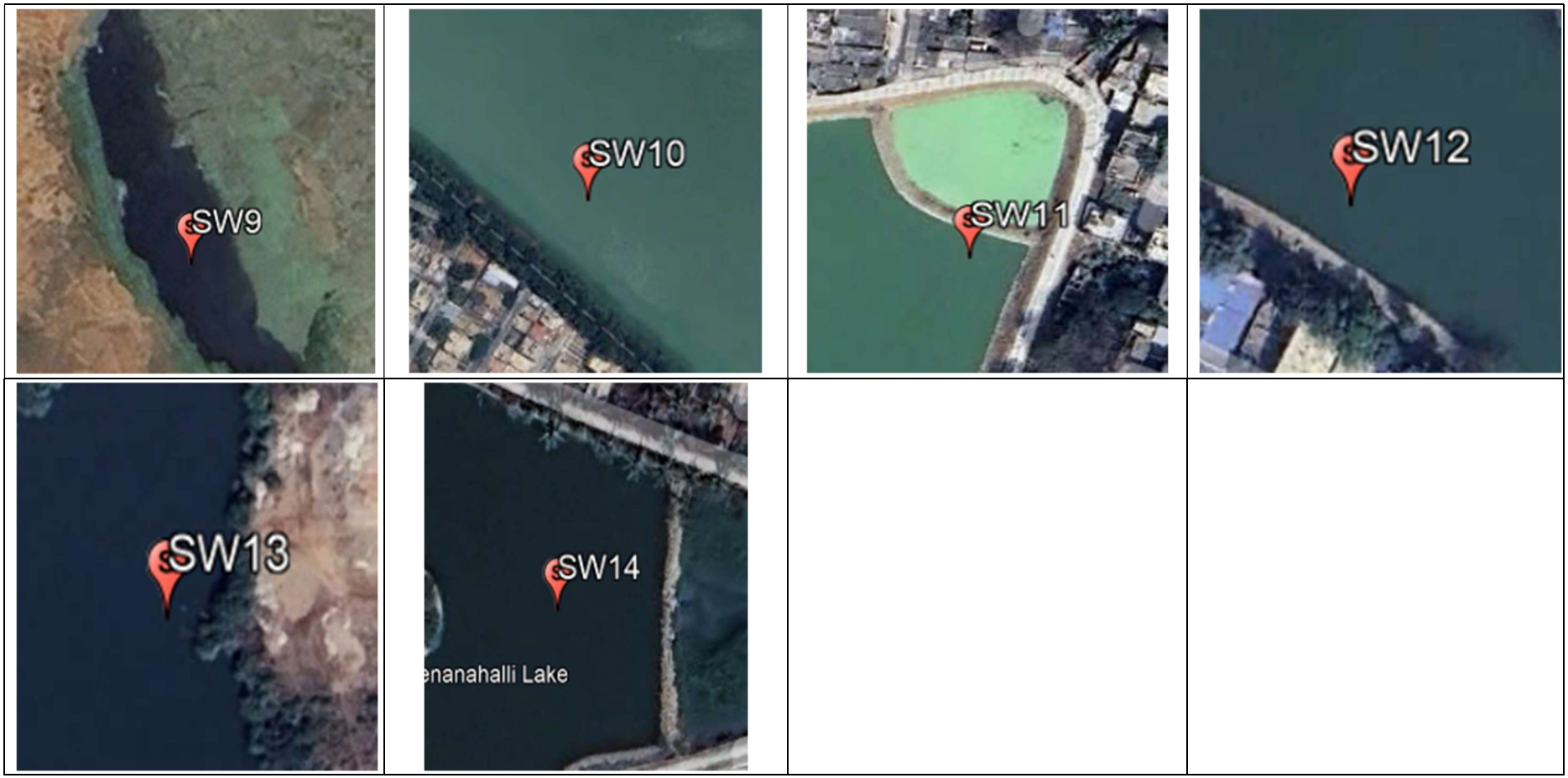
Source: JST



Source: JST based on Google Earth

Figure7-8: Map showing Surface Water Sampling Locations (Lines 3-1 and 3-2)


SW1
SW2
SW3
SW4
SW5
SW6
SW7
SW8
Malur - Byrana
Gail Gas CNG Station , Haroha
Heroha



Source: JST based on Google Earth

Figure7-9: Surface Water Sampling Locations (Zoomed In)

(2) Primary Data Survey Results for Dry Season

The surface water quality data reveals significant pollution, particularly in sites like SW4, SW7, and SW8. pH levels (7.3–9.1) exceed the permissible limit of 8.5 at several locations, indicating alkaline conditions. TDS (218–1,044 mg/L), chloride (36–229 mg/L), and hardness (83–527 mg/L) are elevated but within permissible limits, though above desirable levels. Critically, BOD reaches up to 320 mg/L (well above 3 mg/L limit), DO drops to 1.3 mg/L, and iron exceeds the limit (up to 4.4 mg/L), signaling severe organic pollution and unsuitability for drinking or aquatic life without treatment.

The water quality across 27 locations is generally safe, with no detectable levels of toxic contaminants like lead, arsenic, or E. coli, and most parameters within IS:10500:2012 limits. However, GW-14 shows elevated nitrate (28.9 mg/L) and TDS (1320 mg/L), likely due to agricultural or mineral sources, while GW-17 has high total coliforms (32 CFU/100 mL), indicating microbial contamination. Immediate investigation and remediation at these sites are recommended to ensure drinking water safety.

1) Surface Water Sampling Results

- **pH**: The pH levels ranged from 7.3 to 9.1, not 6.99–7.72. Values above 8.5 (e.g., SW2: 8.9, SW3: 9.1, SW6: 9.1, SW5: 8.8) exceed the permissible limit of 8.5 as per IS:10500-2012. This indicates alkaline conditions, likely due to dissolved minerals, carbonate/bicarbonate ions, or industrial inputs — not slightly alkaline as previously stated.
- **Total Dissolved Solids (TDS)**: TDS ranged from 218 to 1,044 mg/L, not 658–8744 mg/L. While SW4 (1,044 mg/L) exceeds the desirable limit of 500 mg/L, all values are below the permissible limit of 2,000 mg/L. There is no evidence of extreme salinity as claimed; values are moderately elevated but not critically high.
- **Total Hardness (as $CaCO_3$)**: Hardness ranged from 83 to 527 mg/L, not 368.9–3920.88 mg/L. Only SW4 (527 mg/L) exceeds the desirable limit of 200 mg/L and approaches the permissible limit of 600 mg/L, indicating moderate to high hardness, likely due to calcium and magnesium. However, "severe hardness" is overstated, and values are far below 3920 mg/L.
- **Dissolved Oxygen (DO)**: DO levels ranged from 1.3 to 7.3 mg/L. Several locations (e.g., SW7: 2.4 mg/L, SW8: 1.3 mg/L) fall below the 5 mg/L threshold required for healthy aquatic life, indicating poor aeration and organic pollution — this part is partially correct, though the minimum value was misstated as 0.1 mg/L.
- **Biochemical Oxygen Demand (BOD)**: BOD ranged from 2.2 to 320 mg/L, not 20–132 mg/L. The permissible limit for inland surface waters (especially for bathing or ecosystem health) is typically 3 mg/L; thus, most locations exceed this, with SW14 (320 mg/L) showing extreme organic pollution, likely from untreated sewage or industrial discharge — this reflects very high organic load, which is accurate in essence.
- **Chloride (as Cl^-)**: Chloride levels ranged from 36 to 229 mg/L, not 176–3685 mg/L. While SW4 (229 mg/L) is close to the desirable limit of 250 mg/L, no location exceeds the

permissible limit of 1,000 mg/L. There is no evidence of saline water intrusion or severe chloride contamination; levels are relatively low to moderate.

2) Groundwater Sampling Results

- **pH**: The pH of groundwater across the sampled locations ranged from 6.5 to 8.3, indicating slightly acidic to alkaline conditions. While most values are within the desirable range (6.5-8.5), GW-7 (pH 8.3) and GW-27 (pH 8.1) are at the higher end, and GW-9 (pH 6.7) is near the lower limit.
- **Total Hardness**: Not directly provided in the table but can be estimated from calcium and magnesium (not available here). However, Total Alkalinity as CaCO,ÇÉ - often used as an indicator of hardness - ranged from 113 to 488 mg/L, suggesting moderate to high hardness in several locations (e.g., GW-14: 488 mg/L).
- **Total Dissolved Solids (TDS)**: TDS levels varied widely from 257 mg/L to 1,320 mg/L. Several locations (e.g., GW-14: 1,320 mg/L) exceed the desirable limit of 500 mg/L, though all are below the permissible limit of 2,000 mg/L.
- **Chlorides**: Chloride concentrations ranged from 28 mg/L to 260 mg/L. Most values are within the permissible limit of 1,000 mg/L, but GW-16 (260 mg/L) exceeds the desirable limit of 250 mg/L.
- **Alkalinity**: Total alkalinity as CaCO,ÇÉ ranged from 113 mg/L to 488 mg/L, with GW-14 showing the highest value (488 mg/L), exceeding the desirable limit of 200 mg/L but below the permissible limit of 600 mg/L.
- **Nitrates (as NO,ÇÉ)**: Levels ranged from 2.6 mg/L to 28.9 mg/L, with GW-14 (28.9 mg/L) approaching the permissible limit of 45 mg/L. All values are within acceptable limits.
- **Sulphates (as SO,ÇÑ)**: Concentrations ranged from 6 mg/L to 96 mg/L, well below the permissible limit of 400 mg/L.
- **E. coli**: Not detected in any sample (<1 CFU/100 mL), indicating absence of recent fecal contamination.
- Total Coliforms: Absent in all locations.

(3) Primary Data Survey Results for Wet Season

1) Surface water Sampling Results

- **pH**: Ranges from 7.3 to 8.6, with most values slightly alkaline but within the desirable range of 6.5–8.5. However, SW3 (8.6) and SW6 (8.5) are at the upper limit.
- **Turbidity**: Values vary from 2.8 NTU to 85 NTU, with several locations exceeding the desirable limit of 1 NTU. High turbidity in SW6 (85 NTU) and SW7 (66.3 NTU) suggests suspended solids or organic matter.
- **Total Dissolved Solids (TDS)**: TDS levels range from 238 mg/L to 764 mg/L, all below the permissible limit of 2,000 mg/L. While most are within acceptable limits, SW7 (764 mg/L) exceeds the desirable limit of 500 mg/L.

- **Total Hardness**: Hardness varies from 126 mg/L to 348 mg/L as $CaCO_3$, mostly within the desirable limit of 200 mg/L. Only SW13 (348 mg/L) approaches the permissible limit of 600 mg/L.
- **Chloride**: Concentrations range from 25 mg/L to 150 mg/L, all below the permissible limit of 1,000 mg/L. Most values are well within the desirable limit of 250 mg/L.
- **Dissolved Oxygen (DO)**: DO levels range from 2.8 mg/L to 6.5 mg/L, with SW7 (2.8 mg/L) falling below the minimum required level of 5 mg/L for healthy aquatic life, indicating poor aeration and possible organic pollution.
- **Biochemical Oxygen Demand (BOD)**: BOD values range from 4.2 mg/L to 8.8 mg/L, all below the permissible limit of 3 mg/L for inland waters, though higher values suggest moderate organic pollution.

2) Groundwater Sampling Results

- **pH**: The pH values ranged from 6.6 to 8.1, not 6.5–8.3 as previously stated. Most locations fall within the desirable range of 6.5–8.5 (IS:10500-2012). GW-7 (pH 8.1) is at the upper limit, while GW-9 (pH 6.6) is near the lower end. No location exceeds the permissible pH range, so water is slightly acidic to alkaline but generally acceptable.
- **Total Hardness**: Although not directly listed, total hardness can be estimated from calcium and magnesium data. However, in this dataset, "Total Hardness as $CaCO_3$" is missing, but
- **Total Alkalinity**: Total Alkalinity as $CaCO_3$ ranged from 106 to 440 mg/L, with GW-14 (440 mg/L) exceeding the desirable limit of 200 mg/L but below the permissible limit of 600 mg/L. Alkalinity is often correlated with hardness, so high alkalinity suggests moderate to high hardness, especially in GW-14.
- **Total Dissolved Solids (TDS)**: TDS levels ranged from 230 mg/L to 1,280 mg/L. Several locations (e.g., GW-14: 1,280 mg/L) exceed the desirable limit of 500 mg/L, though all are below the permissible limit of 2,000 mg/L. High TDS may affect taste and indicate mineral-rich or contaminated water.
- **Chlorides (as Cl^-)**: Chloride concentrations ranged from 38 mg/L to 196 mg/L (not 28–260 mg/L). All values are well below the permissible limit of 1,000 mg/L, and none exceed the desirable limit of 250 mg/L. Earlier mention of GW-16 at 260 mg/L is incorrect—this value does not appear in the current dataset.
- **Alkalinity**: As above, Total Alkalinity ranged from 106 to 440 mg/L, with GW-14 showing the highest value. This confirms high buffering capacity and likely high carbonate/hardness, but still within permissible limits.
- **Nitrates (as NO_3)**: Nitrate levels ranged from 3.2 mg/L to 32.4 mg/L, not 2.6–28.9 mg/L. GW-14 (32.4 mg/L) is closer to the permissible limit of 45 mg/L, raising concern for potential agricultural or sewage contamination. Still within limits but warrants monitoring.
- **Sulphates (as SO_4)**: Sulphate concentrations ranged from 8 mg/L to 80 mg/L, not 6–96 mg/L. All values are well below the permissible limit of 400 mg/L, indicating no risk from sulphate-related laxative effects or corrosion.

- **Fluoride (as F^-)**: A critical parameter missing in the original summary. Fluoride ranged from 0.24 mg/L to 13.4 mg/L. GW-19 has 13.4 mg/L, which is 9 times higher than the permissible limit of 1.5 mg/L, posing a severe health risk (dental/skeletal fluorosis). This is one of the most serious findings.
- **Iron (as Fe)**: Iron levels ranged from BDL to 0.56 mg/L, with GW-19 exceeding the permissible limit of 1.0 mg/L (still within limit, but close). High iron can cause staining and metallic taste.
- **Turbidity**: Turbidity ranged from 0.2 NTU to 7.6 NTU. GW-19 (7.6 NTU) exceeds the permissible limit of 5 NTU, indicating suspended solids or poor filtration.
- **E. coli**: Not detected in any sample (<1 CFU/100 mL), indicating no recent fecal contamination—this part is correct.
- **Total** Coliforms: Absent in all locations

(4) Comparison of Dry and Wet season

Surface Water Interpretation (Dry vs. Wet Season):

During the dry season, surface water shows severe pollution with high BOD (up to 320 mg/L), low DO (as low as 1.3 mg/L), and elevated pH (>8.5) at several sites, indicating concentrated organic waste and alkaline conditions due to minimal dilution. In contrast, the wet season brings improved DO, lower BOD, and reduced TDS and chloride due to rainwater dilution. However, turbidity increases significantly (up to 85 NTU), reflecting runoff and soil erosion. While overall surface water quality improves in the wet season, persistent issues at sites like SW7 and SW8 suggest ongoing pollution sources.

Groundwater Interpretation (Dry vs. Wet Season):

In the dry season, groundwater is generally safe, with only localized issues like elevated nitrate (GW-14) and coliforms (GW-17). During the wet season, nitrate levels rise further (up to 32.4 mg/L), pointing to agricultural leaching. Most critically, fluoride—previously unreported—is found at dangerous levels (13.4 mg/L in GW-19), posing a serious health risk. Total coliform and E. coli remains absent.

Table7-8: Surface Water Quality Sampling Results for Dry Season

SN	Test Parameters	Unit	Locations							National CPCB	Inter'l WB & EHS
			SW1	SW2	SW3	SW4	SW5	SW6	SW7		
1	Color	Hz	BDL	10	BDL	BDL	BDL	10	25	-	-
2	Odor	---	Agreeable	Agreeable	Agreeable	Agreeable	Non-Agreeable	Non-Agreeable	Agreeable	-	-
3	pH value	---	7.6	8.9	9.1	8.2	8.8	9.1	8.9	5.5-9	6-.9
4	Turbidity	NTU	8.6	7.8	2.4	7.4	9.8	8.8	26	-	-
5	Conductivity	µS/cm	908	888	778	1740	363	635	1255	2250	-
6	Total Dissolved Solids	mg/L	544	532	467	1044	218	380	754	-	-
7	Total Alkalinity as $CaCO_3$	mg/L	220	222	162	455	98	158	310	-	-
8	Total Hardness as $CaCO_3$	mg/L	192	152	131	527	98	162	277	-	-
9	Calcium as Ca	mg/L	44	33	29	140	21	40	63	-	-
10	Magnesium as Mg	mg/L	20	17	14	43	11	15	29	-	-
11	Chloride as Cl	mg/L	130	119	83	229	36	88	132	-	-
12	Sulphate as SO_4	mg/L	28	32	21	39	8	22	46	-	-
13	Nitrates as NO_3	mg/L	6.9	17.4	5.6	9.3	2.6	8.8	22.8	-	-
14	Iron as Fe	mg/L	0.46	1.5	0.36	2.8	2.84	3.2	3.1	3.0	30
15	Copper (as Cu)	mg/L	0.014	0.014	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.011	0.021	0.032	3.0	-
16	Manganese (as Mn)	mg/L	0.028	0.024	0.015	0.909	0.012	0.018	0.041	2.0	-
17	Hexavalent chromium (as Cr^{+6})	mg/L	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-

SN	Test Parameters	Unit	Locations							National CPCB	Inter'l WB & EHS
			SW1	SW2	SW3	SW4	SW5	SW6	SW7		
18	Zinc (as Zn)	mg/L	0.042	0.036	BLQ (LOQ=0.01)	0.033	0.031	0.038	0.058	5.0	-
19	Lead (as Pb)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.1	-
20	Dissolved Oxygen	mg/L	5.5	6	7.3	6.6	5.5	4.5	2.4	-	-
21	Potassium (as K)	mg/L	6	31	20	24	16	19	36	-	-
22	Sodium (as Na)	mg/L	130	97	97	190	42	68	180	-	-
23	Cadmium (as Cd)	mg/L	BLQ (LOQ=0.03)	BLQ (LOQ=0.03)	BLQ (LOQ=0.03)	BLQ (LOQ=0.03)	BLQ (LOQ=0.03)	BLQ (LOQ=0.03)	BLQ (LOQ=0.03)	2.0	-
24	Bio-Chemical Oxygen Demand	mg/L	9.6	4.2	6.8	7.8	19	28	80	30	30
	(5days @ 20ºC)										
25	Chemical Oxygen Demand	mg/L	52	28	32	48	104	136	288	250	125
26	Mercury	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.01	*1
Note: *BLQ; Below Limit of Quantification; LOQ: Limit of Quantification,*											
Remarks: *The Above Sample meets to Acceptable Limits as Per IS 10500:2012 for the above Physico- chemical tests*											
Source*: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results*											

Table7-9: Surface Water Quality Sampling Results for Dry Season

SN	Test Parameters	Unit	Locations							National CPCB	Inter'l WB & EHS
			SW8	SW9	SW10	SW11	SW12	SW13	SW14		
1	Color	Hz	100	BDL	10	10	BDL (DL=1.0)	50	100	-	-
2	Odor	---	Agreeable	Agreeable	Non Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-	-
3	pH value	---	7.8	7.5	8.8	8.2	7.4	8.4	7.3	5.5-9	6-.9
4	Turbidity	NTU	56	1.9	8.6	8.7	0.6	36.3	82	-	-
5	Conductivity	µS/cm	618	784	563	1467	1090	490	1316	2250	-
6	Total Dissolved Solids	mg/L	370	470	338	880	652	294	790	-	-
7	Total Alkalinity as $CaCO_3$	mg/L	144	160	136	467	242	63	280	-	-
8	Total Hardness as $CaCO_3$	mg/L	156	134	113	420	355	83	274	-	-
9	Calcium as Ca	mg/L	41	30	22	111	76	23	57	-	-
10	Magnesium as Mg	mg/L	13	14	14	35	40	6	32	-	-
11	Chloride as Cl	mg/L	78	88	62	198	152	67	136	-	-
12	Sulphate as SO_4	mg/L	18	20	18	65	38	9	44	-	-
13	Nitrates as NO_3	mg/L	5.7	6.2	3.2	8.1	19.2	5.9	18.2	-	-
14	Iron as Fe	mg/L	4.4	0.44	3.8	1.8	0.091	2.7	3.9	3.0	30

SN	Test Parameters	Unit	Locations							National CPCB	Inter'l WB & EHS
			SW8	SW9	SW10	SW11	SW12	SW13	SW14		
15	Copper (as Cu)	mg/L	0.018	BLQ	0.018	BLQ (LOQ=0.01)	0.018	BLQ (LOQ=0.01)	0.031	3.0	-
16	Manganese (as Mn)	mg/L	0.014	0.017	0.024	0.224	0.022	0.057	0.048	2.0	-
17	Hexavalent chromium (as Cr^{+6})	mg/L	BDL (DL=0.05)	BDL	BDL	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-
18	Zinc (as Zn)	mg/L	0.021	0.017	0.028	0.016	0.052	0.014	0.062	5.0	-
19	Lead (as Pb)	mg/L	BLQ (LOQ=0.01)	BLQ	BLQ	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.1	-
20	Dissolved Oxygen	mg/L	1.3	7.1	5	3.8	6.2	3.5	BDL(DL=0.2)	-	-
21	Potassium (as K)	mg/L	17	18	18	27	4	20	24	-	-
22	Sodium (as Na)	mg/L	50	80	65	140	77	68	130	-	
23	Cadmium (as Cd)	mg/L	BLQ(LOQ=0.03)	BLQ	BLQ	BLQ (LOQ=0.03)	BLQ (LOQ=0.03)	BLQ(LOQ=0.003)	BLQ(LOQ=0.003)	2.0	-
24	Bio-Chemical Oxygen Demand (5days @ 20ºC)	mg/L	240	74	18	12	2.2	44	320	30	30
25	Chemical Oxygen Demand	mg/L	760	36	144	72	16	160	720	250	125
26	Mercury	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.01	*1

Note: *BLQ; Below Limit of Quantification; LOQ: Limit of Quantification,*

Remarks: *The Above Sample meets to Acceptable Limits as Per IS 10500:2012 for the above Physico- chemical tests*

Source*: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results*

Table7-10: Surface Water Quality Sampling Results for Wet Season

SN	Test Parameters	Unit	Locations							National CPCB	Inter'l WB & EHS
			SW1	SW2	SW3	SW4	SW5	SW6	SW7		
1	Color	Hz	5	10	5	BDL (DL=1.0)	10	25	50	--	-
2	Odor	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-	-
3	pH value	---	7.7	8.3	8.6	7.9	7.4	8.5	7.5	5.5-9	6-.9
4	Turbidity	NTU	6.3	18.6	13.9	8.6	26.9	85	66.3	-	-
5	Conductivity	µS/cm	808	676	769	765	397	545	1274	2250	-
6	Total Dissolved Solids	mg/L	485	406	461	460	238	327	764	-	-
7	Total Alkalinity as $CaCO_3$	mg/L	244	140	168	160	126	146	324	-	-
8	Total Hardness as $CaCO_3$	mg/L	174	132	166	198	126	168	269	-	-
9	Calcium as Ca	mg/L	43	30	31	26	34	33	61	-	-
10	Magnesium as Mg	mg/L	16	14	20	32	10	21	27	-	-
11	Chloride as Cl	mg/L	73	73	85	80	33	52	150	-	-
12	Sulphate as SO_4	mg/L	10	35	28	27	22	63	5	-	-
13	Nitrates as NO_3	mg/L	4.2	5.6	5.2	3.4	2.8	3.4	3.6	-	-
14	Iron as Fe	mg/L	1.3	1.2	0.35	0.81	1.2	1.44	1.3	3.0	30
15	Copper (as Cu)	mg/L	0.012	0.012	0.011	0.018	BLQ (DL=0.05)	0.021	0.012	3.0	-
16	Manganese (as Mn)	mg/L	0.014	0.021	0.024	0.02	0.014	0.018	0.021	2.0	-
17	Hexavalent chromium (as Cr^{+6})	mg/L	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-

SN	Test Parameters	Unit	Locations							National CPCB	Inter'l WB & EHS
			SW1	SW2	SW3	SW4	SW5	SW6	SW7		
18	Zinc (as Zn)	mg/L	0.031	0.034	BLQ (LOQ=0.01)	0.042	0.021	0.042	0.024	5.0	-
19	Lead (as Pb)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.1	-
20	Dissolved Oxygen	mg/L	6.2	6.1	6	6.36	5.9	6	2.8	-	-
21	Potassium (as K)	mg/L	56	48	62	60	26	30	78	-	-
22	Sodium (as Na)	mg/L	10	9	13	8	6	6	12	-	-
23	Cadmium (as Cd)	mg/L	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	2.0	-
24	Bio-Chemical Oxygen Demand (5days @ 20ºC)	mg/L	6.8	4.2	6.2	4.2	8.4	8.8	22	30	30
25	Chemical Oxygen Demand	mg/L	30	24	28	24	42	60	140	250	125
26	Mercury	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.01	*1
Note: BLQ; Below Limit of Quantification; LOQ: Limit of Quantification,											
Remarks: The Above Sample meets to Acceptable Limits as Per IS 10500:2012 for the above Physico- chemical tests											
***Source**: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results*											

Table7-11: Surface Water Quality Sampling Results for Wet Season

SN	Test Parameters	Unit	Locations							National CPCB	Inter'l WB & EHS
			SW8	SW9	SW10	SW11	SW12	SW13	SW14		
1	Color	Hz	25	10	15	15	BDL (DL=1.0)	5	BDL (DL=1.0)	-	-
2	Odor	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-	-
3	pH value	---	8.3	7.3	7.8	8.7	7.9	7.8	8.5	5.5-9	6-.9
4	Turbidity	NTU	54.3	52	42	59	8	10.4	5.6	-	-
5	Conductivity	µS/cm	584	479	519	314	519	1286	516	2250	-
6	Total Dissolved Solids	mg/L	351	287	311	188	311	772	310	-	-
7	Total Alkalinity as $CaCO_3$	mg/L	144	112	120	116	190	420	134	-	-
8	Total Hardness as $CaCO_3$	mg/L	164	100	154	126	208	348	134	-	-
9	Calcium as Ca	mg/L	37	25	37	26	63	77	31	-	-
10	Magnesium as Mg	mg/L	17	9	15	15	12	38	14	-	-
11	Chloride as Cl	mg/L	60	47	52	25.0.	14	110	48	-	-
12	Sulphate as SO_4	mg/L	17	48	30	5	56	54	22	-	-
13	Nitrates as NO_3	mg/L	4	3.2	24.2	5.2	4.4	10.6	2.7	-	-
14	Iron as Fe	mg/L	1.96	6.8	1.8	1.9	1.7	0.44	0.41	3.0	30
15	Copper (as Cu)	mg/L	BLQ (LOQ=0.01)	0.015	0.014	BLQ (LOQ=0.01)	0.01	0.014	0.011	3.0	-
16	Manganese (as Mn)	mg/L	0.021	0.032	0.024	BLQ (LOQ=0.01)	0.018	0.018	0.24	2.0	-
17	Hexavalent chromium (as Cr^{+6})	mg/L	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-
18	Zinc (as Zn)	mg/L	0.041	0.072	0.034	0.011	0.018	0.028	0.038	5.0	-
19	Lead (as Pb)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.1	-
20	Dissolved Oxygen	mg/L	5.1	6.5	5.6	5.5	6.1	5.7	5.4	-	-
21	Potassium (as K)	mg/L	28	24	32	24	27	69	32	-	-
22	Sodium (as Na)	mg/L	7	5	7	6	8	12	7	-	-
23	Cadmium (as Cd)	mg/L	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	BLQ (LOQ=0.003)	2.0	-

SN	Test Parameters	Unit	Locations							National CPCB	Inter'l WB & EHS
			SW8	SW9	SW10	SW11	SW12	SW13	SW14		
24	Bio-Chemical Oxygen Demand (5days @ 20ºC)	mg/L	12	6.2	8.2	8.8	7.6	8.2	4.6	30	30
25	Chemical Oxygen Demand	mg/L	68	30	56	76	38	58	24	250	125
26	Mercury	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.01	*1

Source: JST

Table7-12: Ground Water Quality Sampling Results for Dry Season

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	GW-8	GW-9		
1	Color	Hazen	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	5	-
2	Odor	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
3	Taste	NTU	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
4	pH value	mg/L	7.4	7.6	7.5	7.2	7.5	7.5	8.3	7.7	6.7	6.5 to 8.5	-
5	Turbidity	mg/L	0.8	0.6	0.6	0.5	0.6	0.9	0.6	0.4	0.1	1	-
6	Total Dissolved Solids	mg/L	528	614	880	792	796	576	257	762	312	500	-
7	Total Alkalinity as $CaCO_3$	mg/L	256	290	366	360	332	210	113	358	120	200	-
8	Hexavalent chromium (aCr^{+6})	mg/L	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-
9	Chloride as Cl	mg/L	116	160	130	188	132	112	46	182	74	250	-
10	Sulphate as SO_4	mg/L	30	38	36	60	56	44	15	66	10	200	-
11	Nitrates as NO_3	mg/L	8.8	8.5	12.2	19.3	18.6	13.8	4.6	20.6	2.6	45	50
12	Fluoride as F	mg/L	0.36	0.44	0.44	0.54	0.46	0.44	0.28	0.48	0.27	1.0	1.5
13	Iron as Fe	mg/L	0.085	0.085	0.079	0.079	0.091	0.086	0.079	0.079	BDL (DL=0.075)	1.0	-
14	Boron (as B)	mg/L	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	0.5	-
15	Cyanide (as CN)	mg/L	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	0.05	(*1)
16	Aluminium (as Al)	mg/L	0.024	0.032	0.046	0.038	0.042	0.026	0.012	0.032	0.013	0.03	(*2)
17	Copper (as Cu)	mg/L	0.011	0.021	BLQ	0.014	0.012	0.011	0.032	0.012	0.011	0.05	2.0

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	GW-8	GW-9		
					(LOQ=0.01)								
18	Manganese (as Mn)	mg/L	0.028	0.018	0.186	0.028	0.014	0.017	BLQ (LOQ=0.01)	0.014	0.012	0.1	(*3)
19	Zinc (as Zn)	mg/L	0.028	0.038	0.19	0.052	0.52	0.042	BLQ	0.032	0.032	5	-
20	Lead (as Pb)	mg/L	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	0.01	0.01 (A.T)
21	Total arsenic (as As)	mg/L	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	LQ (LOQ=0.01)	0.01	0.01 (A,T)
22	Cadmium (as Cd)	mg/L	BLQ (LOQ=0.0003)	BLQ (LOQ=0.0003)	BLQ (LOQ=0.0003)	BLQ (LOQ=0.0003)	BLQ (LOQ=0.0003)	BLQ (LOQ=0.0003)	BLQ (LOQ=0.0003)	BLQ (LOQ=0.0003)	BLQ (LOQ=0.0003)	0.003	0.003
23	Escherichia coli	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	(*4)
24	Total Coliforms	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-
25	Phenolic compounds (as C_6H_5OH)	mg/L	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	0.001	-
26	Mercury (as Hg)	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ(LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.001	0.07
27	Anionic detergents (as MBAS)	mg/L	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	0.2	-
Note: BDL: Below detection Limit DL: Detection Limit; BLQ; Below Limit of Quantification; LOQ: Limit of Quantification,													
Remarks: The Above Sample meets to Acceptable Limits as Per IS 10500:2012 for the above Physico- chemical tests													
Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results													

Table7-13: Ground Water Quality Sampling Results for Dry Season

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-10	GW-11	GW-12	GW-13	GW-14	GW-15	GW-16	GW-17	GW-18		
1	Color	Hazen	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	5	-
2	Odor	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
3	Taste	NTU	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
4	pH value	mg/L	7.9	7.5	7.4	7.8	7.2	7.4	7.7	7.4	7.7	6.5 to 8.5	-
5	Turbidity	mg/L	0.9	1.4	BDL(DL=0.1)	0.5	0.8	0.8	0.9	0.8	0.2	1	-
6	Total Dissolved Solids	mg/L	660	768	561	658	1320	905	936	714	396	500	-
7	Total_ Alkalinity_as_ $CaCO_3$	mg/L	310	340	200	280	488	410	480	318	170	200	-
8	Hexavalent chromium (aCr^{+6})	mg/L	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-
9	Chloride as Cl	mg/L	160	182	144	188	218	202	260	138	68	250	-
10	Sulphate as SO_4	mg/L	40	58	22	60	96	61	70	40	12	200	
11	Nitrates as NO_3	mg/L	21.4	21.8	6.6	12.1	28.9	26.3	15.2	12.6	4	45	50
12	Fluoride as F	mg/L	0.5	0.62	0.14	0.44	0.66	0.58	0.32	0.46	0.22	1.0	1.5
13	Iron as Fe	mg/L	0.1	0.13	BDL	0.079	0.12	0.096	0.091	0.085	BDL (DL=0.075)	1.0	-
14	Boron (as B)	mg/L	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	0.5	-
15	Cyanide (as CN)	mg/L	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	0.05	(*1)
16	Aluminium (as Al)	mg/L	0.014	0.021	0.017	0.028	0.052	0.018	0.052	0.034	0.021	0.03	(*2)
17	Copper (as Cu)	mg/L	0.021	0.014	0.011	0.011	0.011	0.011	0.021	0.018	0.011	0.05	2.0
18	Manganese (as Mn)	mg/L	0.032	0.024	0.014	0.012	0.024	0.012	0.038	0.022	0.021	0.1	(*3)
19	Zinc (as Zn)	mg/L	0.034	0.048	0.024	0.029	0.034	0.038	0.032	0.024	0.051	5	-

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-10	GW-11	GW-12	GW-13	GW-14	GW-15	GW-16	GW-17	GW-18		
20	Lead (as Pb)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A.T)
21	Total arsenic (as As)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A,T)
22	Cadmium (as Cd)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.003	0.003
23	Escherichia coli	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	(*4)
24	Total Coliforms	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	32	<1	-	-
25	Phenolic compounds (as C_6H_5OH)	mg/L	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	0.001	-
26	Mercury (as Hg)	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.001	0.07
27	Anionic detergents (as MBAS)	mg/L	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	0.2	-
Note: BDL: Below detection Limit DL: Detection Limit; BLQ; Below Limit of Quantification; LOQ: Limit of Quantification,													
Remarks: The Above Sample meets to Acceptable Limits as Per IS 10500:2012 for the above Physico- chemical tests													
Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results													

Table7-14: Ground Water Quality Sampling Results for Dry Season

SN	Test Parameters	Unit	Location									IS10S00; 2012	WHO Drinking Water
			GW-19	GW-20	GW-21	GW-22	GW-23	GW-24	GW-25	GW-26	GW-27		
1	Color	Hazen	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	5	-
2	Odor	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
3	Taste	NTU	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
4	pH value	mg/L	7.3	7.7	7.9	6.5	7.3	7.6	7.4	7.9	8.1	6.5 to 8.5	-
5	Turbidity	mg/L	0.3	0.1	0.7	0.2	0.6	1.1	0.4	2.1	0.1	1	-
6	Total Dissolved Solids	mg/L	486	520	750	577	516	654	962	263	286	500	-
7	Total_ Alkalinity_ as_$CaCO_3$	mg/L	236	212	330	228	220	290	410	116	140	200	-
8	Hexavalent chromium (aCr^{+6})	mg/L	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-
9	Chloride as Cl	mg/L	96	106	166	119	118	155	202	52	28	250	-
10	Sulphate as SO_4	mg/L	26	22	58	32	30	38	58	6	10	200	-
11	Nitrates as NO_3	mg/L	11.2	7.4	22.6	5.4	7.6	17.4	16	4.8	3.6	45	50
12	Fluoride as F	mg/L	0.42	0.44	0.6	0.52	0.33	0.36	0.38	0.18	0.22	1.0	1.5
13	Iron as Fe	mg/L	BDL (DL=0.075)	BDL (DL=0.075)	0.085	BDL (DL=0.075)	0.079	0.12	0.079	0.16	BDL (DL=0.075)	1.0	-
14	Boron (as B)	mg/L	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	0.5	
15	Cyanide (as CN)	mg/L	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	0.05	(*1)
16	Aluminium (as Al)	mg/L	0.018	0.024	0.014	0.012	0.019	0.014	0.032	0.014	0.014	0.03	(*2)
17	Copper (as Cu)	mg/L	0.011	0.011	0.011	0.012	0.011	0.014	0.014	BLQ (LOQ=0.01)	0.011	0.05	2.0
18	Manganese (as Mn)	mg/L	0.014	0.012	0.014	0.032	0.026	0.021	0.018	BLQ (LOQ=0.01)	0.012	0.1	(*3)

SN	Test Parameters	Unit	Location								IS10S00; 2012	WHO Drinking Water
			GW-19	GW-20	GW-21	GW-22	GW-23	GW-24	GW-25	GW-26	GW-27	
19	Zinc (as Zn)	mg/L	0.032	0.032	0.028	BLQ (LOQ=0.01)	0.028	0.032	0.032	0.018	0.024	5	-
20	Lead (as Pb)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A.T)
21	Total arsenic (as As)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A,T)
22	Cadmium (as Cd)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.003	0.003
23	Escherichia coli	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	(*4)
24	Total Coliforms	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	- 0.001	- -
25	Phenolic compounds (as C_6H_5OH)	mg/L	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	0.001	0.07
26	Mercury (as Hg)	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.2	-
27	Anionic detergents (as MBAS)	mg/L	BD L(DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	5	-
Note: BDL: Below detection Limit DL: Detection Limit; BLQ; Below Limit of Quantification ; LOQ: Limit of Quantification,													
Remarks: The Above Sample meets to Acceptable Limits as Per IS 10500:2012 for the above Physico- chemical tests													
Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results													

Table7-15: Ground Water Quality Sampling Results for Wet Season

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	GW-8	GW-9		
1	Color	Hazen	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	5	-
2	Odor	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
3	Taste	NTU	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
4	pH value	mg/L	7.6	7.5	7.3	7.6	7.8	7.7	8.1	7.4	6.6	6.5 to 8.5	-
5	Turbidity	mg/L	0.9	0.5	0.7	0.7	0.8	1.2	0.9	0.6	0.2	1	-
6	Total Dissolved Solids	mg/L	536	636	838	768	832	590	230	744	288	500	-
7	Total_ Alkalinity_ as_$CaCO_3$	mg/L	266	300	340	380	380	240	106	318	130	200	-
8	Hexavalent chromium (aCr^{+6})	mg/L	BDL (DL=0.05)	BD L(DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-
9	Chloride as Cl	mg/L	118	132	132	166	138	112	50	138	66	250	-
10	Sulphate as SO_4	mg/L	28	36	46	52	63	46	12	60	8	200	-
11	Nitrates as NO_3	mg/L	9.2	9.9	18.8	24.3	22.4	11.2	3.2	24	3.8	45	50
12	Fluoride as F	mg/L	0.42	0.49	0.56	0.6	0.5	0.36	0.3	0.5	0.36	1.0	1.5
13	Iron as Fe	mg/L	0.0092	0.077	0.077	0.077	0.077	0.098	0.077	0.077	BDL (DL=0.075)	1.0	-
14	Boron (as B)	mg/L	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	0.5	-
15	Cyanide (as CN)	mg/L	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	0.05	(*1)
16	Aluminium (as Al)	mg/L	0.018	0.038	0.042	0.042	0.038	0.032	0.018	0.034	0.012	0.03	(*2)
17	Copper (as Cu)	mg/L	0.014	0.024	0.021	0.023	0.022	0.018	0.021	0.021	BLQ (LOQ=0.01)	0.05	2.0
18	Manganese (as Mn)	mg/L	0.012	0.022	0.018	0.032	0.032	0.021	BLQ (LOQ=0.01)	0.018	BLQ (LOQ=0.01)	0.1	(*3)

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	GW-8	GW-9		
19	Zinc (as Zn)	mg/L	0.032	0.045	0.056	0.064	0.062	0.062	0.022	0.072	0.041	5	-
20	Lead (as Pb)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A.T)
21	Total arsenic (as As)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A,T)
22	Cadmium (as Cd)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.003	0.003
23	Escherichia coli	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	(*4)
24	Total Coliforms	CFU/100 ml	<1	<1	<1	<1	<1	27	<1	<1	<1	-	-
25	Phenolic compounds (as C_6H_5OH)	mg/L	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	0.001	-
26	Mercury (as Hg)	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.001	0.07
27	Anionic detergents (as MBAS)	mg/L	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	0.2	-
Note: BDL: Below detection Limit DL: Detection Limit; BLQ; Below Limit of Quantification; LOQ: Limit of Quantification,													
Remarks: The Above Sample meets to Acceptable Limits as Per IS 10500:2012 for the above Physico- chemical tests													
Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results													

Table7-16: Ground Water Quality Sampling Results for Wet Season

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-10	GW-11	GW-12	GW-13	GW-14	GW-15	GW-16	GW-17	GW-18		
1	Color	Hazen	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	5	-
2	Odor	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
3	Taste	NTU	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
4	pH value	mg/L	8	7.4	7.5	7.5	7.5	7.7	7.9	7.6	7.8	6.5 to 8.5	-
5	Turbidity	mg/L	1	1.7	BDL(DL=0.1)	0.7	0.9	1.2	1.2	0.7	0.2	1	-
6	Total Dissolved Solids	mg/L	652	736	588	688	1280	932	922	736	298	500	-
7	Total_ Alkalinity_ as_$CaCO_3$	mg/L	302	320	210	296	440	380	456	310	110	200	-
8	Hexavalent chromium (aCr^{+6})	mg/L	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-
9	Chloride as Cl	mg/L	144	170	132	138	196	188	196	122	38	250	-
10	Sulphate as SO_4	mg/L	58	55	24	52	80	62	58	38	9	200	-
11	Nitrates as NO_3	mg/L	12.8	22.8	7.2	18.2	32.4	30.4	17.8	13.9	4.4	45	50
12	Fluoride as F	mg/L	0.42	0.66	0.24	0.66	0.7	0.63	0.44	0.42	0.3	1.0	1.5
13	Iron as Fe	mg/L	0.1	0.14	BDL (DL=0.075)	0.077	0.1	0.12	0.082	0.077	BDL (DL=0.075)	1.0	-
14	Boron (as B)	mg/L	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	0.5	-
15	Cyanide (as CN)	mg/L	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	0.05	(*1)
16	Aluminium (as Al)	mg/L	0.018	0.018	0.022	0.032	0.074	0.042	0.044	0.044	0.048	0.03	(*2)
17	Copper (as Cu)	mg/L	0.013	0.013	0.01	0.014	0.028	0.028	0.027	0.032	0.024	0.05	2.0
18	Manganese (as Mn)	mg/L	0.011	0.012	0.018	0.021	0.042	0.021	0.028	0.018	0.018	0.1	(*3)

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-10	GW-11	GW-12	GW-13	GW-14	GW-15	GW-16	GW-17	GW-18		
19	Zinc (as Zn)	mg/L	0.048	0.039	0.033	0.058	0.104	0.072	0.074	0.062	0.078	5	-
20	Lead (as Pb)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A.T)
21	Total arsenic (as As)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A,T)
22	Cadmium (as Cd)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.003	0.003
23	Escherichia coli	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	(*4)
24	Total Coliforms	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-
25	Phenolic compounds (as C_6H_5OH)	mg/L	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BD L(DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	0.001	-
26	Mercury (as Hg)	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.001	0.07
27	Anionic detergents (as MBAS)	mg/L	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	0.2	-
Note: BDL: Below detection Limit DL: Detection Limit; BLQ; Below Limit of Quantification; LOQ: Limit of Quantification,													
Remarks: The Above Sample meets to Acceptable Limits as Per IS 10500:2012 for the above Physico- chemical tests													
Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results													

Table7-17: Ground Water Quality Sampling Results for Wet Season

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-19	GW-20	GW-21	GW-22	GW-23	GW-24	GW-25	GW-26	GW-27		
1	Color	Hazen	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	BDL (DL=1.0)	5	
2	Odor	---	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	
3	Taste	NTU	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	-
4	pH value	mg/L	7.6	7.4	7.8	7.2	7.5	7.5	7.7	8.1	7.8	6.5 to 8.5	-
5	Turbidity	mg/L	0.2	0.3	0.8	0.3	0.7	1.4	0.3	2.6	0.2	1	-
6	Total Dissolved Solids	mg/L	440	544	798	588	532	670	980	238	298	500	-
7	Total_ Alkalinity_ as_$CaCO_3$	mg/L	226	226	356	210	232	320	420	96	110	200	-
8	Hexavalent chromium (aCr^{+6})	mg/L	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	BDL (DL=0.05)	0.1	-
9	Chloride as Cl	mg/L	88	96	138	102	109	144	192	48	38	250	-
10	Sulphate as SO_4	mg/L	22	30	66	36	39	42	60	7	9	200	-
11	Nitrates as NO_3	mg/L	13.4	6.6	20.4	6.8	9.3	15.8	13.8	3.2	4.4	45	50
12	Fluoride as F	mg/L	0.56	0.52	0.52	0.44	0.44	0.43	0.46	0.22	0.3	1.0	1.5
13	Iron as Fe	mg/L	BDL (DL=0.075)	BDL (DL=0.075)	0.088	BDL (DL=0.075)	0.078	0.13	BDL (DL=0.075)	0.14	BDL (DL=0.075)	1.0	-
14	Boron (as B)	mg/L	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	BDL (DL=0.1)	0.5	-
15	Cyanide (as CN)	mg/L	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	BDL (DL=0.02)	0.05	(*1)
16	Aluminium (as Al)	mg/L	0.024	0.038	0.016	0.021	0.022	0.034	0.042	0.018	0.048	0.03	(*2)
17	Copper (as Cu)	mg/L	0.016	0.021	0.021	0.014	0.011	0.018	0.021	BLQ(LOQ=0.01)	0.024	0.05	2.0
18	Manganese (as Mn)	mg/L	0.017	0.018	0.018	0.027	0.013	0.011	0.044	BLQ (LOQ=0.01)	0.018	0.1	(*3)

SN	Test Parameters	Unit	Locations									IS10S00; 2012	WHO Drinking Water
			GW-19	GW-20	GW-21	GW-22	GW-23	GW-24	GW-25	GW-26	GW-27		
19	Zinc (as Zn)	mg/L	0.056	0.042	0.042	0.032	0.024	0.024	0.082	0.024	0.078	5	-
20	Lead (as Pb)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A.T)
21	Total arsenic (as As)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.01	0.01 (A,T)
22	Cadmium (as Cd)	mg/L	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	BLQ (LOQ=0.01)	0.003	0.003
23	Escherichia coli	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	(*4)
24	Total Coliforms	CFU/100 ml	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-
25	Phenolic compounds (as C_6H_5OH)	mg/L	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	BDL (DL=0.001)	0.001	-
26	Mercury (as Hg)	mg/L	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	BLQ (LOQ=0.001)	0.001	0.07
27	Anionic detergents (as MBAS)	mg/L	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL (DL=0.2)	BDL(DL=0.2)	0.2	-
Note: BDL: Below detection Limit DL: Detection Limit; BLQ; Below Limit of Quantification; LOQ: Limit of Quantification,													
Remarks: The Above Sample meets to Acceptable Limits as Per IS 10500:2012 for the above Physico- chemical tests													
Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results													

7.1.3 Soil Environment

(1) Study method

1) Soil Sampling Method

The Manual of Soil Testing in India, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, New Delhi, was followed for the collection of soil samples, preparation for testing and analysing various physico-chemical properties of soil.

Soils vary from place to place. In view of this, efforts were made to take the samples in such a way that it is fully representative of the field. The sample was collected on the blade of the spade and put in a clean bucket. In this way collected samples from all the spots marked for one sampling unit. In case of hard soil, samples were taken with the help of augur from the plough depth and collected in the bucket. Pour the soil from the bucket on a piece of clean paper or cloth and after that it is mixed thoroughly. The soil is spread evenly and divided into 4 quarter. Two opposite quarters were rejected, and the rest were mixed again. The process was repeated until you are left with about a half kilogram of the soil. These were collected in a clean cloth / polyethylene bag. Each bag was properly marked to identify the sample.

2) Storage Technique

The collected samples were immediately transported to the laboratory. They were shade dried in wooden or enamel trays (except for the analysis of moisture content) and stored. The dried soils are ground using mortar and pestle (taking care to break only the clods but not the sand and gravel particles) and sieved through a 2mm mesh sieve.

3) Soil Quality Parameters and Method of Analysis

Meticulous attention was paid to collect adequate amount of composite soil samples for analysis. Sampling Methodology and Analysis was done by- IS: 2720/soil chemical analysis by M.L Jackson.

Table7-18: Methods for Analysis of Soil Properties

S. No.	Parameters	Methods of Analysis
Physical Parameters		
1	Moisture content (%)	Gravimetric
2	Water Holding Capacity (%)	Gravimetric
3	Bulk Density (%)	Gravimetric
4	Texture	Hydrometer Method
Chemical Parameters		
5	pH	Electrometric (pH meter)
6	EC (µg/m)	Electrometric
7	Acidity (mg/kg)	Titrimetric
8	Alkalinity (mg/kg)	Titrimetric
9	Chloride (mg/kg)	Titrimetric
10	Calcium (mg/kg)	Titrimetric
11	Magnesium (mg/kg)	Titrimetric
12	Sodium (mg/kg)	Flame Photometer

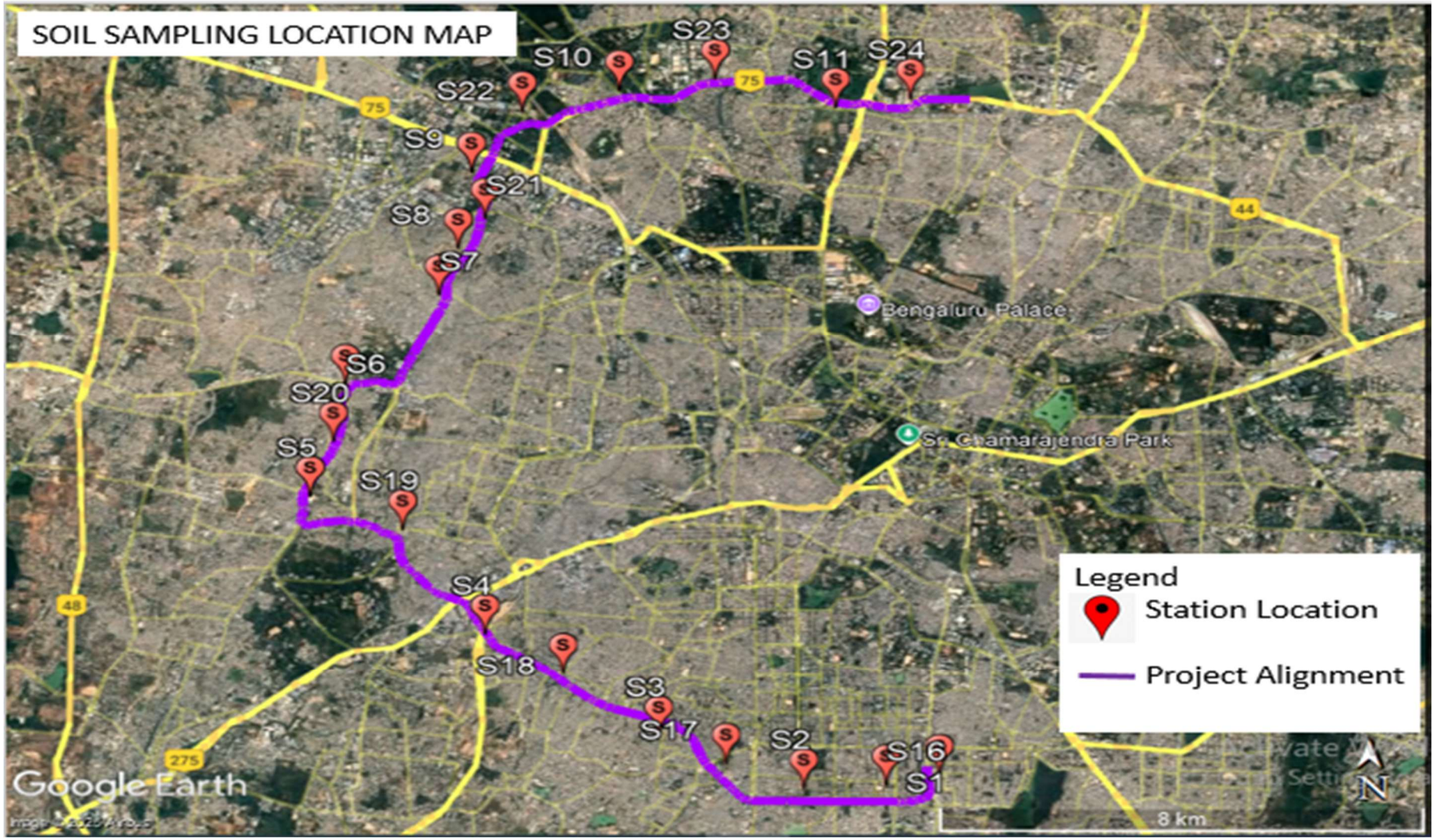
S. No.	Parameters	Methods of Analysis
13	Potassium (mg/kg)	Flame Photometer
14	Available Potassium (mg/kg)	Flame Photometer
15	Sulphate (mg/kg)	Spectro-photometer
16	Nitrate (mg/kg)	Kjedahl
17	Phosphate (mg/kg)	Bray's Extractant
18	Available Phosphorus (mg/kg)	Spectrophotometer
19	Organic Carbon (%)	Wet Digestion

Source: JST

Table7-19: Soil Sample collection Locations

S. No.	Location Name	Latitude	Longitude	Direction	Distance (m)
S1	Ranka Colony	12°54'41.20"N	77°36'5.83"E	E	0.19
S2	J.P. Nagar	12°54'31.47"N	77°34'51.79"E	N	0.26
S3	Padmanabhanagar	12°55'8.10"N	77°33'32.43"E	WSW	0.32
S4	Tollgate Hosakerehalli	12°56'20.10"N	77°31'57.37"E	W	0.05
S5	PapreddyPalya	12°57'57.23"N	77°30'21.63"E	WNW	0.12
S6	Kotiigepalya	12°59'15.99"N	77°30'40.87"E	SW	0.08
S7	Muniswara Nagar	13° 0'19.61"N	77°31'32.09"E	W	0.13
S8	Lakshmi Devi Nagar	13° 0'52.34"N	77°31'42.62"E	W	0.21
S9	Yeswanthpur	13° 1'45.87"N	77°31'49.91"E	E	0.18
S10	BEL Park	13° 2'43.30"N	77°33'10.81"E	NNE	0.19
S11	Near Hebbal Railway Station	13° 2'30.97"N	77°35'9.25"E	S	0.12
S12	Vijayanagar	12°58'29.76"N	77°32'29.84"E	W	0.1
S13	Cauvery Nagar	12°58'52.37"N	77°31'27.23"E	S	0.47
S14	Chikkagollarahatti	12°59'23.83"N	77°28'14.97"E	N	0.10
S15	Kadabagere Cross	12°59'14.33"N	77°26'49.86"E	NW	0.03
S16	Near Corporation Grounds	12°54'34.16"N	77°35'36.81"E	N	0.35
S17	Near NPTI	12°54'48.96"N	77°34'9.24"E	N	0.25
S18	Near Hosakerehalli Cross Water Tank Road	12°55'52.34"N	77°32'40.03"E	NE	0.12
S19	Nagarabhaavi	12°57'33.76"N	77°31'12.26"E	NE	0.19
S20	Kempegowda Layout, Laggere	12°59'53.61"N	77°31'31.50"E	W	0.15
S21	Nandini Layout	13° 1'13.34"N	77°31'57.28"E	E	0.06
S22	Goraguntepalya, Nandini Layout	13° 2'28.52"N	77°32'17.78"E	NW	0.28
S23	Tatanagar, Devinagar	13° 2'51.44"N	77°34'3.24"E	N	0.08
S24	Vayunandana Layout, Yelahanka	13° 2'37.53"N	77°35'50.10"E	N	0.14
S25	Madeshwara Nagar, Sunkadakatte	12°59'16.61"N	77°29'48.74"E	S	0.06
S26	Kempegowdanagar, Bedarahalli	12°59'8.37"N	77°28'54.76"E	N	0.05
S27	Chikkagollarahatti	12°59'31.69"N	77°27'38.65"E	N	0.02

Source: JST

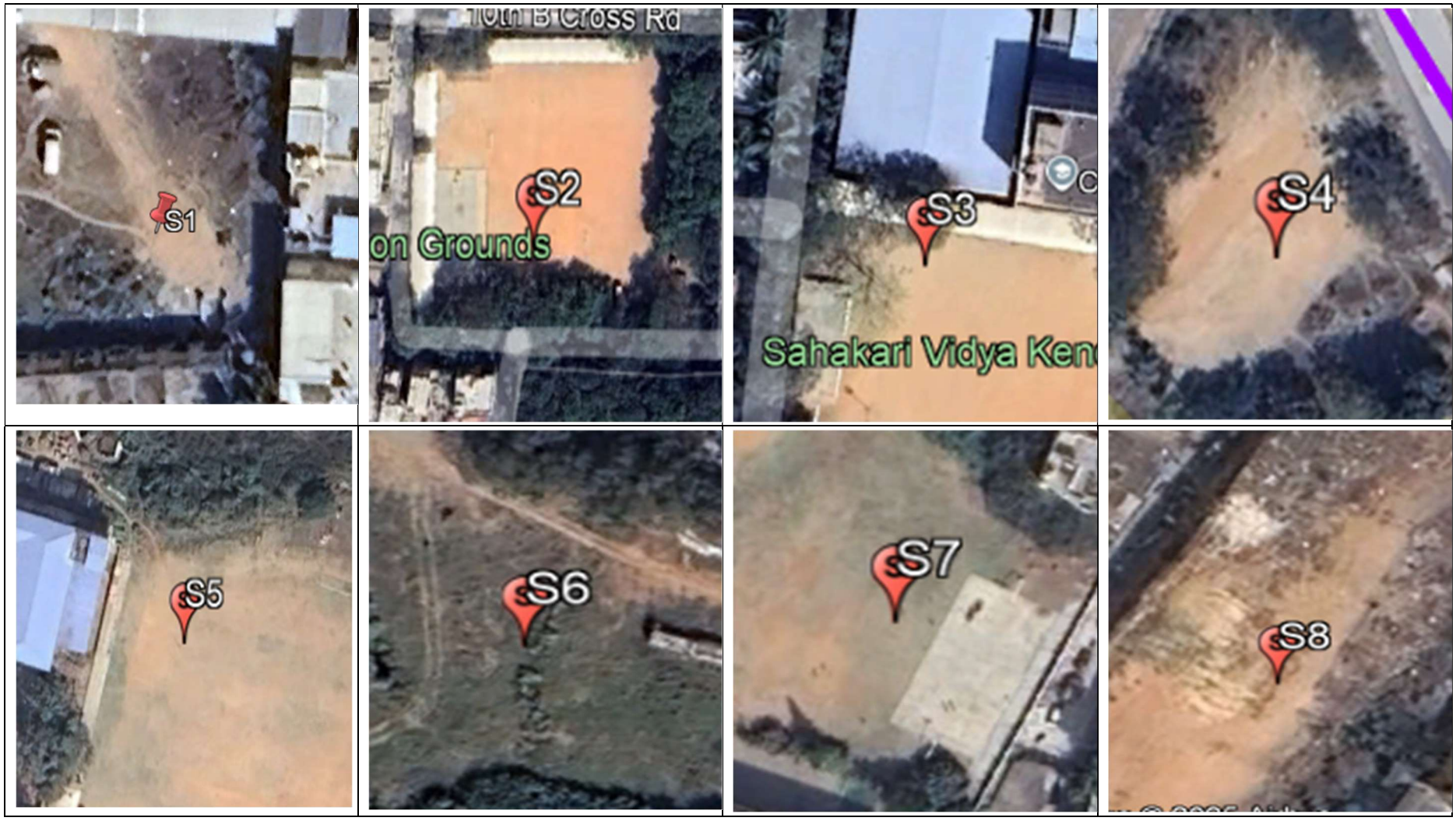


Source: JST based on Google Earth

Figure7-10: Map showing Soil Sampling Locations Map (Line 3-1)

Source: JST based on Google Earth

Figure7-11: Map showing Soil Sampling Locations Map (Line 3-2)


S1
S2
on Grounds
S3
Sahakari Vidya Ken
S4
S5
S6
S7
S8


S9
S10
S11
S12
S13
9th Cross
S14
S15
S16


S17
S18
aya Retail
S19
S20
S21
S22
S23
S24

Source: JST based on Google Earth

Figure7-12: Soil Sampling Locations Map (Zoomed In)

(2) Primary Data

- **pH:** The pH levels across the sampled locations ranged from 6.5 to 8.2, indicating that the soils are slightly acidic to alkaline in nature. Most values fall within the neutral to mildly alkaline range, which is typical for urban and semi-arid soils and generally suitable for vegetation and construction.
- **Electrical Conductivity (EC):** EC values (measured at 1:2 soil-water ratio) ranged from 146 to 230 µmho/cm, indicating low to moderate salinity. These levels suggest no significant accumulation of soluble salts, posing no risk to plant growth or soil structure.
- **Mercury (Hg):** Mercury was not detected (BDL < 0.01 mg/kg) in all samples, well below the USEPA RSL of 4.6 mg/kg. This indicates no mercury contamination and negligible health or environmental risk.
- **Hexavalent Chromium (Cr-VI):** Hexavalent chromium was not detected (BDL < 0.01 mg/kg) in any sample. Total chromium was not measured, but absence of Cr-VI, the more toxic form, suggests low risk from chromium exposure.
- **Lead (Pb):** Lead concentrations ranged from BDL (<0.01 mg/kg) to 46.0 mg/kg, with the highest value at S7. All values are well below the USEPA RSL of 800 mg/kg for residential soils. While low overall, slightly elevated levels in certain areas may reflect urban or traffic-related inputs but do not currently pose a health hazard.
- **Arsenic (As):** Arsenic was not detected (BDL < 0.01 mg/kg) in all samples, significantly below the USEPA RSL of 3 mg/kg. This indicates no arsenic contamination and minimal risk to human health or the environment.
- **Cadmium (Cd):** Cadmium levels ranged from 1.6 to 16.0 mg/kg (corrected from g/cm³, which is a unit error). The maximum value is well below the USEPA RSL of 98 mg/kg. Although cadmium is detectable, concentrations are within safe limits and not of immediate concern.
- **Cyanide:** Cyanide was not detected (BDL < 0.2 mg/kg) in any sample, far below the USEPA RSL of 15 mg/kg, indicating no toxic cyanide contamination.

Table7-20: Soil Analysis Results

SN	Parameter	Units	S1	S2	S3	S4	S5	S6	S7	USEPA RSL mg/kg
1	pH	..	6.9	7.3	7.3	7.6	7.7	7.9	8.2	-
2	Electrical Conductivity (1:2)	µmho/cm	169	176	166.0	168.0	146	198	210.0	-
3	Mercury as Hg	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	4.6
4	Hexavalent Chromium as Cr	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	-
5	Lead as Pb	mg/kg	32.0	21.6	28.0	16.6	39.0	44.0	46.0	800
6	Arsenic as As	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	3
7	Cadmium as Cd	g/cm^3	6.8	4.4	3.8	2.2	5.9	6.8	9.0	98
8	Cyanide	mg/kg	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	15

Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results

Table7-21: Soil Analysis Results

SN	Parameter	Units	S8	S9	S10	S11	S12	S13	S14	S15	USEPA RSL mg/kg
1	pH	..	7.8	7.5	6.7	6.8	7.6	6.5	6.6	7.3	-
2	Electrical Conductivity (1:2)	µmho/cm	206.0	216.0	180	170.0	213	182.0	188.0	196.0	-
3	Mercury as Hg	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	4.6
4	Hexavalent Chromium as Cr	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	-
5	Lead as Pb	mg/kg	22.0	BDL <0.01	6.8	12.6	22.0	18.0	22.0	26.8	800
6	Arsenic as As	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	3
7	Cadmium as Cd	g/cm^3	6.8	8.8	3.6	3.8	16.0	5.6	5.2	6.6	98
8	Cyanide	mg/kg	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	15

Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results

Table7-22: Soil Analysis Results

SN	Parameter	Units	S16	S17	S18	S19	S20	S21	USEPA RSL mg/kg
1	pH	..	7.7	7.9	6.9	6.6	7.2	7.8	-
2	Electrical Conductivity (1:2)	µmho/cm	230.0	216.0	180.0	178.0	186.0	206.0	-
3	Mercury as Hg	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	4.6
4	Hexavalent Chromium as Cr	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	-

SN	Parameter	Units	S16	S17	S18	S19	S20	S21	USEPA RSL mg/kg
5	Lead as Pb	mg/kg	26.0	16.8	13.6	20.2	30.6	17.8	800
6	Arsenic as As	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	3
7	Cadmium as Cd	g/cm^3	3.8	4.4	2.8	1.6	8.8	3.6	98
8	Cyanide	mg/kg	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	15

Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results

Table7-23: Soil Analysis Results

SN	Parameter	Units	S22	S23	S24	S25	S26	S27	USEPA RSL mg/kg
1	pH	..	7.3	7.6	7.5	6.8	6.5	6.6	-
2	Electrical Conductivity (1:2)	µmho/cm	190.0	198.0	208.0	186.0	190.0	178.0	-
3	Mercury as Hg	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	4.6
4	Hexavalent Chromium as Cr	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	-
5	Lead as Pb	mg/kg	30.6	16.6	36.0	28.0	20.6	26.8	800
6	Arsenic as As	mg/kg	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	BDL <0.01	3
7	Cadmium as Cd	g/cm^3	5.8	3.2	9.2	5.2	3.2	3.9	98
8	Cyanide	mg/kg	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	BDL <0.2	15

Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results

7.1.4 Waste

BMRCL, in coordination with contractors, will ensure proper segregation, storage, and disposal of all waste streams—solid, domestic, liquid, and hazardous. Contractors are responsible for daily waste management at their sites, including providing adequate sanitary facilities for temporary waste storage. All non-hazardous waste will be handed over to Bruhat Bengaluru Mahanagara Palike (BBMP) for scientific disposal at authorized sites such as Mavallipura. Construction and Demolition (C&D) waste will be transported only to KSPCB-approved processing facilities, with emphasis on recycling and reuse for filling or road base. Hazardous waste, including used oils, batteries, and solvents, will be stored in labeled, secure containers and disposed of through KSPCB-authorized recyclers with proper documentation (Form 10).

Wastewater from toilets and kitchens will be treated in on-site septic tanks or portable sewage treatment plants (STPs) and reused for landscaping or safely discharged into the sewer network. Regular desludging, cleaning of facilities, and monitoring by BMRCL's Environment Cell will ensure compliance with environmental norms. Public health and cleanliness will be prioritized throughout the project lifecycle to minimize environmental impact and support Bengaluru's sustainable urban development goals.

7.1.5 Ambient Noise Level

(1) Study Method

1) Selection of Sampling Sites

The noise monitoring was done following the CPCB protocol for Noise Monitoring, April 2025, which, among others, include the following cardinal principles:

- Should be located at the ambient level i.e. away from the direct source, away from any vibration and any obstruction.
- Microphone must be placed 1.2 -1.5m above the ground level.
- The instrument should be isolated from strong vibration and shock.
- The monitoring should be carried out minimum 75% of the prescribed Day time (06.00 am to 10.00 pm) and Nighttime (10.00 pm to 06.00 am).
- During ambient noise monitoring sound comes from more than one direction, it is important to choose a microphone and mounting which gives the best possible Omni directional characteristics.
- Noise measurements should not be made in fog and rain.
- Wind shields always be used to prevent interference of reflecting noise.

Noise monitoring has been carried during day and nighttime and Leq values have then been computed hourly. Day time & Nighttime monitoring were conducted from 6 a.m. to 10 p.m. and from 10 p.m. to 6 a.m., respectively. Ambient noise levels were measured using integrated sound level meter (SLM) Lutron (SL-4033).

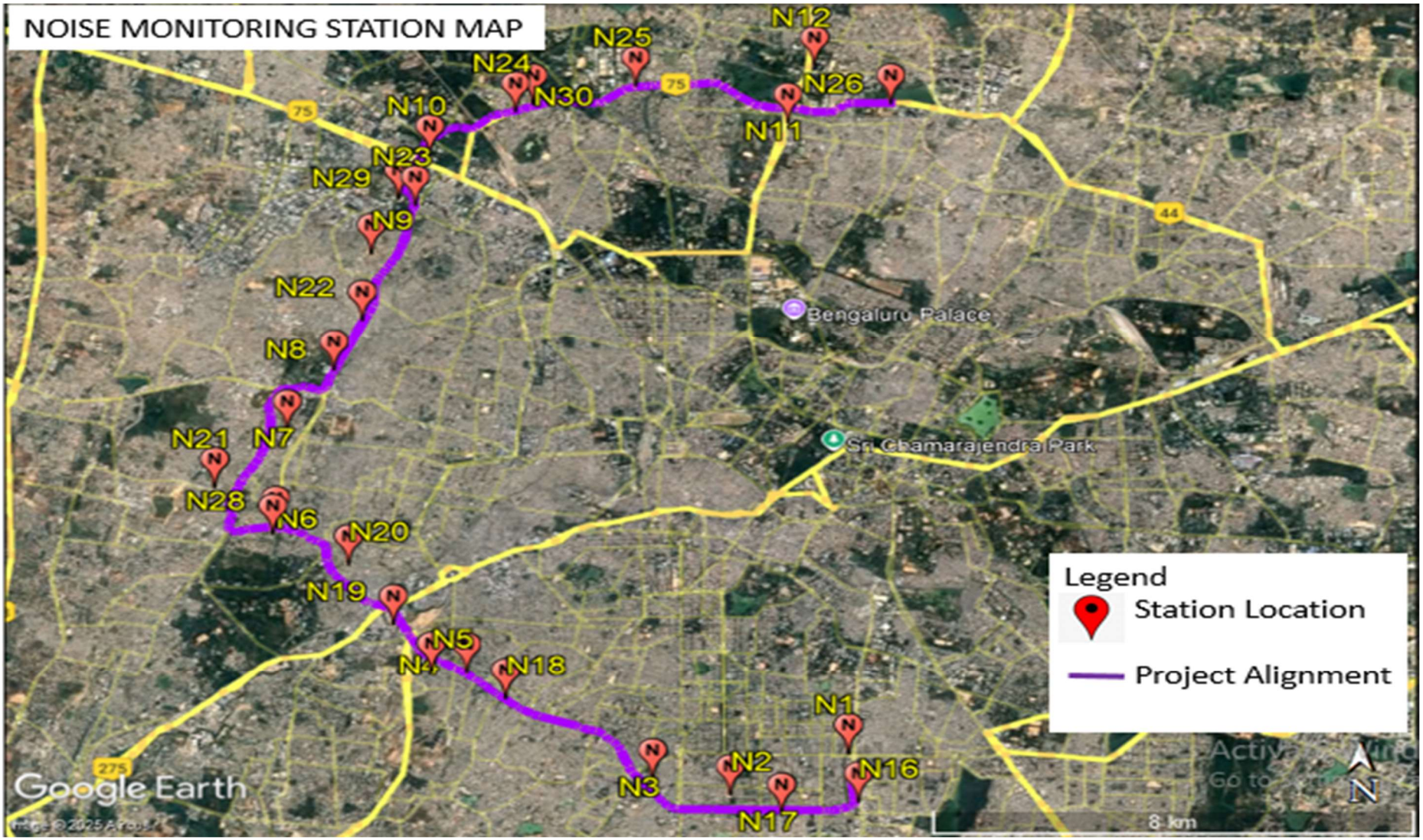
SLM was mounted on a tripod as per the standard methodology for noise measurements. Special care was taken for not making noise during the measurement and ensuring the least amount of reflective

from our body to the meter. Noise levels were recorded at 32 locations by Sound Level Meter. Noise levels were recorded as per IS: 9989 entitled "Assessment of noise with respect to community response" methodology. Noise levels were recorded at approximately 1.5 m above the ground level and about 3 m away from walls, buildings or other sound reflecting sources. Ambient Noise Monitoring Locations and analysis reports are appended below.

Table7-24: Ambient Noise Level Monitoring Stations and Justification

S. No.	Location Name	Latitude	Longitude	Direction from ROW / Distance (m)		Selection Criteria
N1	Jayadeva Hospital Bengaluru	12°55'1.46"N	77°35'57.04"E	N	470	Densel populated area
N2	The Oxford College of Education	12°54'32.92"N	77°34'52.09"E	N	337	N2
N3	NCEGR, Geological Survey of India	12°54'44.01"N	77°34'9.42"E	NEE	160	N3
N4	AV Multi-speciality Hospital - Banashankari	12°55'57.89"N	77°32'27.39"E	N	125	N4
N5	St Peter's School	12°55'58.51"N	77°32'8.05"E	WSW	284	N5
N6	GM Hospitals, Nagarabhavi	12°57'40.39"N	77°30'42.39"E	N	20	N6
N7	Buddha ShanthiKanive, Naagarabhaavi	12°58'47.77"N	77°30'48.79"E	E	286	N7
N8	Dr. Babu JagjivanramBhavana, Sumanahalli	12°59'29.80"N	77°31'14.39"E	W	63	N8
N9	PeenyaEsi Hospital	13° 0'51.57"N	77°31'34.92"E	NW	387	N9
N10	Central Manufacturing Technology Institute, Yeswanthpur	13° 2'0.81"N	77°32'7.07"E	E	150	N10
N11	NRG Hospitals	13° 2'22.91"N	77°35'23.70"E	S	805	N11
N12	Oceanik Institute of Higher Education	13° 2'59.66"N	77°34'17.28"E	N	302	N12
N13	Madhu Super Speciality Hospital and Research Centre, Vijayanagar	12°58'41.86"N	77°32'36.63"E	S	109	N13
N14	Anupama Hospital, Bidarahalli	12°58'59.97"N	77°28'43.27"E	S	267	N14
N15	Kamath Layout	12°59'11.19"N	77°26'48.70"E	N	89	N15
N16	Samved School	12°54'27.89"N	77°36'2.43"E	E	57	N16
N17	Near NPTI	12°54'20.19"N	77°35'20.30"E	S	75	N17
N18	Relife Hospital	12°55'39.77"N	77°32'48.78"E	NE	15	N18
N19	Adithya Enterprises	12°56'31.69"N	77°31'47.04"E	SW	135	N19
N20	Siddaganga Public School	12°57'13.55"N	77°31'22.46"E	E	299	N20
N21	Little Kidz–Nagarabhavi	12°58'7.57"N	77°30'8.84"E	W	350	N21
N22	Sri ShirdiSai Baba Temple	13° 0'4.86"N	77°31'29.93"E	W	27	N22
N23	National Skill Development Corporation - Karnataka	13° 1'25.21"N	77°31'59.06"E	E	12	N23
N24	Renaissance Reserva	13° 2'30.68"N	77°32'54.08"E	SE	25	N24
N25	Rebel's Fitness One	13° 2'48.79"N	77°34'0.17"E	N	16	N25
N26	BWSSB Water Treatment Plant Hebbal	13° 2'36.28"N	77°36'20.30"E	S	22	N26
N27	Gayathri Hospital Pvt Ltd	12°58'26.95"N	77°32'33.64"E	N	7	N27
N28	Fortis Hospital, Nagarbhavi	12°57'34.95"N	77°30'40.82"E	S	150	N28
N29	ESIC model Hospital Peenya	13° 1'30.05"N	77°31'49.96"E	SW	194	N29
N30	Mother Teresa Public School (CBSE)	13° 2'36.18"N	77°33'3.76"E	N	43	N30
N31	Boss Multispeciality Hospital	12°58'55.89"N	77°31'51.56"E	SW	20	N31
N32	Pooja Hospital, Machohalli gate	12°59'27.68"N	77°27'14.99"E	N	32	N32

Source: JST

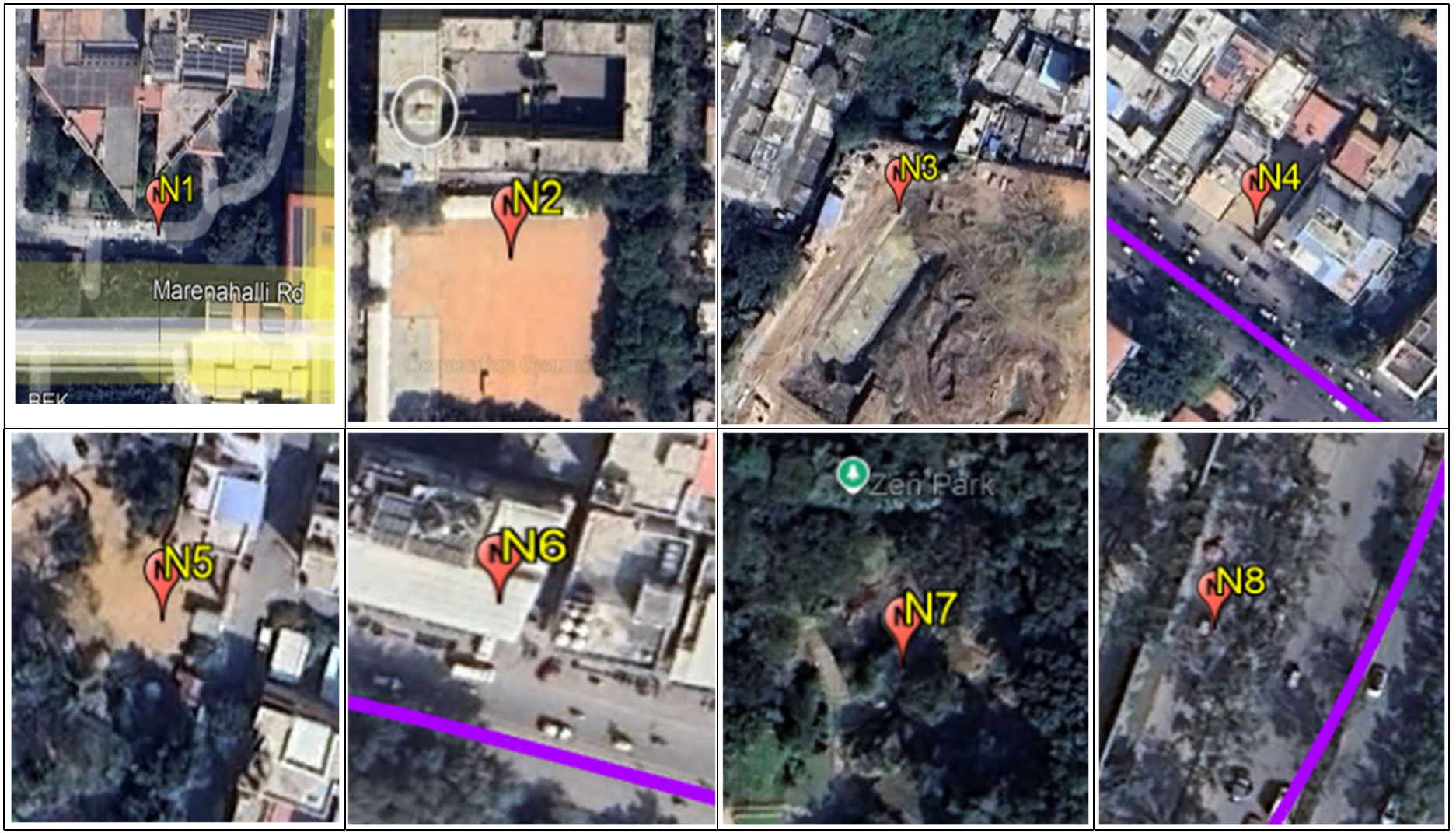


Source: JST based on Google Earth

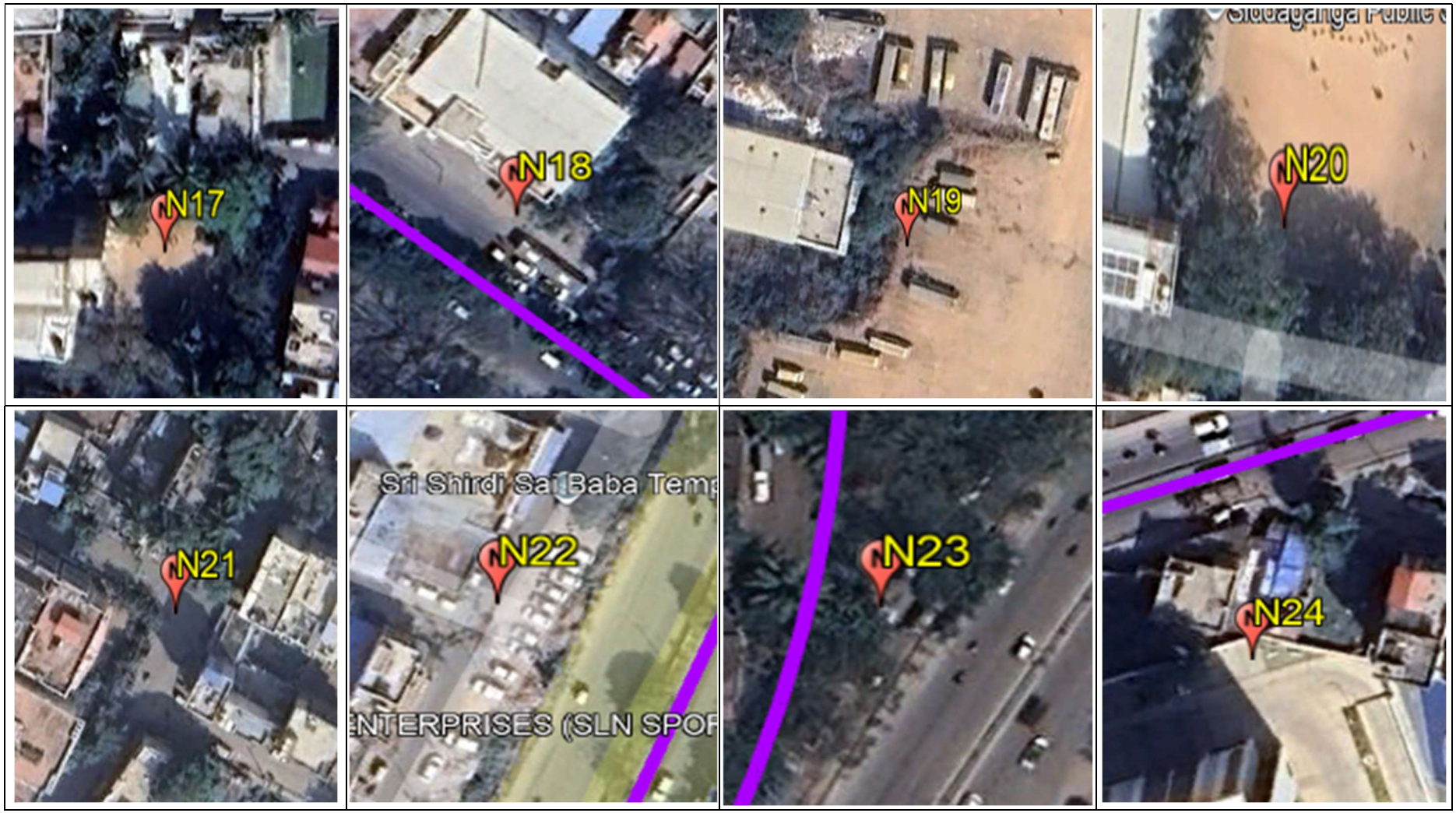
Figure7-13: Map showing Ambient Noise Level Monitoring Locations (Line 3-1)

Source: JST based on Google Earth

Figure7-14: Map showing Ambient Noise Level Monitoring Locations (Line 3-2)


N1
Marenahalli Rd
N2
N3
N4
N5
N6
Zen Park
N7
N8


N9
N10
N11
Manipal Hospita
N12
N13
N14
Anupam
N15
N16


N17
N18
N19
N20
N21
Sri Shirdi Sai Baba Temp
N22
ENTERPRISES (SLN SPOR
N23
N24

Source: JST based on Google Earth

Figure7-15: Ambient Noise Level Monitoring Locations (Zoomed In)

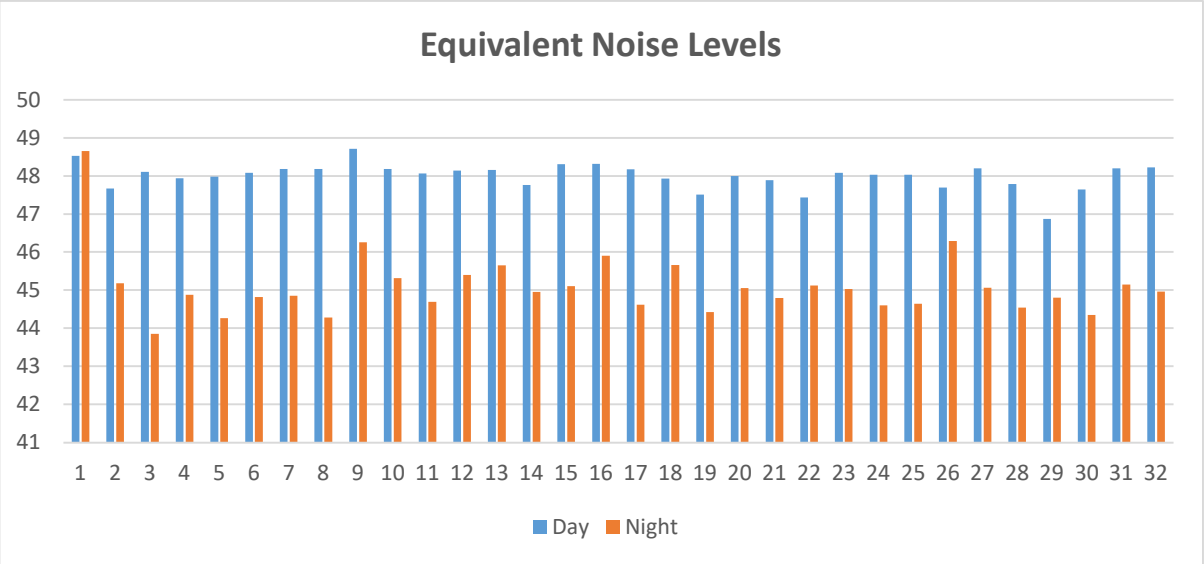
(2) Primary Data

The noise level monitoring conducted across 32 locations in Bengaluru reveals generally low to moderate noise levels, well within the CPCB permissible limits for respective zones. During the daytime, Leq values range from 44 dB(A) to 49.8 dB(A), while nighttime levels vary between 43.85 dB(A) and 46.29 dB(A). All sampling sites fall under Silence, Residential, or Commercial categories, with the Silence Zones (hospitals, schools, temples) showing the most favorable results. Notably, N30 (Mother Teresa Public School) recorded the lowest daytime average (47.64 dB(A)), and N1 (Jayadeva Hospital) had the highest nighttime average (48.65 dB(A)), slightly exceeding the 40 dB(A) night limit for silence zones. However, most values remain close to or within prescribed standards: 50/40 dB(A) for Silence and Residential, and 65/55 dB(A) for Commercial areas. The data indicates minimal noise pollution across the board, likely due to location-specific restrictions, traffic control, or low ambient noise. Despite this, a few sites like N9 (Peenya ESI Hospital) and N26 (BWSSB Hebbal) show nighttime levels approaching or marginally exceeding limits, suggesting localized disturbances. Overall, the study confirms that the monitored areas maintain acoustically comfortable environments, especially in sensitive zones, though continuous monitoring is recommended to prevent future escalation.

Table7-25: Ambient Noise Level Monitoring Results Data

SN	Location Name	Unit	Day		Night		Noise Level Results In Leq dB (A)		National Standard	Inter'l WB EHS
			Min	Max	Min	Max	Day	Night	Day/Night	Day/Night
N1	Jayadeva Hospital Bengaluru	dB(A)	47.6	49.8	47.9	49.5	48.53	48.65	50/40	
N2	The Oxford College of Education	dB(A)	45.6	49	42.1	47.8	47.67	45.18	50/40	
N3	NCEGR, Geological Survey of India	dB(A)	45.6	49.6	41.6	44.9	48.11	43.85	55/45	55/45
N4	AV Multi-speciality Hospital - Banashankari	dB(A)	46.2	49.1	43.5	45.8	47.94	44.88	50/40	
N5	St Peter's School	dB(A)	46.2	49.6	42.6	45.6	47.98	44.26	50/40	
N6	GM Hospitals, Nagarabhavi	dB(A)	47.3	49	43.6	45.9	48.08	44.82	50/40	
N7	Buddha ShanthiKanive, Naagarabhaavi	dB(A)	47.3	49.1	44	45.6	48.18	44.85	65/55	70/70
N8	Dr. Babu Jagjivanram Bhavana, Sumanahalli	dB(A)	47.3	49	43	45.6	48.18	44.28	65/55	70/70
N9	PeenyaEsi Hospital	dB(A)	47.7	49.8	44.3	47.8	48.71	46.26	50/40	
N10	Central Manufacturing Technology Institute, Yeswanthpur	dB(A)	47.2	48.7	42.1	47.8	48.18	45.31	50/40	
N11	NRG Hospitals	dB(A)	46.9	48.8	43.6	46.4	48.06	44.69	50/40	
N12	Oceanik Institute of Higher Education	dB(A)	46.5	48.8	44.2	46.4	48.14	45.40	50/40	
N13	Madhu Super Speciality Hospital and Research Centre, Vijayanagar	dB(A)	46.5	48.8	44.3	46.5	48.16	45.65	50/40	
N14	Anupama Hospital, Bidarahalli	dB(A)	46.1	48.7	44.1	45.7	47.76	44.95	50/40	
N15	Kamath Layout	dB(A)	45.7	49.1	43.9	46.4	48.31	45.10	55/45	55/45
N16	Samved School	dB(A)	45.6	49.8	44.3	47.8	48.32	45.90	50/40	
N17	Near NPTI	dB(A)	46.5	48.7	43.4	45.9	48.17	44.62	65/55	70/70
N18	Relief Hospital	dB(A)	46.2	48.8	44.3	47.8	47.93	45.66	50/40	
N19	Adithya Enterprises	dB(A)	45	48.8	43	45.6	47.51	44.42	65/55	70/70
N20	Siddaganga Public School	dB(A)	47.1	48.9	44.3	45.6	48	45.05	50/40	
N21	Little Kidz–Nagarabhavi	dB(A)	46.5	49.7	42.8	45.8	47.89	44.79	65/55	70/70
N22	Sri Shirdi Sai Baba Temple	dB(A)	45.9	49.1	44.1	45.6	47.43	45.12	50/40	
N23	National Skill Development Corporation - Karnataka	dB(A)	46.2	49.8	44.1	45.9	48.08	45.03	65/55	70/70
N24	Renaissance Reserves	dB(A)	45.9	49.1	43.4	45.8	48.03	44.60	65/55	70/70
N25	Rebel's Fitness One	dB(A)	45.9	49.5	43.5	45.6	48.03	44.64	65/55	70/70
N26	BWSSB Water Treatment Plant Hebbal	dB(A)	45.9	48.6	44.3	47.8	47.69	46.29	65/55	70/70
N27	Gayathri Hospital Pvt Ltd	dB(A)	46.2	48.8	44.2	45.6	48.20	45.06	50/40	
N28	Fortis Hospital, Nagarbhavi	dB(A)	47	48.6	42.3	47.8	47.79	44.54	50/40	
N29	ESIC model Hospital Peenya	dB(A)	45.9	47.6	44.2	45.6	46.87	44.80	50/40	
N30	Mother Teresa Public School (CBSE)	dB(A)	44	49.5	43.5	45.2	47.64	44.35	50/40	
N31	Boss Multispeciality Hospital	dB(A)	47.3	49.1	44.6	45.8	48.20	45.15	50/40	
N32	Pooja Hospital, Machohalli gate	dB(A)	47	49.5	44.1	45.8	48.22	44.96	50/40	

Source: Baseline Monitoring Report, National Analytical Laboratories and Research Center, NABL Accredited Laboratory. Analysis of Results



Source: JST

Figure7-16: Equvalent Noise Levels

Table7-26: Noise Standards as per Noise Regulation (Pollution & Control) Rules, 2000

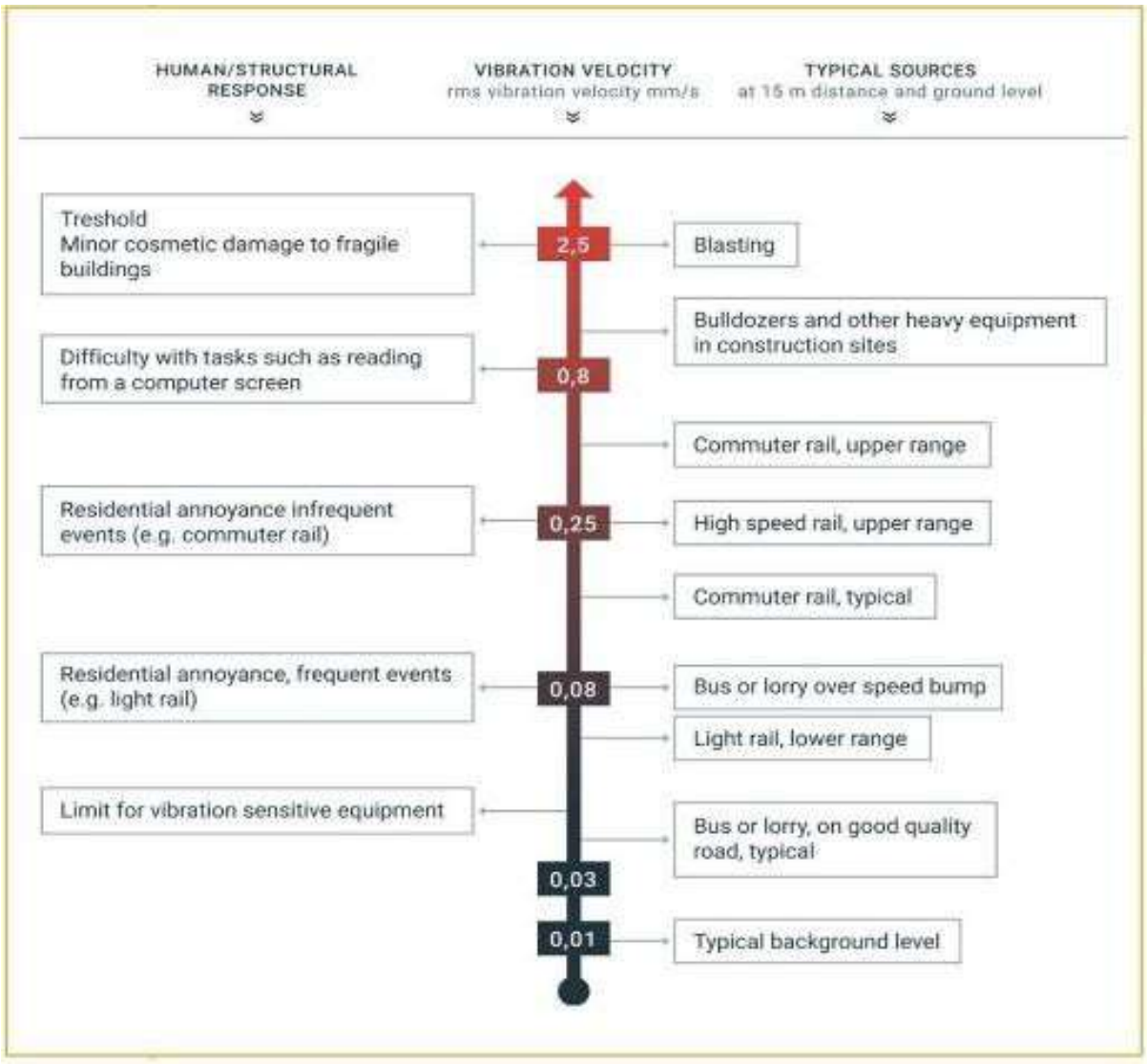
Category of Zones	Categorization of locations	CPCB Standards		WB EHS	
		Day	Night	昼	夜
Industrial	-	75	70	70	70
Commercial	N7, N8, N17, N19, N21, N23, N24, N25, N26	65	55	70	70
Residential	N3, N15	55	45	55	45
Silence Zone	N1, N2, N4, N5, N6, N9, N10, N11, N12, N13, N14, N16, N18, N20, N22, N27, N28, N29, N30, N31. N32	50	40		

Source: JST based on Noise Standards as per Noise Regulation (Pollution & Control) Rules, 2000

7.1.6 Vibration Level

(1) Study Method

The common sources of vibration during metro construction project are the operation of the heavy machineries during construction, and pile driving. The operation of metro trains induces vibration mainly due to the rolling stock, track and the friction between them. It is important to monitor the vibrations to establish the baseline and to know the impact of continuous vibrations by operating metro trains on the buildings. Baseline vibration monitoring was carried out for 24 hours at 32 locations which are adjacent to the proposed metro lines and susceptible for vibrations. The instrumentation used for measuring vibration includes NOMIS instrument. PPV was converted into VdB using the formula recommended by Transit Noise and Vibration Impact Assessment. Vibration limits specified in FTA-VA-90-1003-06 specifications have been suggested for comparison of the results.



Source: section 5. 2 of "Guidelines for the Assessment of Vibration in Buildings Due to Construction and Demolition Activities"Published by the British Standards Institution (BSI) as part of BS 7385-2:1993.

Figure7-17: Vibration Velocity Levels, Impacts, and Sources

Since road traffic is a continuous one, the structure around it is subjected to ground vibrations continuously, Vibration limits applicable to mines where the problem is high are not suitable for continuous vibrations like that from road traffic. Hence vibration limits specified in FTA-VA-90- 1003-06 specifications have been suggested for comparison of the results.

(2) Collection of baseline data

- The main data collected from the field was vibrations produced by moving vehicles.
- PPV of Ground Vibrations in 3 axes was measured at 32 sampling locations for 24 hours using NOMIS Instruments.
- PPV was converted into VdB using the formula recommended by *Transit Noise and Vibration Impact Assessment (1995)*,

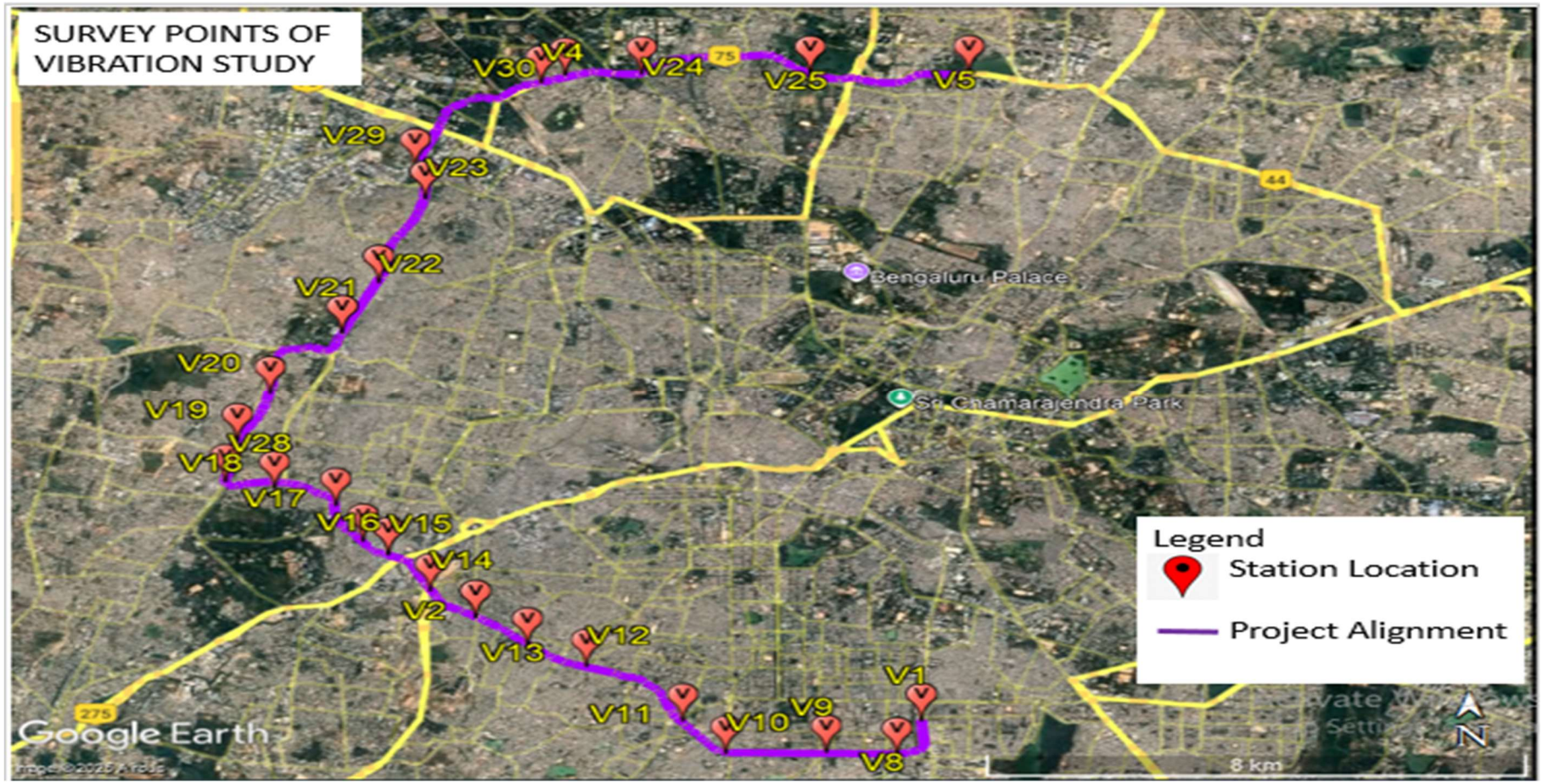
$$L_v = 20.\log_{10}\left(\frac{v}{v_{ref}}\right)$$

- $Lv$is the velocity levels in decibels.
- v is the recorded velocity amplitude,
- $vref$ is the reference velocity amplitude

Table7-27: Vibration Monitoring Locations

S. No.	Location Name	Latitude	Longitude	Distance (m)	Direction	Section Criteria
V1	3rd Phase, J. P. Nagar	12° 54'45.48"N	77° 35' 59.03"E	7.30	S	Near Station
V2	RVS Public School, Banashankari	12° 56' 3.63"N	77° 32' 19.79"E	18.01	SW	Sensitive Location Near School
V3	Event Management Institute, Sunkadakatte	12°59'17.34"N	77°30'40.14"E	20. 0	S	Near Even Management Institute
V4	Gokula Extension, Jalahalli	13° 2' 29.99"N	77° 32' 51.93"E	16.38	S	Near Residential Area
V5	Nagavara Lake	13° 2' 38.56"N	77° 36' 25.33"E	19.5	N	Sensitive Area Lake
V6	Sri Adhichuchanagiri English Primary & High School	12°58'26.30"N	77°32'39.76"E	20.50	E	Near Highschool
V7	Machohalli Village	12° 57'42.81"N	77° 30' 17.47"E	12.05	E	In Village area
V8	Phase 4, J. P. Nagar	12° 54'22.64"N	77° 35' 47.72"E	15.70	S	Densly populated area
V9	2nd Phase, J. P. Nagar	12° 54'22.34"N	77° 35' 11.45"E	17.45	N	Sensly Populated area
V10	Ramakrishna Nagar	12° 54'22.78"N	77° 34' 24.50"E	20.0	N	Near Metro Station
V11	Eshwara Nagar	12° 54'44.72"N	77° 34' 3.67"E	18.05	NE	Open Plot area
V12	Kamakya Depot, Banashankari	12° 55'26.34"N	77° 33' 12.71"E	12.05	N	Near Bus Depot
V13	BBMP Office Ward 161	12° 55'42.70"N	77° 32' 43.41"E	18.7	SW	Commercial Area
V14	Hosakerehalli Outer Ring Road	12° 56'18.22"N	77° 32' 3.29"E	17.8	SW	Near Outer Ring Road
V15	Global steel, NayandaHalli	12° 56'50.02"N	77° 31' 27.04"E	6.8	N	Near residential area
V16	Menakshi parking NayandaHalli	12° 56'53.63"N	77° 31' 25.51"E	13.65	SE	Near vehicle Parking
V17	Jyothi Nagar, NayandaHalli	12° 57'20.99"N	77° 31' 11.35"E	16.66	E	On Outer Ring Road
V18	Govindaraja Nagar Ward, Naagarabhaavi	12° 57'42.95"N	77° 30' 17.39"E	0.02	N	Near Residential Area
V19	Annapurneshwari Nagar	12° 58' 8.80"N	77° 30' 22.39"E	16.50	S	On Residential Area
V20	KLE's INDEPENDENT PU COLLEGE, NAGARABHAVI	12°58'44.27"N	77°30'38.67"E	14.05	E	Sensitive Area near collage area
V21	JagajeevanRaoJBvavan	12° 59' 28.36"N	77° 31' 14.63"E	18.5	W	Near Government Office
V22	SVS Public School	13° 0' 9.55"N	77° 31' 31.53"E	20.0	SE	Near School Area
V23	Dr. RajkumarMemorial	13° 1' 8.64"N	77° 31' 55.62"E	14.56	E	Near Tourist Place
V24	Bel Academy For Excellence	13° 2'37.16"N	77°33'41.42"E	14.75	N	Near Educational Academy
V25	Hebbal Lake	13° 2' 38.61"N	77° 35' 0.14"E	12.45	SE	Near lake
V26	Anjana Nagar	12° 59' 9.91"N	77° 29' 23.75"E	16.49	S	Near project site
V27	Hosahalli	12° 59'10.17"N	77° 28' 13.87"E	11.75	S	On the project alignment
V28	Fortis Hospital, Nagarbhavi	12°57'34.95"N	77°30'40.82"E	153.53	S	Sensitive area Hospital
V29	ESIC model Hospital Peenya	13° 1'30.05"N	77°31'49.96"E	201.4	W	Hospital
V30	Mother Teresa Public School (CBSE)	13° 2'36.18"N	77°33'3.76"E	45.23	NW	Sensitive area in school
V31	Boss Multispeciality Hospital	12°58'55.89"N	77°31'51.56"E	19.02	SW	Near Hospital
V32	Pooja Hospital, Machohalli gate	12° 59'27.00"N	77° 27'15.00"E	24.15	NW	Near Hospital

Source: JST



Source: JST based on Google Earth

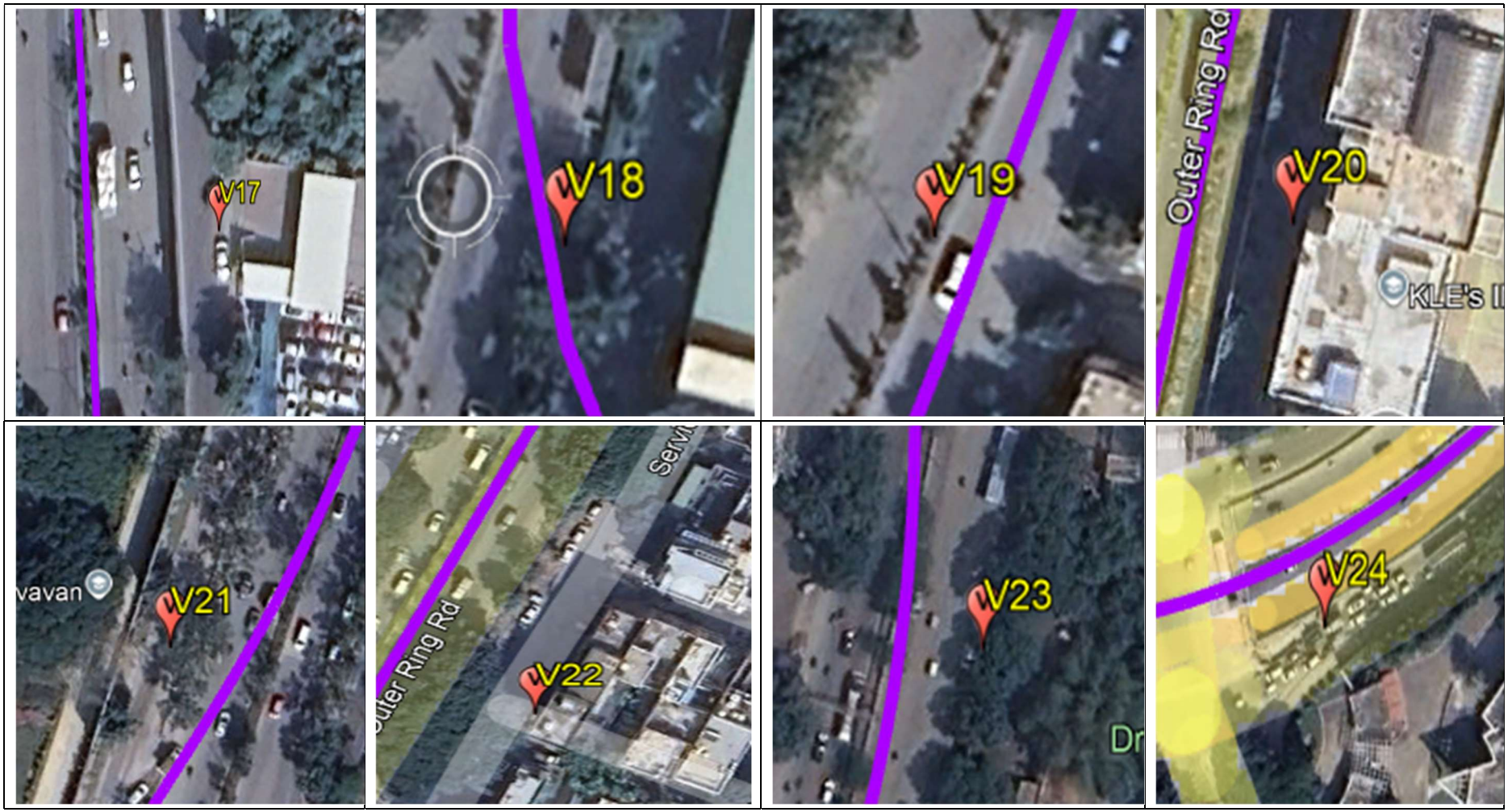
Figure7-18: Map showing Vibration Monitoring Locations (Line 3-1)

Source: JST based on Google Earth

Figure7-19: Map showing Vibration Monitoring Locations (Line 3-2)


V1
V2
V3
V4
V5
44
V6
85
V7
V8


V9
kitchen
Outer Ring Rd
V10
V11
V12
V13
V14
V15
V16


V17
V18
V19
Outer Ring Rd
V20
KLE's
vavan
V21
Outer Ring Rd
V22
V23
V24

Source: JST based on Google Earth

Figure7-20: Vibration Monitoring Locations (Zoomed In)

(3) Primary Data Survey Results

The survey results shows that all sites within the FTA standards.

Table7-28: Ambient Vibration Level Monitoring Results Data

Location Code	Location	DATE		Average Baseline Vibration Levels (VdB)	Inter'l Standard FTA
		Day shift	Night Shift		
V1	3rd Phase, J. P. Nagar	05-06-2025	06-06-2025	58.7	102
V2	RVS Public School, Banashankari	13-07-2025	14-07-2025	46.9	102
V3	Event Management Institute, Sunkadakatte	17-07-2025	18-07-2025	47.2	102
V4	Gokula Extension, Jalahalli	06-06-2025	07-06-2025	45.8	102
V5	Nagavara Lake	07-06-2025	08-06-2025	58.0	102
V6	Sri Adhichuchanagiri English Primary & High School	10-07-2025	11-07-2025	33.4	102
V7	Machohalli Village	01-06-2025	02-06-2025	48.7	102
V8	Phase 4, J. P. Nagar	02-06-2025	03-06-2025	46.2	102
V9	2nd Phase, J. P. Nagar	03-06-2025	04-07-2025	45.1	102
V10	Ramakrishna Nagar	04-07-2025	05-06-2025	48.4	102
V11	Eshwara Nagar	19-06-2025	20-06-2025	45.3	102
V12	Kamakya Depot, Banashankari	20-06-2025	21-06-2025	49.1	102
V13	BBMP Office Ward 161	21-06-2025	22-06-2025	47.6	102
V14	Hosakerehalli Outer Ring Road	23-06-2025	24-06-2025	58.9	102
V15	Global steel, NayandaHalli	24-06-2025	25-06-2025	57.6	102
V16	Menakshi parking NayandaHalli	25-06-2025	26-06-2025	48.7	102
V17	Jyothi Nagar, NayandaHalli	26-07-2025	27-06-2025	50.2	102
V18	Govindaraja Nagar Ward, Naagarabhaavi	27-06-2025	28-06-2025	58.4	102
V19	Annapurneshwari Nagar	28-07-2025	29-07-2025	48.2	102
V20	KLE's Independent Pu College, Nagarabhavi	07-07-2025	08-07-2025	31.5	102
V21	Jagajeevan RaoJBvavan	30-06-2025	01-07-2025	46.9	102
V22	SVS Public School	12-07-2025	13-07-2025	45.8	102
V23	Dr. RajkumarMemorial	01-07-2025	02-07-2025	49.3	102
V24	Bel Academy for Excellence	16-07-2025	17-07-2025	50.6	102
V25	Hebbal Lake	02-07-2025	03-07-2025	48.1	102
V26	Anjana Nagar	03-07-2025	04-04-2025	49.5	102
V27	Hosahalli	04-07-2025	05-07-2025	45.8	102
V28	Fortis Hospital, Nagarbhavi	05-07-2025	06-07-2025	39.1	102
V29	ESIC model Hospital Peenya	14-07-2025	15-07-2025	35.7	102
V30	Mother Teresa Public School (CBSE)	15-07-2025	16-07-2025	37.9	102
V31	Boss Multispeciality Hospital	11-07-2025	12-07-2025	48.7	102
V32	Pooja Hospital, Machohalli gate	08-07-2025	09-07-2025	32.8	102

Note: RMS Vibration Levels (VdB) category 3 is applied. U.S. FTA (2006) defines frequent events "as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category

Source: JST

7.1.7 Ground Subsiding

According to the DPR, all corridors under Phase 3 are planned as elevated structures with no underground or tunnel sections.

Construction will be carried out using pile foundations, precast or in-situ concrete girders, and elevated station structures supported by columns. Soil investigation, utility mapping, and building condition surveys will be undertaken to ensure safety and minimize impacts, but the absence of tunneling means the risk of ground subsidence is low. Settlement concerns are limited to localized foundation works, with

continuous monitoring implemented where necessary. In sum, tunneling technologies are not applicable to Phase 3, which focuses on the development of cost-efficient, rapidly buildable elevated corridors.

7.2 Natural Environment

7.2.1 Study Method

The natural flora and fauna of the land habitats constitute the terrestrial ecosystem. The study of terrestrial ecosystem is important as a part of monitoring for environmental changes. The present study on the floral assessment for the project activity is based on the field survey of the area. By following the forest inventory methodology, the survey of biological parameters was conducted within the core zone (within PROW) and buffer zone (100m radial distance from PROW) per standard methods during the study period. A preliminary survey of the study area was performed to get a general picture of the landscapes in vegetation.

Details of flora & fauna with special reference to endemic/threatened species if any reported from the study area along with details of existing forest cover in the study area.

(1) Collection of Baseline Data

Ecology & Biodiversity Expert visited the site during Dry season (March-May 2025) and Wet Season (June-July 2025) to collect a list of species in the study area, create an inventory, and check the distribution of plants and animals, rare, endangered and endemic species in the area from the site.

- Identify project area of data collected for species.
- Conducting baseline surveys for flora (trees, shrubs and herbs) and fauna (mammals, birds, reptiles, and insects) utilizing established scientific methodologies.

Birds were sampled by using point count method and opportunistic bird sightings; The total area covered is 100m along the alignment. By sighting of different birds all around

Mammals: Random opportunistic surveys along the corridors were carried out across the sites to assess the presence of mammals. social survey along the alignment using a structured questionnaire. During the survey, photographs of *Macaca radiata* and other species categorized as Endangered, Vulnerable (VU), and Near Threatened (NT), as mentioned in the Terms of Reference (ToR), were shown to local respondents to gather information regarding their presence in the area

Reptiles: Visual Encounter Survey method (VES) method was used for studying the reptile fauna.

Butterflies: For the sampling of butterflies, the standard 'Pollard Walk' method was employed.

- Identification of additional sites of ecological importance (deemed/city forests/green areas) along and in the vicinity of the metro corridors, if any.

(2) Data Analysis

- Screening of flora and fauna, with specific emphasis on the IUCN categorization of species and their status in accordance with the revised Indian Wildlife Protection Act of 1972.
- Identification of forest types in case of reserve or protected forests that occur within and nearby

the metro corridors, if any

- Identification of forests as well as city forests located within and in close proximity to the metro corridors, if any.
- Identification of the primary expected effects on biodiversity throughout the construction and operational stages of the metro project.
- Conducting an assessment of the expected effects on biodiversity and developing appropriate strategies to mitigate each impact.
- Conduct Critical Habitat Assessment

(3) Ecosystem

Survey area: 100 meters range on both sides of the planned route, planned depots and detention lines (2 locations).

(4) Methodology

1. Identification of important habitats
   - Identification and mapping of geographic information using GIS analysis and map data.
   - Comparative analysis with existing protected area databases (KBA, IBA, Ramsar wetlands, etc.).
2. Distribution of flora and fauna and inventory of endangered species
   - Field surveys (visual surveys, auditory surveys, camera trap surveys).
   - Leverage secondary data (including databases such as eBird and iNaturalist).
   - Habitat and population data collection (identification of breeding and nesting sites).

7.2.2 Protected Area

There are no protected areas located near the corridor. Bannerghatta is the nearest protected area (National Park) from the project alignment which is located 7.05 km away.

7.2.3 Ecosystem: Flora and fauna

The natural flora and fauna of the land habitats constitute terrestrial ecosystem. The study of terrestrial ecosystem is important as a part of the monitoring environmental changes

The present study on the floral assessment for the project activity is based on the field survey of the area. The survey of biological parameters has conducted within the PROW and 100m radial distance from the PROW as per standard methods during the study period. A preliminary survey of the study area has performed to get a general picture of the landscapes in vegetation.

Details of flora & fauna with special reference to endemic/threatened species if any reported from the study area along with details of existing forest cover in the study area.

(1) Flora

During site visit, a common tree species, found were:

- *Swietenia macrophylla*
- *Tabebuia rosea*
- *Pongamia pinnata*
- *Ficus religiosa* (Pipal)
- *Mangifera indica*
- *Eucalyptus tereticornis* (Eucalyptus)

The list of identified plant species is shown below.

Table7-29: Checklist of flora observed in the study area

SN	Botanical Name	Habit	Family	Common Name	Season		IUCN Status
					Dry	Wet	
1	*Abies spp.*	Tree	Pinaceae	Christmas tree	+	+	NL
2	*Aegle marmelos*	Tree	Rutaceae	Bilvapatre	+	+	NT
3	*Albizia lebbeck*	Tree	Fabaceae	Nerale	+	+	LC
4	*Alstonia scholaris*	Tree	Apocynaceae	Alstonia	+	+	LC
5	*Alternanthera ficoidea*	Hb	Amaranthaceae	Joyweed	+	+	NE
6	*Anona reticulata*	Tree	Annonaceae	Sitapala	-	+	NL
7	*Argyranthemum frutescens*	Hb	Asteraceae	Paris Daisy	+	+	NE
8	*Argythamnia simulans*	Herbaceous	Euphorbiaceae	Silverleaves	+	+	NE
9	*Artocarpus heterophyllus*	Tree	Moraceae	Jack Fruit	+	+	NL
10	*Asclepias curassavica*	Hb	Apocynaceae	Tropical Milkweed	+	+	NE
11	*Azadirachta indica*	Tree	Meliaceae	Bevu	+	+	LC
12	*Bauhinia purpurea*	Tree	Fabaceae	Kadu Badami	+	+	LC
13	*Bauhinia racemosa*	Tree	Fabaceae	Nandibatlu	+	+	LC
14	*Bauhinia spp.*	Tree	Fabaceae	Burge	+	+	NL
15	*Bauhinia tomentosa*	Tree	Fabaceae	Thorematti	+	+	LC
16	*Bauhinia variegata*	Tree	Fabaceae	Jaali	+	+	LC
17	*Bismarckia nobilis*	Tree	Arecaceae	Bismarck Palm	+	+	LC
18	*Bougainvillea spectabilis*	Climber	Nyctaginaceae	Beautiful Bougainvillea	+	+	NE
19	*Broussonetia papyrifera*	Tree	Moraceae	Paper mulberry	+	+	LC
20	*Caesalpinia decapetala*	Shrub	Fabaceae	Caesalpinia Decapeta	+	+	LC
21	*Callistemon citrinus*	Tree	Myrtaceae	Bottle Brush	+	+	NL
22	*Calotropis gigantea*	Shrub	Apocynaceae	Ekka	+	+	NL
23	*Campsis*	Climber	Bignoniaceae	Trumpet Vines	+	+	NE
24	*Cassia fistula*	Tree	Amaryllidaceae	Rain Lilies	+	+	NE
25	*Catharanthus roseus*	Hb	Apocynaceae	Periwinkle	+	+	NE
26	*Chloris*	Grass	Poaceae	Windmill Grasses	+	+	NE
27	*Chromolaena odorata*	Shrub	Asteraceae	Jack in the Bush	-	+	NE
28	*Cinnamomum camphora*	Tree	Moraceae	Badraxi	-	+	LC
29	*Clitoria ternatea*	Climber	Fabaceae	Butterfly Pea	+	+	NE
30	*Cocos nucifera*	Tree	Arecaceae	Coconut	+	+	NL
31	*Conocarpus erectus*	Tree	Combretaceae	Conocarpus	+	+	LC
32	*Crotalaria pallida*	Sh	Fabaceae	smooth crotalaria	+	+	LC
33	*Croton bonplandianus*	Hb	Euphorbiaceae	Bonpland's Croton	-	+	NE
34	*Dalbergia sissoo*	Tree	Fabaceae	Sissoo	-	+	LC
35	*Datura metel*	Hb	Solanaceae	Devil's Trumpets	+	+	NE
36	*Delonix regia*	Tree	Fabaceae	Gulmohar	-	+	LC
37	*Elettaria cardamomum*	Tree	Zingiberaceae	Elachi	+	+	NL

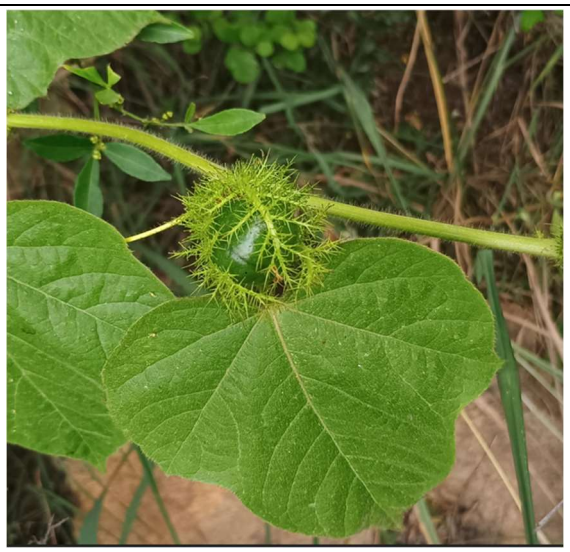
SN	Botanical Name	Habit	Family	Common Name	Season		IUCN Status
					Dry	Wet	
38	*Erigeron bonariensis*	Hb	Asteraceae	Flax-leaved Horseweed	+	+	NE
39	*Eucalyptus globulus*	Tree	Myrtaceae	Nilagiri	-	+	LC
40	*Euphorbia heterophylla*	Hb	Euphorbiaceae	Wild Poinsettia,	+	+	LC
41	*Ficus benghalensis*	Tree	Moraceae	Alamaddi	-	+	NL
42	*Ficus carica*	Tree	Fabaceae	Atti Mara	+	+	LC
43	*Ficus elastica*	Tree	Moraceae	Rubber Plant	+	+	LC
44	*Ficus microcarpa*	Tree	Moraceae	Baare	+	+	LC
45	*Ficus racemosa*	Tree	Moraceae	Gaalimara	+	+	LC
46	*Ficus religiosa*	Tree	Moraceae	Kakke	+	+	LC
47	*Flueggea leucopyrus*	Sh	Phyllanthaceae	Indian snowberry	+	+	LC
48	*Garuga pinnata*	Tree	Burseraceae	Garuga	+	+	LC
49	*Gonioma kamiesbergense*	Shrub	Anacardiaceae	Goni	+	+	NL
50	*Gossypium spp.*	Tree	Malvaceae	Gasagase	+	+	NL
51	*Guazuma ulmifolia*	Tree	Malvaceae	West Indian Elm	+	+	LC
52	*Hemidesmus indicus*	Vine	Apocynaceae	Indian Sarsaparilla	+	+	NE
53	*Hibiscus mutabilis*	Sh	Malvaceae	Sleeping Hibiscus	+	+	NE
54	*Hibiscus rosa-sinensis*	Tree	Moraceae	Sacred Fig	+	+	LC
55	*Holoptelea integrifolia*	Tree	Ulmaceae	Divaruba	+	+	LC
56	*Hymenocallis littoralis*	Hb	Amaryllidaceae	Beach Spider Lily	+	+	NE
57	*Hypocenomyce scalaris*	Lichen	Cladoniaceae	Common Clam Lichen	+	+	NE
58	*Indigofera sp.*	Sh	Fabaceae	Common Indigo	+	+	LC
59	*Ipomoea obscura*	Climber	Convolvulaceae	Obscure Morning Glory	+	+	NE
60	*Ixora sp.*	Shrub	Rubiaceae	West Indian Jasmine	-	+	NE
61	*Jacaranda mimosifolia*	Tree	Bignoniaceae	Jacaranda	+	+	VU
62	*Kigelia africana*	Tree	Bignoniaceae	Sausage Tree	+	+	LC
63	*Lantana camara*	Shrub	Verbenaceae	Common Lantana	+	+	LC
64	*Lantana montevidensis*	Shrub	Verbenaceae	Creeping Lantana	+	+	NE
65	*Leucaena leucocephala*	Tree	Fabaceae	Sababul	+	+	NL
66	*Mangifera indica*	Tree	Anacardiaceae	Mango	+	+	DD
67	*Martynia annua*	Hb	Martyniaceae	Devil's Claws	+	+	NE
68	*Michelia champaca*	Tree	Magnoliaceae	Sampige	-	W	LC
69	*Mimosa pudica*	Hb	Fabaceae	Sensitive Plants	+	+	NE
70	*Mimusops elengi*	Tree	Sapotaceae	Nagalinga Puspa	+	+	LC
71	*Monoon longifolium*	Tree	Annonaceae	False Ashoka	+	+	LC
72	*Moringa oleifera*	Tree	Moringaceae	Dalichandra	+	+	LC
73	*Muntangia calabura*	Tree	Muntingiaceae	Singapore Cherry	+	+	NE
74	*Myrica esculenta*	Shrub	Myricaceae	Celeta	+	+	NL
75	*Neolamarckia cadamba*	Tree	Rubiaceae	Kadamba	+	+	NL
76	*Nerium oleander*	Sh	Apocynaceae	Oleander	+	+	LC
77	*Nyctanthes arbor-tristis*	Tree	Oleaceae	Parijatha	+	+	LC
78	*Nymphaea pubescens*	Hb	Nymphaeaceae	Hairy Water-Lily	+	+	LC
79	*Passiflora foetida*	Climber	Passifloraceae	Stinking passionflower	+	+	NE
80	*Oxalis corniculata*	Hb	Oxalidaceae	Creeping Woodsorrel	+	+	NE
81	*Paspalum nutans*	Grass	Poaceae	brownseed crowngrass.	-	+	NE
82	*Peltophorum pterocarpum*	Tree	Fabaceae	Hoovarasi	-	+	LC
83	*Phoenix canariensis*	Tree	Arecaceae	Palm tree	+	+	LC
84	*Plectranthus*	Hb	Lamiaceae	Spurflowers	+	+	NE
85	*Plumbago auriculata*	Shrub	Plumbaginaceae	Blue Plumbago	+	+	NE
86	*Plumbago zeylanica*	Hb	Plumbaginaceae	White leadwort	+	+	NE

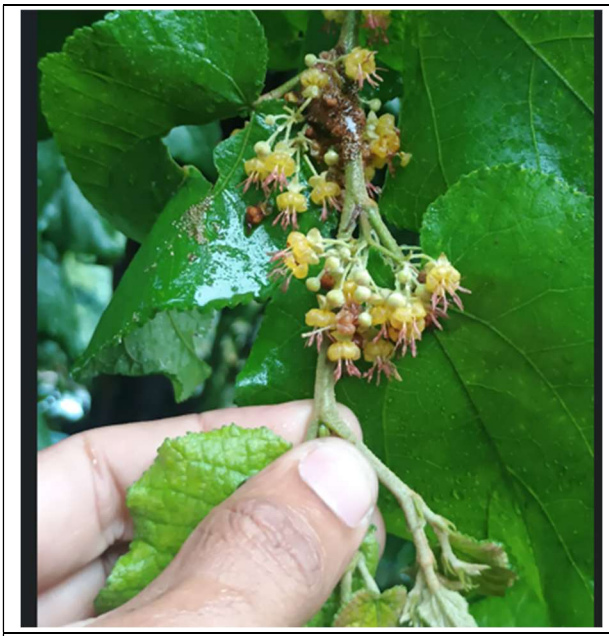
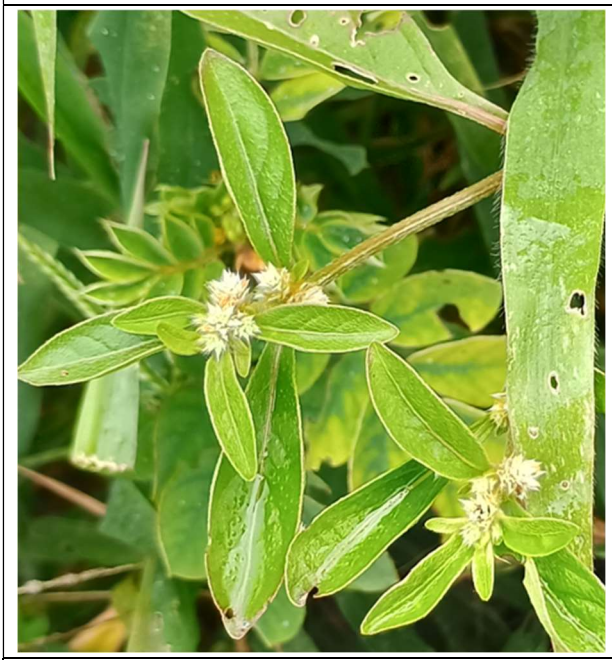
SN	Botanical Name	Habit	Family	Common Name	Season		IUCN Status
					Dry	Wet	
87	*Plumeria alba*	Tree	Apocynaceae	Kanaka champa	-	+	LC
88	*Plumeria obtusa*	Tree	Apocynaceae	Kanigale	+	+	LC
89	*Plumeria rubra*	Tree	Apocynaceae	Kanagale	+	+	LC
90	*Polyalthia longifolia*	Tree	Annonaceae	Honge	+	+	LC
91	*Polygonum aviculare*	Hb	Polygonaceae	Small Knotweed	+	+	LC
92	*Polyscias spp.*	Tree	Araliaceae	Arali	-	+	NL
93	*Pongamia pinnata*	Tree	Fabaceae	Indian Beech Tree	+	+	LC
94	*Portulaca oleracea*	Herb	Portulacaceae	Common Purslane	+	+	NE
95	*Prosopis juliflora*	Tree	Fabaceae	Banni Mara	+	+	LC
96	*Prunus spp.*	Tree	Rosaceae	Cherry	+	+	LC
97	*Psidium guajava*	Tree	Myrtaceae	Guava	+	+	LC
98	*Psydrax dicoccos*	Sh	Celastraceae	Ceylon Boxwood	+	+	LC
99	*Ricinus Communis*	Sh	Euphorbiaceae	Castor bean	+	+	NE
100	*Samanea saman*	Tree	Fabaceae	Rain Tree	+	+	LC
101	*Santalum album*	Tree	Santalaceae	Kali sandana	+	+	VU
102	*Senna siamea*	Tree	Fabaceae	Kassod Tree	+	+	LC
103	*Setaria viridis*	Grass	Poaceae	green foxtail	+	+	LC
104	*Simarouba glauca*	Tree	Simaroubaceae	Simarouba	-	W	LC
105	*Spathodea campanulata*	Tree	Nyctaginaceae	Africal Tulip	+	+	LC
106	*Stachytarpheta jamaicensis*	Hb	Verbenaceae	Blue Porterweed	+	+	LC
107	*Stylosanthes hamata*	Hb	Fabaceae	Caribbean Stylo	+	+	NE
108	*Swietenia macrophylla*	Tree	Meliaceae	Mahogany	-	W	EN
109	*Synedrella nodiflora*	Hb	Asteraceae	Cinderella Weed	+	+	NE
110	*Tabebuia rosea*	Tree	Bignoniaceae	Tabebuia Rosea	+	+	LC
111	*Tabernaemontana divaricata*	Sh	Apocynaceae	Crepe Jasmine	+	+	LC
112	*Tamarindus indica*	Tree	Fabaceae	Tamarind	+	+	LC
113	*Tecoma stans*	Tree	Bignoniaceae	Tecoma	+	+	LC
114	*Tecomaria capensis*	Sh	Bignoniaceae	Cape Honeysuckle	+	+	LC
115	*Tectona grandis*	Tree	Lamiaceae	Teak Wood	+	+	EN
116	*Tephrosia villosa*	Tree	Fabaceae	Thaare	+	+	LC
117	*Terminalia arjuna*	Tree	Combretaceae	Halmaddi	+	+	LC
118	*Terminalia catappa*	Tree	Combretaceae	Madagascar Almond	+	+	LC
119	*Thespesia populnea*	Tree	Malvaceae	Portia Tree	+	+	LC
120	*Thunbergia erecta*	Vine	Acanthaceae	Bush Thunbergia	+	+	NE
121	*Thunbergia alata*	Vine	Acanthaceae	Black-eyed Susan vine	+	+	NE
122	*Tribe Apieae*	Herb	Apiaceae	Carrot	+	+	LC
123	*Triumfetta rhomboidea*	Hb	Tiliaceae	Burr Bush	-	+	NE
124	*Wrightia tinctoria*	Sh	Apocynaceae	Pala indigo plant	-	+	LC
125	*Xanthium strumarium*	Sh	Asteraceae	ommon Cocklebur	+	+	NE
126	*Zephyranthes candida*	Tree	Amaryllidaceae	White Rain-Lily	+	+	NE

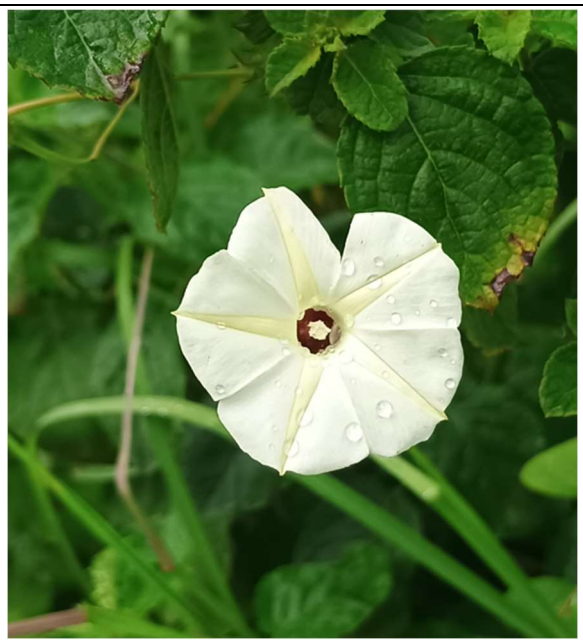
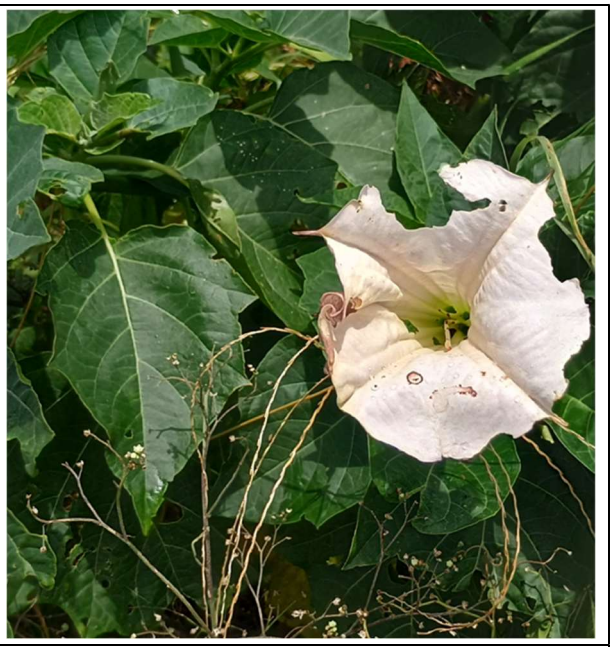
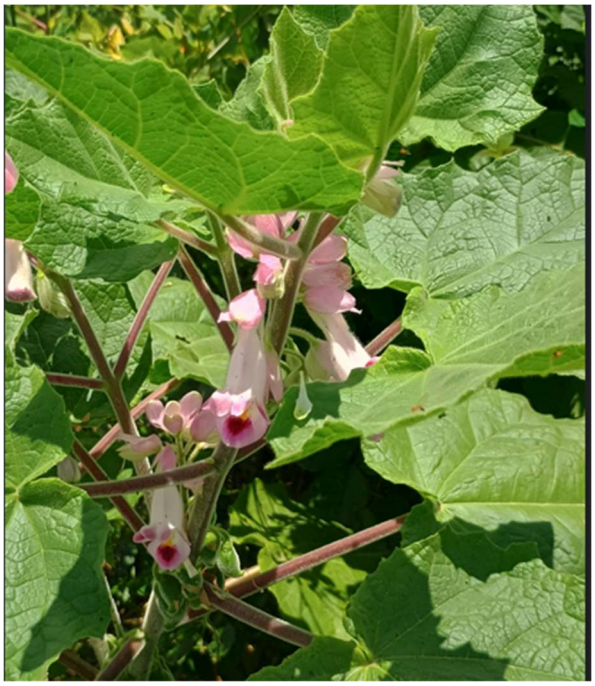
Note: Not Evaluated (NE), Not listed (NL), Least Concern (LC), Near Threaten (NT), Endangered (EN), Vulnerable (VU), Data Deficient (DD)

Source: JST

	
Hemidesmus indicus	Crotalaria pallida
	
Plumbago zeylanica	Chromolaena odorata

	
Paspalum nutans	Clitoria ternatea
	
Triumfetta rhomboidea	Thunbergia alata
	
Passiflora foetida	Mimosa pudica

	
Guazuma ulmifolia	Setaria viridis
	
Alternanthera ficoidea	Stachytarpheta sp.

	
Ipomoea obscura	Datura metel
	
Martynia annua	Thespesia populnea

	
Dalbergia sissoo	Alternanthera philoxeroides
	
Vegetation near Hebbal Lake	Indian Sandalwood (Santalum album)
	
Teak Wood	Nilgiri Eucalyptus Plant https://greenparadiselive.com/products/nilgiri-eucalyptus-plant?srsltid=AfmBOorq6iDeXc7kEHdQIhoSJNdRiPWjOLWK70QGXTrmBF3dAm4nHh_b

Source: JST

Figure7-21: Plants observed at project area

(2) Fauna

A total of 4 mammals, 2 reptiles and 18 bird species, 15 insect species, were recorded during the current survey. All species are listed as Least Concern (LC) under International Union for Conservation of

Nature (IUCN) red list.

Fauna species that are recorded in the baseline surveys along the proposed metro corridors area are listed below:

Table7-30: Checklist of fauna observed in the study area

SN	*Scientific Name*	Family	Common Name	IUCN Status	Listing in Schedule of WPA 1922
Mammals					
1	*Funambulus pennantii*	Sciuridae	Five-striped palm squirrel	LC	Schedule IV
2	*Canis lupus familiaris*	Canidae	Indian pariah dog	--	--
3	*Rattus rattus*	Muridae	House Rat	LC	--
4	*Sus scrofa domesticus*	Suidae	Domestic pigs	--	--
Reptiles					
1	*Calotes versicolor*	Agamidae	Garden calotes	LC	--
2	*Ptyas mucosa*	Colubridae	Oriental rat snake	LC	Sch I
Avifauna					
1	*Eudynamys scolopaceus*	Cuculidae	Asian Koel	LC	--
2	*Milvus migrans*	Accipitridae	Black Kite	LC	--
3	*Bubulcus ibis*	Ardeidae	Cattle Egret	LC	Sch IV
4	*Acridotheres tristis*	Sturnidae	Common Myna	LC	Sch IV
5	*Corvus splendens*	Corvidae	House Crow	LC	Sch V
6	*Columba livia*	Columbidae	Rock Pigeon (Blue Rock Pigeon)	LC	--
7	*Psilopogon viridis*	Megalaimidae	White-cheeked Barbet	LC	--
8	*Halcyon smyrnensis*	Alcedinidae	White-throated Kingfisher	LC	Sch IV
9	*Egretta garzetta*	Ardeidae	Little Egret	LC	Sch IV
10	*Ardea alba*	Ardeidae	Great egret	LC	Sch IV
11	*Ardea cinerea*	Ardeidae	Grey herons	LC	Sch IV
12	*Haliastur indus*	Accipitridae	Brahminy kite	LC	--
13	*Plegadis falcinellus*	Threskiornithidae	Glossy Ibis	LC	--
14	*Centropus sinensis*	Cuculidae	greater coucal	LC	--
15	*Porphyrio poliocephalus*	Rallidae	grey-headed swamphen	LC	--
16	*Metopidius indicus*	Jacanidae	Bronze-winged Jacana	LC	--
17	*Mycteria leucocephala*	Ciconiidae	Painted Stork	NT	--
18	*Threskiornis melanocephalus*	Threskiornithidae	Black-headed Ibis	LC	--
Insect					
1	*Delias eucharis*	Pieridae	Common Jezbell butterfly	--	--
2	*Eurema hecabe*	Pieridae	Common Grass Yellow	--	Sch II (Part II)
3	*Neurothemis tullia*	Libellulidae	pied paddy skimmer	LC	
4	*Ariadne merione*	Nymphalidae	Common Castor	--	--
5	*Oecophylla smaragdina.*	Formicidae	weaver ant	--	--
6	*Hypolimnas bolina*	Nymphalidae	common eggfly	--	--
7	*Lathrecista asiatica*	Libellulidae	Asiatic blood tail	LC	--
8	*Parantica agle*	Nymphalidae	Glassy tiger	--	--
9	*Euploea core*	Nymphalidae	common crow	LC	--
10	*Cepora nerissa*	Pieridae	common gull	--	--
11	*Junonia lemonias*	Nymphalidae	Lemon pansy	--	--
12	*Belenois aurota*	Pieridae	Pioneer white	--	--
13	*Acraea terpsicore*	Nymphalidae	Tawny coster	--	--
14	*Pareronia valeria*	Pieridae	Common wanderer		
15	*Catopsilia pomona*	Pieridae	Common Emigrant		

Source: JST

Field officer during field visit

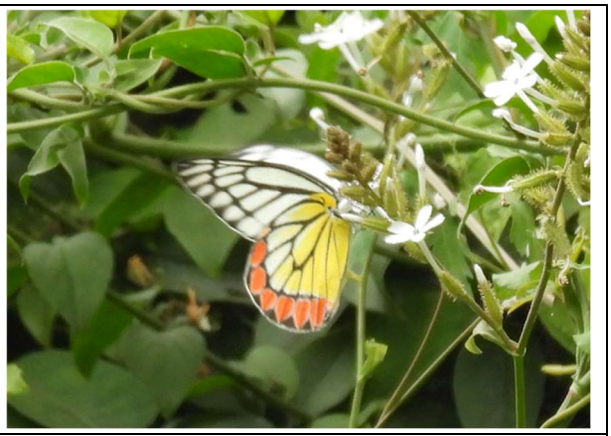
Rohu and Tilapia fish at Hebbal Lake

Fishing at Hebbal Lake

Oriental Rat snake near Ch. 1.700

Common Castor

Common Crow butterfly

	
Common gull butterfly	Jezebel butterfly
	
Emigrant butterfly	Peacock pansy butterfly
	
Common wanderer	Pioneer white
	
Tawny coster	Common grass yellow

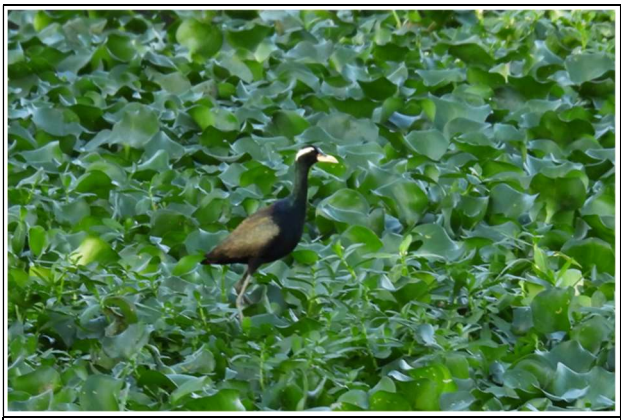
Euchrysops cnejus, Oriental gram blue

Greater Coucal

Brahminy kite

Grey Heron

Moorhen



Bronze Winged Jacana

Glossy Ibis

Source: JST

Figure7-22: Fauna observed at project area

(3) Aquatic Ecosystem

The proposed Metro Phase 3 alignment does not traverse any water bodies such as lakes or dams. However, three lakes—Hebbal Lake, Nagavara Lake, and Herohalli Lake—are located in close proximity to the alignment. These lakes support local fishing activities, with commonly observed species including Rohu, Catla, and Tilapia.

7.2.4 Assessment of EN, VU, NT species in the study area

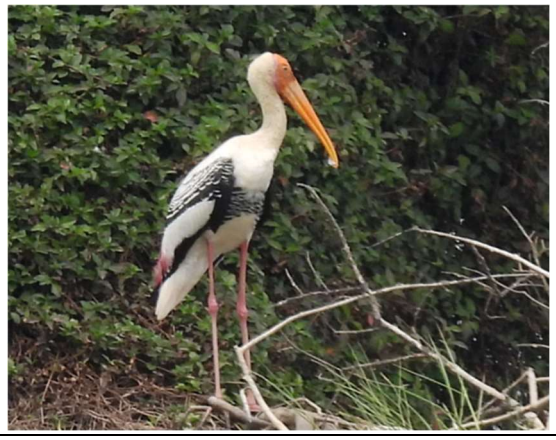
The following table presents a list of EN, VU, and NT species on the IUCN Red List that may occur in Bengaluru, together with their confirmed presence or absence within the survey area.

Table7-31: Potential EN, VU, and NT Species in Bengaluru and Their Occurrence Status in the Survey Area

SN	Species Given in TOR		IUCN status	Presence within study area
	Scientific Name	Common Name		
A	**Mammals**			
1	*Macaca radiata*	Bonnet Macaque	VU	+
2	*Panthera pardus*	Indian Leopard	VU	-
3	*Melursus ursinus*	Sloth Bear	VU	-
4	*Elephas maximus*	Asian Elephant	EN	-
B	**Birds**			
1	*Anhinga melanogaster*	Asian Snakebird	NT	-
2	*Pelecanus philippensis*	Spot-billed Pelican	NT	-
3	*Ciconia episcopus*	Asian Woolly-necked Stork	VU	-
4	*Aquila rapax*	Tawny Eagle	VU	-
5	*Clanga clanga*	Greater Spotted Eagle	VU	-
6	*Grus antigone*	Sarus Crane	VU	-
7	*Sterna aurantia*	Swift	VU	-
8	*Phylloscopus tytleri*	Tytler's leaf warbler	NT	-
9	*Aquila rapax*	Tawny eagle	VU	-
10	*Falco chicquera*	Red-necked Falcon	NT	-
11	*Circus macrourus*	Pallid harrier	NT	-
12	*Pelargopsis amauroptera*	brown-winged kingfisher	NT	-
13	*Mycteria leucocephala*	Painted Stork	NT	+
C	**Reptiles**			

SN	Species Given in TOR		IUCN status	Presence within study area
	Scientific Name	Common Name		
1	*Python molurus*	Indian Python	NT	-
2	*Geochelone elegans*	Indian Star Tortoise	VU	-
3	*Crocodylus palustris*	Crocodile	VU	-
4	*Varanus bengalensis*	Bengal monitor lizard	NT	-
5	*Lissemys punctata*	Indian Spotted Turtle	NT	-
6	*Eryx conicus*	Anacondaboa	NT	-
D	**Flora**			
1	*Santalum album*	Indian Sandalwood	VU	+
2	*Pterocarpus santalinus*	Red Sandalwood	EN	-
3	*Shorea roxburghii*	White Meranti	VU	-
4	*Mesua ferrea*	Ceylon Ironwood	NT	-
5	*Pterocarpus santalinus*	Red-bellied tree	EN	-
6	*Aegle marmelos*	Bael	NT	+
7	*Jacaranda mimosifolia*	Jacaranda	VU	+
8	*Swietenia macrophylla*	Mahogany	EN	+
9	*Tectona grandis*	Teak Wood	EN	+

Note: '+' indicates that the species was confirmed in this survey, while '–' indicates that it was not.
Source: JST



Painted Stork (Mycteria leucocephala) - NT
Observed near Hebbal Lake within 100m from ROW

Indian Sandalwood (Santalum album) – VU
Observed near Ch.8.900

Source: JST

Figure7-23: EN, VU, NT species found in the study area

The distribution of endangered (EN), vulnerable (VU), and near-threatened (NT) species was assessed in the survey area. As a result of the field reconnaissance, the following species were recorded through direct visual observation:

- One near-threatened (NT) bird species: Painted Stork (Mycteria leucocephala)
- Two vulnerable (VU) plant species: Sandalwood (Santalum album) and Jacaranda (Jacaranda mimosifolia)
- One near-threatened (NT) plant species: Bael (Aegle marmelos)
- Two endangered (EN) plant species: Mahogany (Swietenia macrophylla) and Teak (Tectona grandis)

All of these species are commonly observed in Bengaluru.

Regarding the Bonnet Macaque (*Macaca radiata*), which is listed as Vulnerable (VU) on the IUCN Red List, no direct observation confirmed its distribution in the vicinity of the project site. However, given its widespread occurrence in Bengaluru and its highly mobile behavior, the possibility of its presence in the project area is considered high. A structured questionnaire survey, using photographs of the species, was conducted with local residents at 16 locations along the planned alignment. Based on their responses, the presence of the Bonnet Macaque was confirmed at the following three locations:

1. J. P. Nagar 3rd Phase (12°54'40.00" N, 77°35'47.00" E)
2. Vicinity of Herohalli Cross (12°59'14.62" N, 77°29'35.78" E)
3. Vicinity of Shri Shanimahatma Swami Devasthana, Sunkadakatte (12°59'18.37" N, 77°30'2.71" E)

Table7-32: Survey Locations for Questionnaire on Bonnet Macaque Distribution

Sr. No	Name of Location	Latitude	Longitude
1	J. P. Nagar, 3rd Phase	12°54'40.00"N	77°35'47.00"E
2	Kottigepalya	12°59'8.36"N	77°30'41.69"E
3	Near Shri Shanimahatma Swami Devasthana Sunkadakatte	12°59’18.37”N	77°30’2.71”E
4	Machohalli	12°59'31.84"N	77°27'34.92"E
5	Peenya, Modern Bread Factory	13° 1'33.20"N	77°31'57.52"E
6	Naagarabhaavi	12°58'35.46"N	77°30'36.14"E
7	Dr. Ambedkar Institute Of Technology, Kengunte Circle	12°57'48.00"N	77°30'19.00"E
8	Nayanda Halli, Kamala Nursery	12°56'56.50"N	77°31'19.40"E
9	National Council of Educational Research and Training, Hosakerehalli	12°55'45.66"N	77°32'39.07"E
10	Geological Survey of India	12°54'37.19"N	77°34'7.14"E
11	A S C Jalahalli	13° 2'28.98"N	77°32'43.63"E
12	Hebbal Lake Park	13° 2'38.46"N	77°35'3.95"E
13	Herohalli Lake, Byadarahalli	12°59'13.72"N	77°29'29.80"E
14	Herohalli Cross	12°59'14.99"N	77°29'38.12"E
15	HVR Layout, KHB Colony	12°58'54.00"N	77°32'0.98"E
16	At Nagarbhavi 5th block Water tank	12°58'39.87"N	77°30'36.70"E

Source: JST

In addition, the Indian Flying Fox (*Pteropus medius*, formerly *Pteropus giganteus*) was re-assessed in 2021 on the IUCN Red List and classified as Near Threatened (NT). This species was not recorded during the present field survey, which is considered to be due to its activity pattern occurring mainly from dusk through the night, making it less likely to be observed during daytime-focused surveys.

In practice, however, the species has been observed flying and roosting in roadside trees in green spaces and near water bodies within Bengaluru City, and therefore it is likely to occur in the vicinity of the project area as well. On the other hand, as no ecologically significant behaviors such as breeding have been confirmed in the surroundings, the project’s impacts on this species are evaluated as not significant.

The threatened species confirmed in this study are all considered to be adapted to the existing urban environment, and no critical behaviors such as nesting or breeding have been observed in or around the project site. Accordingly, the project site cannot be regarded as an important habitat for these species.

7.3 Social Environment

7.3.1 Study Method

The socio-economic survey covered demographic structure, availability of basic social infrastructure such as housing, education, and health services, occupation, water supply, sanitation, communication and electricity supply, prevalence of diseases in the region, as well as characteristics such as tourism resources and archaeological sites of value. By examining these parameters, the potential impacts of project activities on the surrounding areas could be identified, predicted, and assessed.

Baseline data on population dynamics, occupational structure, education, health, and other basic social infrastructure in the survey area were collected and compiled.

(1) Baseline Status

The latest available data has been complied to generate the existing socio-economic scenario of the study area. Information on socio-economic profile was collected from the Census of India 2011 including the population details of the region.

(2) Study Area

The study area was defined as an area which is comprised of project Lines 3-1 and 3-2 as well as within a 100 m both side of the stations of the Project alignment.

(3) Methodology applied for selection of sample & data collection

The methodology which is applied for primary data collection i.e. gathering data through field survey for socio-economic environment is explained below:

(4) Sampling Method

A judgmental and purposive sampling method was used for choosing respondents of various sections of the society i.e. Sarpanch, adult males and females, teachers, medical practitioners, businessmen, agriculture laborers, unemployed group etc. Judgmental and purposive sampling method includes the right cases from the total population that helps to fulfil the purpose of research needs.

The respondents included: Adult Males and Females, Teachers, Businessmen, Students, Shop Owners, Government Officials, Government Staff and Employees, Small Shop Owners and Vendors, Unemployed Group etc.

(5) Field Visits and Data Collection

Field survey and observations is made at each sampling villages and the socio-economic status of that region was studied. Visits are made to hospitals, primary health centres to know the health status of the region. Various governmental organizations such as statistical department, department of census operations are visited to collect the population details of that region.

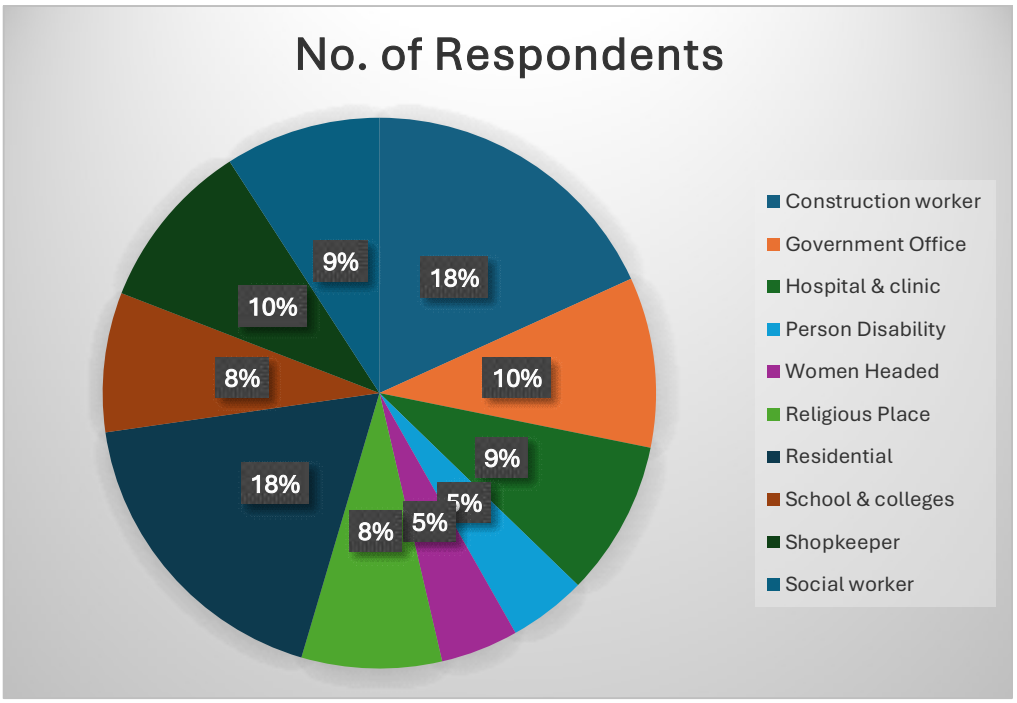
(6) Interview Method

Structured interview method is used to collect data regarding the awareness and opinion of sample selected from various socio-economic sections of the community. Structured interviews involve the use of predetermined set of questions that includes fixed and alternative questions. The questionnaire mainly highlights the parameters such as income, employment and working conditions, housing, food, clothing, water supply, sanitation, health, energy, transportation, communication, education, environment and pollution to assess the quality of life of that particular region, general awareness and opinion of the respondents about the project. Interview method helps to collect error free and accurate information to the interviewer during the field survey. The respondents were asked for their awareness / opinion about the project and also the impacts of the project which is an important aspect of socio-economic environment, viz. job opportunities, education, health care, transportation facility and economic status**.**

Table7-33: Details of Samples Collected during Socio Economic Survey

Name of the Corridor	No. of Stations	No. of Respondents		Total No. of Respondents	Remarks
		Male	Female		
Line 3-1 (JP Nagar to Kempapura)	22	57	26	83	Line 3-1 (JP Nagar to Kempapura)
Line 3-2 (Hosahalli to Kadabagere)	9	13	14	27	Line 3-2 (Hosahalli to Kadabagere)
Total	31	**70**	**40**	**110**	Total

Source: JST



Source: JST

Figure7-24: Representing the Category of Respondents Interviewed During Survey

Table7-34: List of the Locations for Field Survey of Socio-Economic Survey

S.N.	Line 3−1	Line 3−2
1	JP Nagar 4th Phase	Hosahalli
2	JP Nagar 5th Phase	KHB colony
3	JP Nagar	Kamakshipalya
4	Kadirenahalli	Sumanahalli Cross
5	Kamakya Junction	Sunkadakatte
6	Hosakerehalli	Herohalli
7	Dwaraka Nagar	Byadarahalli
8	Mysore Road	Kamath Layout
9	Nagarbhavi Circle	Kadabagere
10	Vinayaka Layout	
11	Papireddypalya	
12	BDA Complex Nagarbhavi	
13	Sumanahalli Cross	
14	Chowdeshwari Nagar	
15	Freedom Fighter's colony	
16	Kanteerava Nagar	
17	Peenya	
18	Muthyala Nagar	
19	BEL Circle	
20	Nagashettyhalli	
21	Hebbal Railway Station	
22	Kempapura	

Source: JST

7.3.2 Land acquisition/ Resettlement

Refer to Chapter 15.

7.3.3 Livelihoods

The major sources of employment are available in the service industries such as information technology, telecommunications, hotels, banking, media, and tourism. Construction, power, health and community services and real estate are also important to the city's economy. Bengaluru has one of India's largest and fastest growing retail industries. Karnataka's large consumer market and the availability of skilled labour has also attracted foreign investment.

7.3.4 Socially Vulnerable

The social affiliation of a group creates differentiation in receiving benefits under government schemes. Social groups indicate social ranking, preferences, and vulnerability within the society. In general, families belonging to Scheduled Castes (SC) and Scheduled Tribes (ST), under the provisions of the Constitution of India, receive preferential treatment in government programs, as these groups include people who are traditionally vulnerable. Except for the General Category, other groups are in socially and economically backward conditions, and therefore require due consideration and appropriate measures.

Under Articles 244 and the Fifth and Sixth Schedules of the Constitution of India, "Scheduled Areas" are designated to protect the residential and livelihood rights of Scheduled Tribes, and special laws such as the *Panchayats (Extension to Scheduled Areas) Act, 1996* are applied to these areas. However, there are

no such designated Scheduled Areas in Karnataka State, and no Scheduled Areas or autonomous tribal regions have been identified around the project area.

In the social survey conducted for the Resettlement Action Plan (RAP), a small number of households belonging to Scheduled Tribes were identified. However, all of them are settled in urban areas and do not maintain traditional land use systems or socio-cultural institutions. Therefore, they do not meet the definition of "Indigenous Peoples" as defined under the World Bank Environmental and Social Standard 7 (ESS7).

Accordingly, support for vulnerable groups including Scheduled Tribes will be implemented through the Environmental Management Plan (EMP) and the RAP, but no special consideration is required for Indigenous Peoples in this project.

7.3.5 Social Infrastructure

Table7-35: Social Infrastructure and Services within 50 Meters along the Metro

Station Location	Hospital / Clinic	Schools / Educational Institutions	Offices / Govt. Quarters / Parks / Academies	Religious Places
Line 3-1: JP Nagar 4th Phase – Kempapura				
JP Nagar 4th Phase	Ayurvita Hospital (adjacent)	-	JP Nagar 6th Phase Park (nearby), Layout roads	Sri Durgamma Temple (opposite)
JP Nagar 8th Phase	-	-	Residential layout, Open space	Sri Anjaneya Swamy Temple
Banashankari 3rd Stage	Banashankari Health Centre (within 100m)	-	BBMP Garden, Bus stop area	Sri Kalabhairava Temple
NS Palya	-	-	Residential colony, Footpath markets	Sri Maramma Temple
Yelachenahalli	-	-	Yelahanka Urban Co-op Bank, Park	Sri Veerabhadra Swamy Temple
Kanakapura Road	Columbia Asia Hospital (within 150m)	-	Major junction, Commercial hub	Sri Lakshmi Venkateshwara Temple
Konanakunte Cross	-	-	Layout park, Junction area	Sri Durgamma Temple
Haralur Road	-	-	IT corridor access, Residential	Sri Anjaneya Temple
Hebbagodi	BGS Health & Wellness Centre (nearby)	-	Tech Parks, Apartment complexes	Sri Shiva Temple
Huskur	-	-	Residential layout, Open space	Sri Gangamma Temple
Electronics City	Apollo Clinic, Medicover (nearby)	-	E-City Bus Terminal, Corporate offices	Prayer Hall (in commercial complex)
Kudlu Gate	-	-	Kudlu Lake Park, Residential	Sri Durgamma Temple
Singasandra	-	-	BBMP Office, Market area	Sri Anjaneya Swamy Temple
Bommasandra	Bommasandra Government Dispensary	Bommasandra Government School	Panchayat Office, Ground	Sri Veerabhadra Temple
Attibele	Attibele Government Hospital	Attibele High School	Town Municipal Office, Bus Stand	Sri Lakshmi Temple
Kempapura	-	-	Residential area, Junction park	Sri Maramma Temple
Line 3-2: Hosahalli – Kadabagere				

Station Location	Hospital / Clinic	Schools / Educational Institutions	Offices / Govt. Quarters / Parks / Academies	Religious Places
Hosahalli	-	-	Rural access point, Open land	Sri Durgamma Temple
Kadabagere	Kadabagere Government Dispensary	Kadabagere Government School	Village Panchayat Office, Ground	Sri Veerabhadra Swamy Temple

Source: JST

7.3.6 Utility

(1) Access to Infrastructure

A socio-economic survey (SES) was conducted to assess the status of access to basic infrastructure facilities among residents in the project-affected areas along the BMRCL Phase 3 alignment. The survey collected data on key services including electricity, water supply, sanitation, telecommunications, and solid waste collection.

The results indicate a high level of access to essential public services:

- 98% of respondents are connected to the Karnataka Power Transmission Corporation Limited (KPTCL) grid for electricity.
- 95% rely on tap water supplied by the Bangalore Water Supply and Sewerage Board (BWSSB), with the remainder depending on borewells or water tankers.
- 72% of households have private septic tanks for toilet and sewage disposal; only some older neighborhoods are connected to the BBMP sewer network.
- 100% of respondents own mobile phones, with widespread use of private telecom services such as Airtel, Jio, and Vi.
- 90% have access to BBMP's door-to-door solid waste collection service, with segregation of biodegradable and non-biodegradable waste in many areas.

These findings show that while core infrastructure is generally in place, gaps remain with regard to sewer connectivity and compliance with waste segregation. These issues will be addressed in coordination with municipal authorities during the project implementation stage.

(2) Utility Diversion

In Phase 3, elevated viaducts are to be constructed along major arterial roads, and the alignment traverses areas with dense concentrations of both underground and aboveground utilities. These include water mains, sewer lines, power transmission lines, telecom cables, traffic signals, and streetlights. Proper utility mapping, diversion, and relocation are essential to prevent construction delays, service interruptions, and safety risks.

Prior to construction, comprehensive utility surveys will be conducted using ground-penetrating radar (GPR) and trial trenching in order to accurately identify the location, depth, and condition of all utilities. Diversion plans will be prepared in coordination with the concerned agencies.

(3) Underground Utilities

The proposed elevated corridor passes through high-density commercial, institutional, and residential zones of Bengaluru, where multiple utility lines run beneath the road corridors. The following agencies and their services are expected to be affected:

Table7-36: Utilities and Agencies Affected by the Project

S. No.	Agency / Department	Utility Services
1	Bangalore Water Supply and Sewerage Board (BWSSB)	Water supply mains (150–600 mm diameter), service lines, hydrants, and pumping stations.
2	Bruhat Bengaluru Mahanagara Palike (BBMP)	Stormwater drains, open/closed nallahs, local sewers, and soak pits.
3	Karnataka Power Transmission Corporation Ltd. (KPTCL)	Underground power cables (11 kV and 33 kV), cable ducts, and manholes.
4	BESCOM (Bangalore Electricity Supply Company)	Distribution cables, transformers, and junction boxes in urban stretches.
5	BSNL, Airtel, Jio, Vi, and other telecom providers	Optical fiber cables (OFC), telecom ducts, manholes, and distribution boxes.
6	BBMP / Traffic Police	Underground cabling for traffic signals and smart city systems.
7	Indira Gandhi Institute of Child Health (IGICH), Hospitals, etc.	Dedicated service lines (in institutional zones).
8	Private Developers / Apartment Complexes	Internal utility lines (may affect compound walls and access).

Source: JST

Aboveground Utilities

To accommodate the elevated viaduct, piers, and overhead equipment (OHE), numerous aboveground utilities and structures will need to be relocated. These include:

- Street-light poles
- Traffic-signal poles and controller cabinets
- Telecom poles and overhead cables
- Distribution transformers and LT/HT poles
- Signage boards and surveillance cameras
- Bus shelters and kiosks

7.3.7 Cultural Heritage

There are no UNESCO World Heritage Sites, centrally protected monuments (ASI), or state-protected heritage structures within the project alignment or within a 100-m radius of the proposed stations and viaducts. Accordingly, the project will not impact any officially designated cultural-heritage structures. The project respects local cultural sensitivities and incorporates mitigation measures to safeguard community religious sites. All construction activities near such locations will be carried out with due care to preserve the cultural fabric of the neighbourhoods.

7.3.8 Water Use

In the Social Impact Assessment (SIA) conducted along the Bengaluru Metro Phase 3 alignment, all 318 respondents reported that the primary source of household water is tap water supplied by the Bangalore Water Supply and Sewerage Board (BWSSB). No respondents reported relying on nearby lakes, ponds,

or rivers for activities such as washing, fishing, or irrigation. The use of lake water is restricted due to pollution and regulatory prohibitions, and groundwater is used only as a supplementary source through borewells in some areas, primarily for non-potable purposes.

According to the *Dynamic Groundwater Resources of Karnataka* (2023), of the 12 assessment units (talukas) falling within the project corridor—primarily Bengaluru Urban, Anekal, Devanahalli, and Kanakapura—6 units (50%) are categorized as "Over-exploited," 4 (33.3%) as "Critical," and 2 (16.7%) as "Semi-critical," with no unit in the "Safe" category. This highlights the existing stress on groundwater resources in the region.

7.3.9 Social Acceptability

Site visits were conducted at each proposed station along Line 3-1 (JP Nagar 4th Phase – Kempapura) and Line 3-2 (Hosahalli – Kadabagere). The survey team interviewed respondents available near the proposed station locations to understand their awareness of, and views on, the project and its potential impacts. A summary is provided below; details are presented in the Resettlement Action Plan (RAP).

- Residents generally stated that the metro construction would contribute to the development of under-developed and peri-urban areas in south and west Bengaluru. In more remote yet fast-growing areas—such as Kempapura, Doddathogur, Anjanapura, and Kadabagere—improved connectivity is expected to deliver substantial benefits and accelerate urban expansion along the Kanakapura Road and Mysuru Road corridors.
- Approximately 92% of respondents—both men and women—expressed a positive opinion of the project. They highlighted worsening issues of traffic congestion, air and noise pollution, frequent honking, and road accidents.
- While women primarily use BMTC buses for daily travel, they indicated a preference to use the metro for longer commutes to employment hubs such as Electronics City, Kengeri, and the Airport, citing the need for faster, safer, and more reliable transport.
- Respondents observed that, although buses run frequently, they lack punctuality and travel times are prolonged due to congestion. Auto-rickshaws are often perceived as costly with non-metered fares; respondents therefore strongly supported the metro as a safer, more affordable, and efficient alternative.
- Many felt that existing transport facilities are inadequate and overcrowded. Residents in JP Nagar, Yelachenahalli, Hosahalli, and Kengeri reported long waiting times and expect the metro to substantially reduce travel time and improve comfort.
- Residents of peri-urban and industrial areas reported severe peak-hour congestion and risks of accidents and harassment (particularly for women) due to overcrowded buses and autos. They believe the metro will ease the burden on existing systems and improve road safety.
- Across the surveyed locations, residents welcomed the project as an easy, convenient, and reliable transport option expected to enhance access to schools, hospitals, offices, and commercial areas.
- Sixty-eight percent of respondents believed the metro would reduce air pollution by inducing a modal shift from private vehicles to mass transit.

- While women respondents were broadly supportive, 70% requested women-only coaches and 30% suggested priority seating for women within general coaches.
- Cited causes of traffic accidents along the corridors included the high number of vehicles, lack of lane discipline, inadequate signage, reckless driving, and overcrowded public transport.
- Respondent profiles along Line 3-1 (JP Nagar – Kempapura): 22% street vendors/hawkers, 18% government/private employees, 15% students, 12% skilled workers, 10% homemakers, 8% daily-wage laborers, 7% auto/taxi drivers, and 8% others (retailers, delivery workers, small business operators).
- Respondent profiles along Line 3-2 (Hosahalli – Kadabagere): 26% street vendors/hawkers, 20% private-sector workers, 14% students, 12% government employees, 10% skilled workers, 8% daily-wage laborers, 6% retailers, and 4% others (drivers/service sector).
- Average monthly income: INR 10,000–20,000 for vendors and laborers; INR 25,000–60,000 for government/private employees.
- Average monthly transport expenditure: INR 500–1,000 for 44% (Line 3-1) and 50% (Line 3-2) of respondents, mainly on buses, autos, and fuel.
- Respondents expected the project to create local employment opportunities during both construction and operation, particularly for youth and skilled workers in adjacent neighborhoods.
- On quality of life, respondents reported high satisfaction with access to schools, hospitals, offices, and commercial facilities, while expressing strong dissatisfaction regarding road safety, crowding, air/noise pollution, and lack of green spaces.
- As key factors for improving quality of life, 72% (Line 3-1) and 80% (Line 3-2) prioritized employment opportunities; ~76% emphasized access to healthcare; respondents along both corridors viewed safe and reliable transport as critical to raising urban living standards.
- Field verification and coordination with the Karnataka State Department of Archaeology and Heritage confirmed that there are no archaeologically or culturally significant sites within 50 m of the proposed station locations along either corridor.

7.4 Others

7.4.1 Road Safety

All 318 respondents reported experiencing long travel durations and heavy traffic leading to traffic incidents in the city.

7.4.2 Cross-Border Impact and Climate Change

The Bengaluru Metro Rail Corporation Limited (BMRCL) Phase 3 project plays a pivotal role in addressing climate change and enhancing regional connectivity across the Greater Bengaluru region. By promoting a shift from private vehicles to high-capacity, energy-efficient public transport, the metro system is expected to significantly reduce greenhouse-gas emissions. The project incorporates sustainable infrastructure designs—including solar-powered stations, rainwater harvesting systems, sewage recycling, and green-building practices aligned with IGBC standards—thereby enhancing resilience to climate-

induced challenges such as urban flooding and water scarcity. As part of Bengaluru's long-term urban-transport strategy, Phase 3 will help decongest key corridors such as Kanakapura Road and Mysuru Road and support economic growth by improving access to employment and education hubs.

7.4.3 Traffic / Public Access

Since most construction for Bengaluru Metro Phase 3 will take place along the medians of major corridors such as Kanakapura Road, Mysuru Road, and ORR, the median and two adjacent lanes will be temporarily used for construction. During piling, foundation works, and pier construction, a working width of approximately 9 m will be required and cordoned off with safety barricades.

To minimize disruption, two traffic lanes will be maintained on either side of the work zone. Where road widths are insufficient, temporary road widening will be undertaken by utilizing service lanes or obtaining temporary-encroachment permissions, subject to BBMP and traffic-police approvals. On high-volume stretches—such as Silk Board Junction, Hosahalli, JP Nagar, and Kengeri—one-way regulation or staggered flow may be introduced during peak construction phases. Depending on site conditions and progress, these measures are expected to remain in place for at least 4–6 months per segment.

In lower-volume areas—such as Kempapura, Doddathogur, and Kadabagere—full closures or major diversions will not be required. Short-term, localized diversions will be implemented only for critical activities such as girder launching or heavy-machinery movement, in close coordination with local authorities.

8. Impact Assessment

8.1 Overview of the Environmental Impact Assessment

The table below provides a summary of the environmental impact assessment; detailed justifications are presented in subsequent sections. These impact evaluations were carried out for each environmental component identified through scoping as potentially affected, based on the results of field surveys and analyses. Further assessment is recommended at the next phase where applicable.

Table8-1: Impact Assessment

Impact Items	Evaluation	Scoping		Impact Assessment		Reason for Evaluation
		Before construction Under construction	Operation	Before construction Under construction	Operation	
Pollution						
1	Air Pollution	✓	✓	A-	B+/-	Pre-construction: (-) Noncompliance with consent conditions may result in generating pollution and may trigger legal action against the project proponent. (-) During construction and demolition activities and land clearance, dust will be generated, adversely affecting air quality in the surrounding area. Construction: (-) Operation of construction machinery, vehicles, and loading/unloading of

Impact Items	Evaluation	Scoping		Impact Assessment		Reason for Evaluation
		Before construction Under construction	Operation	Before construction Under construction	Operation	
						construction materials will generate dust and gaseous pollutants, temporarily and locally degrading air quality. (-) Operation of temporary facilities (asphalt plants, quarries, disposal sites, etc.) and access roads will further deteriorate local air quality. (-) Increased traffic and congestion will also contribute to deterioration.
						Operation: (+) Overall, the use of metro lines is expected to reduce vehicle trips, thereby improving air quality. (+) The double-deck viaduct will add vehicular lanes, which may ease congestion and facilitate smoother traffic compared to the existing situation. (-) Around stations, increased traffic from metro users, commercial activities, and operation/maintenance activities may cause local deterioration of air quality. (-) Additional lanes may help in decongesting the corridor, but congestion may still occur at end sections where existing lanes cannot absorb increased traffic.
2.	Water Pollution	✓	✓	B-	B-	Pre-construction/Construction: (-) Turbid water is expected to occur, especially due to flows of silts and sediments. (-) Improper management of stockpiles of excavated soil and construction materials may expose them to erosion, particularly during the rainy season, and discharge into water bodies, thereby contributing to siltation/sedimentation of nearby drainage systems or natural waterways. (-) Discharge of wastewater and contaminated pollutants (oil, hazardous materials, coal tar, paints, etc.) from construction sites is expected to pollute water quality. Operation: (-) Cleaning of stations, depots, offices, and trains is expected to generate wastewater in metro premises.
						Operation: (-) Cleaning of stations, depots, offices, and trains is expected to generate wastewater within the metro facilities.
3	Waste	✓	✓	A-	B-	Pre-construction/Construction: (-) Solid waste such as debris from demolition of structures and excavated soil generated during land clearing and construction activities may be produced and could be inappropriately handled. (-) Improper management of hazardous waste generated during construction may

Impact Items	Evaluation	Scoping		Impact Assessment		Reason for Evaluation
		Before construction Under construction	Operation	Before construction Under construction	Operation	
						not only deteriorate the quality of the surrounding environment but could also lead to accidents. (-) Improper siting of disposal areas may cause contamination of soil and water.
						Operation: (-) Improper handling of waste generated from stations, depots, and maintenance activities may degrade the surrounding environment.
4	Soil Pollution	✓	✓	B-	B-	Construction: (-) Soil transported from construction sites may be contaminated with heavy metals and could spread into surrounding areas, potentially affecting the health of workers and local residents. (-) Soil may also be contaminated due to leakage of chemicals from construction vehicles and construction equipment.
						Operation: (-) Improper management of solid waste and wastewater generated at stations and depots may contaminate the surrounding soil.
5	Noise and Vibration	✓	✓	A-	B-	The noise level in the project area already exceeds the permissible limits. Pre-construction/Construction: (-) Construction activities such as operation of heavy machinery, dump trucks, and concrete placing equipment, as well as traffic congestion, are expected to increase noise and vibration levels, potentially affecting sensitive receptors in the area (e.g., residents, offices, schools, hospitals, religious facilities, wildlife). (-) Increased vibration and high-load operations (e.g., piling) may pose risks of damage to buildings and impacts on people. (-) Use of equipment that generates high levels of noise and vibration may affect workers' health.
						Operation: (-) Increased noise from metro and station operations, vehicular traffic, and maintenance activities, as well as the expansion of commercial activities, may affect surrounding residents and other sensitive receptors. (-) Increased vibration levels from metro operations and vehicular traffic may cause ground-borne vibration (GBV) in nearby buildings and structures.
6	Ground Subsidence	✓	✓	D	D	No significant ground subsidence has been recorded in the past. Construction: (-) There remains a possibility of unexpected incidents occurring.

Impact Items	Evaluation	Scoping		Impact Assessment		Reason for Evaluation
		Before construction Under construction	Operation	Before construction Under construction	Operation	
						Operation: (-) No impacts are expected during operation.
7	Odor	✓	✓	B-	B-	Construction: (-) Improper treatment of domestic wastewater at construction camps may cause unpleasant odors.
						Operation: (-) Improper operation and maintenance of sewage treatment plants (STPs) for domestic wastewater generated at metro stations may cause unpleasant odors.
Natural Environment						
8	Protected Areas			D	D	Construction: (-) The corridor does not pass through any protected areas.
						Operation: (-) No impacts from the project are anticipated.
9	Ecosystem	✓	✓	A-	B+/-	Pre-construction: (-) Laying the metro and road double-deck viaduct requires permissions from the Forest Department and other relevant authorities. (-) Approximately 6,828 trees will be affected by construction activities, with impacts also on local flora and fauna. The Tree Expert Committee (TEC) will determine whether the trees are to be felled, transplanted, or pruned. (-) Construction activities will require the felling of about 6,828 trees (including some considered forest), potentially affecting plant and animal life. (-) Endangered species listed in the IUCN Red List, such as the Bonnet Macaque, are distributed in the project area. Construction and operation of facilities may affect their habitats and behavior. Construction: (-) The ecosystem may be degraded due to human activities such as noise, vibration, and light. (-) Tree felling or transplantation may disturb bird nests and nesting sites.
						Operation: (+) Afforestation activities may enhance the conservation value of the project area. (-) Operation of the facilities may affect the habitats and behavior of flora and fauna around the project area, including species such as the Bonnet Macaque listed as threatened in the IUCN Red List.

Impact Items	Evaluation	Scoping		Impact Assessment		Reason for Evaluation
		Before construction Under construction	Operation	Before construction Under construction	Operation	
10	Hydrology	✓	✓	B-	B-	Construction: (-) The planned alignment passes through drainage channels. Insufficient drainage facilities during construction may cause localized flooding. (-) Pier construction within drainage channels may impact surface water flows. (-) During monsoon or heavy rainfall, flooding may occur, damaging construction activities and threatening worker safety.
						Operation: (-) The construction of a double-deck viaduct under this project will increase impervious paved surfaces; if drainage channel capacity is insufficient, localized flooding may occur.
11	Topography/Geology	✓		B-	B-	Construction: (-) Earthquakes and soil liquefaction may affect construction structures and schedules, posing safety risks to workers and local residents.
						Operation: (-) Earthquakes and soil liquefaction may affect railway facilities and operations, posing safety risks to staff, passengers, and nearby residents.
Social Environment						
12	Land Acquisition and Resettlement	✓		A-	D	Construction / Pre-construction: (-) Since the project corridor runs along existing roads, acquisition of some land adjacent to the existing road right-of-way will be required. (-) For PAPs (Project Affected Persons) who are forced to relocate, permanent resettlement will be necessary.
						Operation: (-) No impacts are anticipated from the project.
13	Livelihood and Living Standards	✓	✓	A+/-	A+	Construction / Pre-construction: (-) Traffic restrictions due to construction activities may temporarily reduce the income of businesses and industries along the corridor. (+) The project will directly create a considerable number of jobs and indirectly generate employment through related activities.
						Operation: (+) The metro and road are expected to increase employment opportunities, improve the local economy, and enhance quality of life through higher incomes, shorter travel times, and improved connectivity.
14		✓	✓	B+/-	B+	Construction / Pre-construction:

Impact Items	Evaluation	Scoping		Impact Assessment		Reason for Evaluation
		Before construction Under construction	Operation	Before construction Under construction	Operation	
	Vulnerable Groups					(-) If vulnerable groups and gender equality are not adequately considered, their opinions may not be reflected in public hearings or consultations, leading to loss of opportunities for participation in decision-making. (-) The project may affect small businesses in the area, which may also impact socially vulnerable groups associated with them. (+) Construction works may create employment opportunities for vulnerable groups.
						Operation: (+) Metro cars are equipped with priority seats for elderly people and women, and the first car is designated exclusively for women. (+) Operation of the metro is expected to increase job opportunities and improve access to education and other social infrastructure.
15	Cultural Heritage	✓	✓	C	D	Construction: (-) No cultural heritage sites exist along the corridor, but chance finds are possible.
						Operation: (-) No impacts are anticipated.
16	Landscape	✓	✓	B-	D	Construction: (-) The planned corridor runs mainly along existing roads and urban metro systems, where landscape characteristics have already changed. Stations and structures will be similar to existing ones. (-) Inadequate management of construction sites and improper waste disposal may cause temporary nuisance to local residents.
						Operation: (-) No new landscape or visual impacts are anticipated during operation.
17	Ethnic Minorities / Indigenous Peoples	✓		D	D	Construction / Pre-construction: (-) According to the census, no ethnic minorities or indigenous peoples are present in the project area.
						Operation: (-) No impacts are anticipated from the project.
18	Existing Social Infrastructure and Services (including basic infrastructure)	✓	✓	A-	B+	Construction / Pre-construction: (-) "No Objection Certificates (NOC)" from relevant departments are required, and non-compliance with conditions may result in legal action against the project proponent. (-) Temporary or permanent relocation of utilities may cause temporary impacts on local communities.

Impact Items	Evaluation	Scoping		Impact Assessment		Reason for Evaluation
		Before construction Under construction	Operation	Before construction Under construction	Operation	
						(-) In congested areas, residents' access to some social services such as hospitals, schools, and religious facilities may be temporarily restricted.
						Operation: (+) The metro and road will improve access to certain facilities.
19	Working Conditions (including Occupational Health and Safety)	✓	✓	B-	B-	Construction / Pre-construction: (-) Occupational accidents may occur due to inadequate maintenance of vehicles and machinery or lack of protective equipment. (-) Dust and noise generated by heavy machinery and construction materials may affect workers' health.
						Operation: (-) During operation and maintenance, accidents and injuries may occur due to poor maintenance of vehicles and equipment or insufficient training. (-) Inequality in employment opportunities, wages, and treatment among workers may arise.
20	Community Health, Safety and Security	✓	✓	A-	B-	Construction / Pre-construction: (-) Traffic and pollution caused by land development and construction activities may affect the health and safety of communities along the corridor. (-) Residents may be involved in accidents near construction sites or access roads. (-) Influx or increase of construction workers may pose risks of gender-based violence (GBV) or sexual exploitation and abuse (SEA) within nearby communities, although such risks are expected to be limited.
						Operation: (-) Passenger intrusion onto the tracks may pose safety risks to metro operations. (-) During operation, unpredictable events may cause accidents or injuries. (-) Elevated structures may affect the privacy of residents in surrounding areas.
Others						
21	Transboundary Impacts and Climate Change	✓	✓	B-	B+	Construction: (-) Temporary emissions of greenhouse gases are expected from construction activities. (-) Felling of trees will result in the loss of their function of converting carbon dioxide into oxygen. (+) Compensatory plantation will enhance oxygen supply and absorption of carbon dioxide from the atmosphere. (-) Extreme weather events may affect the performance of construction

Impact Items	Evaluation	Scoping		Impact Assessment		Reason for Evaluation
		Before construction Under construction	Operation	Before construction Under construction	Operation	
						materials, paint quality, and ground stability.
						Operation: (+) A modal shift from private cars, buses, and motorcycles to metro use is anticipated, contributing to the reduction of greenhouse gas emissions.

Note:

✔: Items for which project impacts are anticipated, or where impacts are uncertain and additional information is required; therefore, these items are subject to impact assessment.

A+/-: Significant positive/negative impacts are expected.

B+/-: Moderate positive/negative impacts are expected.

C: The degree of positive/negative impact is uncertain (further investigation is required, and the impacts may become clearer as the study progresses).

D: No impacts are expected.

N/A: No impacts were identified at the scoping stage; therefore, no impact assessment will be conducted.

Source: JST

8.2 Details of Adverse Environmental Impacts

The anticipated impacts are classified into pre-construction, construction, and operation phases. The environmental components considered include land environment, air quality, soil, water environment, noise environment, biological environment, and socio-economic environment.

8.2.1 Pre-construction and Construction Phase

(1) Pollution

1) Air Pollution

- Excavation, demolition, and material transportation during metro construction will generate a large quantity of dust, increasing concentrations of suspended particulate matter (PM_{10} and $PM_{2.5}$) in the air.
- Earthworks and temporary stockpiling of materials may further aggravate dust dispersion, particularly under dry and windy conditions.
- Heavy machinery such as bulldozers, cranes, and trucks emit pollutants including carbon monoxide (CO), nitrogen oxides (NO_2), sulfur oxides (SO_2), and particulate matter from diesel engines.
- Disturbance of soil from excavation, tunneling, and foundation works may release naturally occurring particulates into the atmosphere, thereby worsening air pollution.

2) Water Pollution

Construction activities may increase surface runoff and soil erosion, potentially contaminating nearby rivers with sediments, debris, and chemicals. In addition, improper management of construction wastes

and chemicals, including lubricants and fuels, poses risks of water contamination.

3) Waste

Pre-construction and construction stages involve demolition, land leveling, foundation works, and embankment filling, which will generate construction and demolition waste. Part of the material will be reused for backfilling, while the remainder will be recycled. Improper handling of solid waste generated from land clearing, construction activities, and domestic refuse from workers' camps could lead to soil, air, and water contamination, adversely affecting the health of workers and nearby residents. Improper disposal of hazardous waste from construction may degrade environmental quality through soil and groundwater contamination, and the release of odor or harmful gases. Furthermore, inappropriate storage or disposal of combustible and chemical waste may cause accidents such as fire, explosions, or health hazards for workers.

It is estimated that about 10–15% of total construction materials and wastes will be generated, including surplus material from contractor camps, packaging, and household refuse. Since all Phase 3 corridors are either elevated or at grade (with no underground stations), waste will primarily originate from construction activities, temporary labor camps, site offices, and station operations. Based on data from previous phases of Bengaluru Metro (Namma Metro) and similar urban infrastructure projects, it is estimated that during peak construction periods, approximately 40–45 m^3 of solid waste per day will be generated across all stations and depots. This includes surplus construction material, plastics, cardboard, kitchen waste, and sanitary waste.

4) Soil Contamination

During the pre-construction and construction phases, activities such as site clearing, demolition, construction, civil works, and maintenance are expected to generate waste. This will include non-hazardous waste (demolition debris, cleared soil, unsuitable/excess soil, waste concrete, domestic refuse, office waste, bottles, cigarette butts, packaging materials, etc.) and hazardous waste (broken bulbs, batteries, rags used for equipment repairs, cement bags, and empty containers of paint, lubricants, and pesticides). Heavy machinery and site equipment such as dump trucks, excavators, cranes, and bulldozers may leak engine oil, lubricants, and hydraulic fluids into the surrounding environment, contaminating soil and potentially affecting groundwater. If excavated soil at construction sites is contaminated with heavy metals, it may spread to surrounding areas, adversely impacting the health of workers and local residents.

5) Noise

Although construction noise is unlikely to directly impair hearing among residents, it may adversely affect quality of life. Noise can irritate people, cause stress, and disturb sleep, potentially leading to high blood pressure, anxiety, and hostility toward project authorities and government.

Construction noise may disturb people depending on proximity, affecting households, offices, retail businesses, public institutions, and religious facilities. Noise is particularly problematic in residential

areas at night and in commercial areas during daytime operations. The major sources of construction noise include movement of construction vehicles transporting materials and the on-site construction activities themselves. Metro construction is highly equipment-intensive, and noise prediction modeling has been conducted assuming simultaneous operation of multiple pieces of equipment.

The results of noise prediction are presented in the following table.

Table8-2: Predicted Noise Levels during Construction

Distance (m)	Concrete Hopper + Concrete Mixer Truck (dB(A))		Auger Drill + Dump Truck + Generator + Slurry Plant (dB(A))		Dump Truck + Hydraulic Excavator + Pneumatic Tools (dB(A))		Japanese Standards (dB(A))
	Lmax Maximum Sound Pressure Level	Leq Equivalent Noise Level	Lmax Maximum Sound Pressure Level	Leq Equivalent Noise Level	Lmax Maximum Sound Pressure Level	Leq Equivalent Noise Level	
5	92.7	87.5	94	92.5	94.9	93.3	80
10	86.7	81.5	88	86.5	85.8	85.3	80
15	83.1	77.9	84.5	83	82.3	81.8	80
20	80.6	75.4	82	80.5	79.8	79.3	80
25	78.7	73.5	80.1	78.6	77.9	77.4	85
30	77.1	71.9	78.5	77	76.3	75.8	85
35	75.8	70.6	77.1	75.6	75	74.5	85
40	74.6	69.4	76	74.5	73.8	73.3	85
45	73.6	68.4	75	73.4	72.8	72.3	85
50	72.7	67.5	74	72.5	71.9	71.4	85
55	71.9	66.7	73.2	71.7	71	70.5	85
60	71.1	65.9	72.5	71	70.3	69.8	85
65	70.4	65.2	71.8	70.3	69.6	69.1	85
70	69.8	64.6	71.1	69.6	68.9	68.4	85
75	69.2	64	70.5	0.09	68.3	67.8	85
80	68.6	63.4	70	68.5	67.8	67.3	85
85	68.1	62.9	69.4	67.9	67.3	66.8	85
90	67.6	62.4	68.9	67.4	66.8	66.3	85
95	67.1	61.9	68.5	67	66.3	65.8	85
100	66.7	61.5	68	66.5	65.8	65.3	85

Source: JST

6) Vibration

Vibrations during construction may have significant impacts on surrounding buildings and infrastructure. Heavy equipment such as excavators, pile drivers, and shield machines generate strong ground vibrations, which may cause cracks in walls, foundations, and pavements, particularly in aged or poorly constructed buildings. These vibrations may also affect underground utilities such as water pipes and gas pipelines, creating risks of leakage or damage.

The results of the estimated vibration levels are shown in the following table, and impacts are expected within a range of up to 30 m from the edge of the Right of Way (ROW).

Table8-3: Predicted Vibration Levels during Construction

建設時の距離別振動レベル（VdB）							Vibration Levels by Distance during Construction (VdB) FTA Standard Vibration Levels for Category 2 (VdB)
Equipment		Distance					
		10 m	20 m	30 m	40 m	50 m	
Pile Driver (Impact)	Upper Range	109.23	103.26	99.68	97.18	95.25	100
	typical	101.78	95.81	92.24	89.74	87.80	100
Pile Driver (Sonic)	Upper Range	102.91	96.95	93.37	90.87	88.93	100
	typical	90.21	84.24	80.67	78.17	76.23	100
Clam shovel drop (slurry wall)		91.71	85.74	82.16	79.67	77.73	100
Hydromill (slurry wall)	in soil	63.66	57.69	60.67	51.62	49.68	100
	in rock	70.21	64.24	75.05	58.17	56.23	100
Large Bulldozer		84.59	78.62	75.05	72.55	70.61	100
Caisson drilling		84.59	78.62	75.05	72.55	70.61	100
Loaded Truck		83.22	77.25	73.67	71.18	69.24	100
Jackhammer		76.48	70.51	66.94	64.44	62.5	100
Small Bulldozer		55.14	49.15	45.6	43.1	41.16	100

Source: JST

7) Ground Subsidence

Areas with potential risk of ground subsidence will be carefully identified and avoided based on comprehensive geotechnical investigations and geo-engineering studies to be conducted as part of detailed project planning. Given the scope of site investigations and engineering measures to be implemented under the BMRCL Phase 3 Project, significant ground subsidence is not anticipated. Prior to construction, detailed baseline condition surveys of existing buildings and structures along the planned alignment will be conducted. The condition of structures will be continuously monitored throughout the construction phase to enable early detection of potential impacts and protection of surrounding assets.

8) Odor

During the construction phase of the BMRCL Phase 3 Metro Project, improper handling of domestic refuse and wastewater from workers' camps and construction sites may generate unpleasant odors. As a large number of personnel will be stationed at these locations, wastes such as food residues, organics, and excreta will be generated on a daily basis.

(2) Natural Environment

1) Protected Areas

There are no protected areas in the vicinity of the planned corridor. The nearest protected area (national park) is Bannerghatta, located 7.05 km from the alignment. Therefore, no impacts on protected areas are anticipated.

2) Ecosystem

Potential impacts from the proposed metro are as follows:

Loss of Trees

- Felling of approximately 6,828 trees is anticipated, resulting in a reduction of the urban tree canopy.

Biodiversity Disturbance

- Loss of habitats for birds and insects, particularly around lakes and parks.

Urban Heat Island Intensification

- Local temperature increases due to reduced shading and evapotranspiration.

Soil Compaction and Erosion

- Degradation of soil health due to the use of heavy machinery.

Micro-habitat Alteration

- Changes in light, humidity, and temperature affecting native vegetation.

Dust Generation

- Increased concentrations of $PM_{2.5}$/PM_{10} adversely affecting health and photosynthesis.

Noise and Vibration Impacts

- Disturbance to fauna—stress among birds and mammals from loud machinery;
- Potential damage to fragile structures—vibration effects on cultural properties and heritage buildings.

Impacts from Waste and Hazardous Substances

- Improper disposal of construction spoil contaminating soils and waterways;
- Leakage of hazardous wastes—paints, solvents, and fuel oils adversely affecting ecosystems.

3) Aquatic Ecosystems

- **Potential Inflows to Water Bodies**
- Drainage from the elevated structures (including the double-deck viaduct) constructed under the project may discharge into nearby lakes (e.g., Hebbal, Rachenahalli/"Rovari"*, Nagavavi/Nagarabhavi*). However, these lakes already receive runoff from existing roads, and the nature of inflows is not expected to change significantly due to the project. Accordingly, significant adverse impacts on lake aquatic ecosystems are not anticipated.

  [Note: Lake names standardized to common English spellings if needed in final editing.]

4) Hydrogeology

Surface Water

The construction of metro and road infrastructure in Phase 3 — such as elevated structures and station foundations — may temporarily affect local surface-water drainage systems. Activities such as pier construction, establishment of temporary construction yards, and excavation near stormwater drains may obstruct natural drainage routes, impede surface runoff, and increase the risk of localized inundation during the monsoon season.

If dewatering activities are not properly managed, surface water may overflow or be discharged into adjacent stormwater drains or lakes. In addition, the introduction of impervious surfaces (e.g., temporary roads and material stockyards), as well as accidental blockage of drains by sediments or spoil, may exacerbate surface runoff and reduce drainage efficiency.

Drainage from the proposed double-deck viaduct may flow into nearby lakes (e.g., Hebbal Lake, Rachenahalli Lake, and Nagarabhavi Lake). However, these lakes already receive road runoff, and a significant change in the characteristics of inflows due to the project is not anticipated.

The potential implications of drainage discharge on downstream agricultural water use, including water rights, have also been examined. At present, runoff from the planned alignment is connected to existing road drainage systems, and downstream agricultural water use areas are located at a considerable distance from the project site. Therefore, no substantial increase or decrease in water volume, nor any significant deterioration in water quality, is expected to occur in downstream agricultural areas as a result of this project.double-deck

Groundwater

Bengaluru's groundwater system predominantly occurs within weathered/fractured granitic formations, with aquifers generally shallow and localized. Construction activities such as deep excavation, tunneling, and piling may alter natural groundwater flow patterns, particularly in areas with high water tables.

Dewatering associated with construction of underground stations and tunneling across aquifers may temporarily lower groundwater levels and affect nearby borewells and private sources. Uncontrolled dewatering may induce soil consolidation or settlement in vulnerable areas. Inflows of groundwater into tunnel sections could pose technical challenges and require careful hydrogeological assessment.

5) Geology and Topography

Bengaluru exhibits complex geology dominated by hard crystalline igneous rocks (primarily Peninsular gneiss and granites), interspersed with lateritic horizons and residual soils. These rock masses are highly weathered and fractured, especially in the upper zones, which has implications for foundation design.

In areas with deep weathered layers or thick overburden, specialized ground-stabilization techniques—such as soil nailing, micropiles, and secant piles—will be required to ensure slope stability and prevent collapse during excavation.

The alignment lies within an undulating terrain at elevations of approximately 800–950 m, posing additional engineering challenges. Grading and excavation for station boxes, access ramps, and viaducts will be carefully planned to minimize cut-and-fill quantities and avoid slope destabilization. In hilly and sloped sections, terracing, retaining structures, and erosion-control measures will be implemented.

Land preparation activities—vegetation clearance, grading, and excavation—may temporarily increase topsoil loss and erosion risks, particularly during heavy rainfall events.

(3) Social Environment

1) Land Acquisition

Refer to the RAP.

2) Livelihoods

Construction activities—particularly at elevated corridor and station locations—may temporarily disrupt local commercial activities. Reduced access, lower footfall, and reduced visibility may affect small vendors and roadside businesses. BMRCL will implement staged construction, traffic-management plans, and community outreach to minimize economic impacts and support business continuity.

3) Vulnerable Groups

Migrant workers, low-income households, persons with disabilities, and the elderly may face disproportionate impacts, including mobility constraints, reduced access to services, and exposure to construction risks. BMRCL will ensure universal design (ramps, tactile paving, elevators), conduct targeted stakeholder consultations, and strengthen access to the grievance redress mechanism (GRM) through multilingual support and community facilitators.

During the pre-construction and construction stages, women, elderly persons, low-income households, migrant workers, and persons with disabilities may experience disproportionate impacts, particularly in terms of restricted mobility, reduced access to essential services, and limited access to project information.

4) Cultural Heritage

No heritage structures have been identified along the route; however, heritage surveys will be conducted in sensitive sections prior to construction. Where activities occur near important structures, protective measures—such as vibration monitoring and isolation trenches—will be introduced to prevent damage.

5) Landscape

Temporary construction facilities (site offices, stockyards, embankments, fencing) will alter the local landscape during construction. BMRCL will undertake site beautification, install green screens, and carry out post-construction landscaping to restore visual quality. Architectural design measures will be incorporated in elevated sections to harmonize with the urban streetscape.

6) Existing Social Infrastructure and Services (including basic infrastructure)

Phase 3 routes intersect existing utilities such as power lines, telecom cables, water mains, and gas pipelines. Approximately 500 utility assets (e.g., poles, manholes, high-tension lines, junction boxes) will require relocation. BMRCL will coordinate planned diversions with BWSSB, BESCOM, and

BSNL to minimize service interruptions. Temporary access diversions will be designed to maintain connectivity to schools, hospitals, and public facilities.

Additionally, major temples and religious facilities, which serve as important social assets for local communities, will also be ensured safe and continuous access during construction.

Access routes will be maintained or temporarily rerouted through consultations with local residents and temple committees, with appropriate signage and pedestrian safety measures.

7) Working Conditions (including Occupational Health and Safety)

Workers face risks from machinery, electrical hazards, falls, and extreme heat. BMRCL will mandate PPE, safety training, site audits, and 24-hour medical support. During summer, heat-stress countermeasures (shading, potable water, staggered shifts) will be implemented. All contractors must comply with OSHA-equivalent safety standards.

8) Community Health, Safety and Security

Communities may be affected by dust, noise, and traffic. BMRCL will implement dust suppression (water sprinkling, coverings), noise barriers, and controlled blasting. Workers' camps will be sited away from residential areas; sewage will be treated prior to discharge to prevent water-quality impacts.

(4) Others

1) Climate Change

Rising temperatures and irregular rainfall may affect construction schedules and worker safety. Heat-wave response plans and monsoon-ready drainage systems will be introduced. During operation, risks of rail buckling due to extreme heat will be mitigated through thermal-stress monitoring, speed restrictions, and rail-stress management. Stations will be designed for flood resilience and energy efficiency.

8.2.2 Operation Phase

(1) Pollution

1) Air Pollution

All BMRCL metro systems are electric and produce no direct emissions during operation. Indirect emissions arise from power generation (predominantly thermal), but are substantially lower than emissions from equivalent private-vehicle use. Localized dust and fumes may arise during maintenance activities (e.g., welding, grinding).

2) Water Pollution

Wastewater from stations, depots, and maintenance yards may contain organics, detergents, oils, and

low-level chemicals. All such wastewater will be treated at on-site STPs and reused for landscaping/cleaning, or safely discharged in compliance with CPCB and BWSSB standards. Oil-water separators and grit chambers will prevent contamination of stormwater drains.

3) Waste

Three waste streams will be managed:

- **Solid waste** (passenger refuse, packaging): segregation, daily collection, and recycling;
- **Biodegradable waste**: composting at the depot;
- **Hazardous waste** (used oils, batteries, solvents): collection and treatment through authorized agencies (approved by KSPCB).
  Illegal dumping or untreated disposal is strictly prohibited.

4) Soil Contamination

As operations occur in controlled environments with proper waste management, the risk of soil contamination is minimal. Preventive measures include sealed storage of chemicals, spill-prevention kits, and periodic inspections.

5) Noise

Operational noise may arise from train wheel–rail interaction, station equipment (ventilation, escalators), and passenger movements, potentially affecting nearby residents.

6) Vibration

Operations in underground and elevated sections may cause minor rattling of windows or low-level "rumbling" but structural damage is not anticipated. Vibration levels will be monitored, and vibration-attenuating track or isolation systems implemented to comply with RDSO 2015 guidelines (72 VdB in residential areas).

7) Odor

Odors may arise from toilets, sewage facilities, and accumulated waste at stations and depots. BMRCL will implement:

- Daily cleaning and bio-enzyme treatment;
- Adequate ventilation and automatic deodorization systems;
- Regular sludge removal and STP maintenance.

(2) Natural Environment

1) Ecosystems

Green areas around stations and depots will be enhanced through landscaping and urban afforestation. While minor effects due to noise and lighting are possible, significant impacts on urban-adapted species

are not expected.

The Indian Flying Fox (*Pteropus giganteus*), a nocturnal species, could not be fully assessed during daytime baseline surveys. Although no active roosts were confirmed, the species may forage within the project influence area. Therefore, a potential impact cannot be ruled out, and additional species-specific nocturnal surveys will be conducted prior to construction to verify the presence of any roosting or feeding activity.

2) Hydrogeology

In areas with high groundwater tables (e.g., Basavangudi, Jayanagar), underground stations and tunnels will be protected using cut-off walls and grouting. Drainage systems will be integrated with the BBMP stormwater network to prevent localized flooding. Tunnel drainage will be treated and reused to minimize excessive groundwater drawdown.

3) Geology and Topography

Although Bengaluru lies in Seismic Zone II (low risk), metro structures will be designed to IS:1893 standards. Due to competent rock masses, liquefaction risk is low. Tunnel routes avoid major faults based on geological surveys.

(3) Social Environment

1) Vulnerable Groups

Elevators, tactile tiles, ramps, and audio guidance will be provided. Fare concessions will be offered for students, seniors, and persons with disabilities. Awareness campaigns and community engagement will promote equitable access.

2) Water Use

Operational water demands (cleaning, sanitation, cooling) will be met through BWSSB supply and tanker water. Rainwater harvesting will be installed at all stations and depots. Dual plumbing will facilitate reuse, and smart meters will monitor consumption to prevent wastage.

3) Occupational Health and Safety

Operations staff will be protected through regular training, PPE, and health checkups. Air-conditioned work environments will be provided. Emergency drills and fire-protection systems will be in place.

4) Community Health and Safety

Risks from overcrowding, poor lighting, and inadequate access will be mitigated through CCTV coverage, adequate illumination, and crowd management. Pedestrian-only pathways and safe crossings will be provided. Fire detection, suppression, and evacuation plans will be implemented.

(4) Others

1) Transboundary Impacts and Climate Change

Risks of thermal rail buckling will be managed through thermal-stress monitoring, rail-stress adjustment, and speed restrictions. Underground stations will adopt flood-resilient design (elevated entrances, dewatering pumps). Energy efficiency will be enhanced through LED lighting and regenerative braking; solar PV will be installed on depot and station rooftops.

As described in **Section 22.3.4 Economic Benefits (5) Benefits from Reduced Pollutant Emissions**, the project will promote a modal shift to rail, leading to reductions in greenhouse gas (GHG) emissions. Based on estimates using JICA's Climate-FIT tool and related guidelines, substantial post-opening reductions in CO_2 emissions are expected, along with co-benefits from reduced air pollutants. Accordingly, the project is confirmed to contribute to both local and transboundary air-pollution mitigation and climate-change mitigation.

8.2.3 Disaster Risk Assessment

Objective and Methodology

In accordance with the Terms of Reference, a disaster risk assessment was conducted for flooding (fluvial/pluvial) and earthquakes in the Bengaluru Metropolitan Region, applying the *JICA Climate-FIT (Adaptation)* framework. For flooding, in addition to historical inundation records, scenarios with return periods of 30 and 100 years for fluvial flooding and 10, 25, and 50 years for pluvial flooding were analyzed. For earthquakes, the Design Basis Report (Phase 2, IRS-compliant) prepared by the DDC was reviewed to confirm consideration of seismic loads, with particular focus on the seismic performance of the double-deck viaducts. Once BMRCL receive the Design Basis Report for the project from DDC, the Detaied Design will be updated.

Following the Climate-FIT (Adaptation) procedure, (i) hazard inventory, (ii) vulnerability assessment (identification of assets and causes of functional disruption), (iii) risk assessment, and (iv) adaptation options (design/operational recommendations) are presented.

(1) Flood Risk Assessment

The flood risk assessment was carried out in line with the ToR using the JICA Climate-FIT (Adaptation) analytical framework. Flooding was categorized into fluvial (river/lake overflows) and pluvial (urban drainage failures), and multiple probability rainfall scenarios were examined for each.

Representative inundation depths were set using thresholds commonly employed in urban flood risk assessments (0.1/0.3/0.9/1.5 m), integrating the following information:

- Flood data obtained from BBMP: rainfall records and flood history from 1983–2022;
- BBMP "Critical Flood-Prone Locations" (2021 Action Plan): observed hotspots;
- Urban flood models by IISc/KSNDMC/BBMP (UFM; WLS observations): validation of depth ranges;
- Previous studies (e.g., Ramachandra & Mujumdar 2009).

Because the BBMP dataset does not record inundation depths directly, representative depth classes (pluvial: 0.1–0.3 / 0.3–0.9 / 0.9–1.5 m; fluvial: 0.3–0.9 / >1.5 m) were established by reconciling past heavy-rain events (e.g., 150–185 mm/24 h in May 2019 and June 2020) with UFM observations and model results.

Table8-4: Flood Risk Assessment

Risk	Major Measures	Design/Operation	Expected Effect
Pluvial flood 0.3–0.9 m	Elevating entrances, pit waterproofing, increasing drainage capacity	Design	Reduction of inundation inside stations and quicker recovery
Fluvial flood 0.9–1.5 m	Elevation of critical equipment, reinforcement of embankments/obstruction removal, emergency shutoff	Design/Operation	Avoidance of long-term service suspension
Early warning	WLS threshold × operation trigger, securing alternative routes	Operation	Preemptive suspension and ensured safety

Source: JST

(2) Seismic Risk Assessment

The seismic risk assessment was conducted in accordance with the requirements of the Terms of Reference (TOR), applying the analytical framework of JICA Climate-FIT (Adaptation). Although Climate-FIT is primarily intended for climate change adaptation, it also includes a screening process for natural disaster risks in general; therefore, in this study, seismic risk was assessed in addition to flood risk.

First, regarding the hazard of seismic occurrence, Bengaluru Urban District, the project area, is classified as Zone II (low seismic hazard zone) in the seismic zoning defined by the Bureau of Indian Standards (BIS: IS 1893:2002). Zone II represents the lowest seismic hazard classification in India, approximately equivalent to a maximum intensity of V on the Modified Mercalli scale. Within Karnataka State, this zone is considered to have minimal seismic risk (refer to Section 2, “Current status of Environmental and Social Conditions ”).

For the evaluation of structural vulnerability to earthquakes, particularly for double-deck viaducts and similar structures, reference was made to the Design Basis Report (DBR) prepared by the Detailed Design Consultant (DDC). The DBR serves as the technical document outlining the basic design principles of the project. Since the DBR for Phase 3 is still under preparation, the DBR disclosed for Phase 2 was used for reference.

As for design standards, the Indian Railway Standards (IRS) are applied. IRS stipulates the seismic load requirements for railway structures in India, ensuring structural safety for bridges, viaducts, and major station facilities. According to confirmation by Japanese experts (JST), the disclosed DBR indicates that seismic loads have been duly considered in compliance with IRS.

In addition, Phase 3 will adopt the same double-deck viaduct structural concept as Phase 2. For seismic design, a horizontal seismic coefficient of 0.10, which is specified for Zone II under the Indian Railway Standards (IRS), will be applied. These seismic design conditions will be updated and formally applied

once BMRCL receives the final design completion report (DBR) from the Detailed Design Consultant (DDC).

Table8-5: Seismic Risk Assessment

Item	Content
Design Standard	Compliant with IRS, based on DDC Design Basis Report (Phase 2)
Target Structures	Double-deck viaducts, major stations
Vulnerability	Seismic loads already considered; no additional reinforcement required (within current design scope)
Risk Level	Low

Notes:

- The detailed design for Phase 3 is still ongoing, and the final seismic design conditions will be updated by the DDC.
- This assessment is a provisional confirmation based on the publicly available Phase 2 DBR and IRS standards, positioned as part of the disaster risk screening in line with the Climate-FIT tool framework.

Source: JST

9. Mitigation Measures and Costs for Implementation

9.1 Environmental Management Plan (Pre-construction, Construction, Operation)

Table9-1: Environmental Management Plan

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
Pre-construction / Construction Stage						
Pollution						
1	Air Pollution	Pre-construction:(-) Non-compliance with permit conditions may cause pollution and result in legal action against the project entity. (-) Dust may be generated during construction, demolition, or site preparation activities, adversely affecting the air quality of surrounding areas. Construction: (-) Operation of construction machinery and vehicles, as well as loading/unloading of construction materials, may emit dust and gaseous pollutants, temporarily and locally deteriorating air quality. (-) Additional sources include temporary facilities (asphalt plants, quarries, disposal sites) and access roads, further degrading regional air quality. (-) Increased traffic volume and congestion will add to air quality deterioration.	• Conduct regular inspections to ensure compliance with permit conditions • Provide training to workers on environmental regulations and permit requirements • Implement dust suppression measures during excavation, leveling, filling, and waste handling. Dust emissions from transport, handling, construction, or storage must be confined within the project area. • Ensure vehicles and machinery comply with emission standards and undergo regular inspection/maintenance • Cover transported materials to prevent dust dispersion • Install vehicle washing pits and clean with high-pressure water • Place stockpiled soil at designated sites with slopes, and conduct continuous sprinkling or equivalent dust suppression • Traffic management and congestion mitigation measures such as scheduling material transport during off-peak hours, optimizing routing and consolidating deliveries to reduce the number of vehicle trips, establishing designated haul routes that avoid sensitive receptors, implementing temporary traffic regulations, and providing advance information to road users and local communities.	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)
2	Water Pollution	Pre-construction / Construction: (-) Turbid water may be generated during construction, and runoff of silt and sediments is anticipated. (-) If excavation soil and construction materials are inappropriately stored, especially during the rainy season, they may be subject to erosion, flow into water bodies, and cause	• Formulate and implement a comprehensive water management plan, ensuring segregation and treatment of solid, liquid, and hazardous wastes in accordance with local regulations. • Promote recycling and reuse to minimize wastewater generation. • Keep exposed soil areas to a minimum and cover them as early as possible.	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
		sedimentation in nearby drainage systems and natural waterways. (-) Wastewater and pollutants (oil, hazardous substances, coal tar, paints, etc.) from construction sites are expected to contaminate water quality.	• Transport surplus soil and other excavated materials to designated disposal sites. • Formulate and implement site management plans to prevent soil erosion from entering water bodies.			
3	Waste	Pre-construction / Construction: (-) Solid wastes such as debris from demolition, excavated soil from land clearing, and construction activities may be generated and improperly handled. (-) Improper management of hazardous wastes generated during construction may not only deteriorate the surrounding environment but also pose risks of accidents. (-) Improper siting of disposal areas may lead to soil and water contamination.	• Formulate and implement a comprehensive waste management plan, ensuring segregation and treatment of solid and hazardous wastes in accordance with local regulations. • Implement 3R measures (Reduce, Reuse, Recycle) to minimize waste generation. • Dispose of construction and demolition (C&D) waste at authorized C&D recycling facilities. • Store hazardous wastes on impermeable flooring with protective measures against leakage, spillage, or damage, and entrust disposal only to licensed recyclers. • Place surplus excavated soil at disposal sites in layers and compact mechanically.	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)
4	Soil Contamination	Construction: (-) Soil excavated and transported from construction sites may be contaminated with heavy metals and spread to surrounding areas, potentially affecting the health of workers and nearby residents. (-) Soil may also be contaminated by leaks of chemicals from construction vehicles and equipment.	• Conduct a comprehensive soil survey prior to construction to identify existing contaminants and establish baseline conditions. • If contamination is detected, prepare a remediation plan to minimize impacts. • Handle and dispose of all wastes (including hazardous wastes) during construction in compliance with environmental regulations. • In case of spillage or leakage, immediately apply the emergency response plan (spill control) and occupational health and safety plan. • Chemicals (e.g., grease, oil) used during construction shall be stored on impermeable precast concrete flooring to prevent infiltration into soil. • Regularly inspect construction sites to ensure compliance with soil contamination prevention measures.	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)
5	Noise & Vibration	Pre-construction / Construction: (-) Construction activities involving heavy machinery, dump trucks, and concrete mixers, as well as traffic congestion, may increase noise and vibration levels, affecting sensitive receptors (e.g., residents, offices, schools,	[Source-based measures] • Use low-noise and low-vibration machinery. • Install silencers/mufflers as needed to keep machinery noise within permissible limits. [Community-level measures] • Restrict noisy activities to daytime hours (06:00–	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
		hospitals, religious sites, wildlife). (-) Increased vibration and high-intensity works (e.g., pile driving) may pose risks of damage to buildings and human health. (-) Operation of noisy and vibration-intensive equipment may affect workers' health.	22:00). • Adjust work schedules near schools to avoid disruption of classes. • Install noise barriers where necessary to minimize impacts on residential areas and sensitive receptors. • Introduce vibration-damping techniques such as isolating machinery from the ground. • Conduct pre-construction surveys of nearby buildings and install temporary supports or reinforcements where necessary. • Maintain proper planning, coordination, and communication with local communities. [Worker protection] • Provide personal protective equipment such as earplugs and conduct training.			
6	Land Subsidence	Construction: (-) There remains a possibility of unforeseen incidents occurring.	• Conduct detailed surveys of buildings and houses along the planned route. • Monitor the condition of buildings and houses during construction.	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)
7	Odor	Construction: Improper treatment of domestic wastewater at construction camps may cause unpleasant odors.	• Implement effective waste management. • Provide sufficient sanitation facilities such as portable toilets and waste containers at construction sites. • Ensure regular collection and disposal of wastes to prevent accumulation and minimize odor generation.	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)
Natural Environment						
8	Ecology	Pre-construction: (-) Construction of metro and double-deck viaducts/roads requires clearance from the Forest Department and related authorities. (-) About 6,828 trees will be affected by construction activities, impacting flora and fauna; felling, transplantation, or pruning will be decided by the Tree Expert Committee (TEC). (-) Approximately 6,828 trees (some classified as forest trees) will need to be cut, potentially impacting plant and animal species. (-) Species listed in the IUCN Red List, such as the Bonnet Macaque, are found in the project area and may be affected in terms of habitat and behavior due to project construction and operation.	• Conduct regular inspections and staff training to ensure compliance with permit conditions. • Clearly mark trees to be felled and minimize the number of trees cut. • Protect and maintain trees identified by the Forest Department/TEC as conservation priority during construction. • In line with the Karnataka High Court ruling (20 Aug 2020), plant 10 saplings for every tree felled. • Transplant trees where feasible in accordance with Forest Department guidelines. • Undertake compensatory plantation on BMRCL land or Forest Department–designated land where possible. • Check for rare species nesting in trees marked for transplantation. • Demarcate and protect parks, gardens, and urban	Contractor	BMRCL & TEC	Part of contract cost (borne by Contractor)

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
		Construction: (-) Ecosystems may be degraded by anthropogenic activities (noise, vibration, light, etc.). (-) Nesting birds may be disturbed during tree transplantation or felling.	forests, restricting access during construction. • Avoid high-noise activities during nighttime.			
		Bonnet Macaque (Macaca radiata, VU): Risk of habitat fragmentation/disturbance due to construction noise/vibration, tree felling, and worker activities.	• Conduct pre-construction surveys (camera traps, community consultations) to confirm distribution. • Install canopy bridges where needed to ensure movement corridors. • Plant native trees (e.g., Ficus) to supplement foraging habitat. • Implement noise/vibration reduction (noise barriers, low-noise machinery). • Provide worker training on environment/wildlife protection. • Introduce non-lethal deterrents and deploy rapid-response teams to mitigate human-wildlife conflicts. • Submit quarterly monitoring reports to BMRCL.	Contractor	BMRCL, TEC	Approx. INR 3,020,000 (including first 3 years of post-construction monitoring)
9	Hydrology	Pre-construction / Construction: (-) The proposed alignment crosses drainage channels; inadequate drainage works may cause localized flooding. (-) Pile construction within drainage channels may affect surface water. (-) Flooding may occur during monsoons/heavy rainfall, damaging construction activities and endangering worker safety.	• Conduct surveys of surface/groundwater levels, flow conditions, and groundwater depth to assess potential hydrological impacts. • BMRCL to construct flood protection walls and desilt drainage channels before the monsoon to secure drainage capacity. • Implement regular water level and water quality monitoring at nearby wells around construction sites.	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)
10	Topography & Geology	Construction: (-) Earthquakes or soil liquefaction may affect construction structures and schedules, posing safety risks to workers and local communities.	• Conduct geological/geotechnical surveys prior to construction to assess topography, soil, rock, faults, and seismic activity for safe design. • Integrate permanent erosion control measures into the project. • Regularly monitor ground conditions during construction.	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)
Social Environment						
11	Land Acquisition and Resettlement	Pre-construction / Construction: (-) As the project alignment follows existing roads, some adjacent land acquisition will be required. (-) Permanent resettlement will be required for	Refer to RAP	Refer to RAP	Refer to RAP	Refer to RAP

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
		PAPs (Project Affected Persons) subject to displacement.				
12	Livelihoods	Pre-construction / Construction: (-) Construction-related traffic restrictions may temporarily reduce income of roadside businesses and industries. (+) The project will generate a significant number of direct jobs and indirect employment through related activities.	• Ensure access to local businesses so that serious disruption to operations is avoided. • Conduct consultations with business owners, employees, and other stakeholders so that concerns and issues are reflected in decision-making and timely information is provided.	Contractor	PIU / BMRCL	Part of overall project cost
13	Vulnerable Groups	Pre-construction / Construction: (-) If vulnerable groups and gender equality are not adequately considered, their views may not be reflected in public hearings/consultations, leading to loss of participation in decision-making. (-) The project may affect small-scale businesses, with socially vulnerable groups at risk of being disproportionately impacted. (+) Construction works may create job opportunities for vulnerable groups.	• Prioritize use of local materials and contractors to stimulate the local economy and create jobs for vulnerable groups. • Engage vulnerable and marginalized groups—including women, elderly, poor households, single parents, and persons with disabilities—so that their concerns are reflected and they can share in project benefits and opportunities. • Establish a Grievance Redress Mechanism (GRM) to ensure affected people have a channel to express concerns. • Mitigation measures for women and vulnerable groups shall be implemented following the monitoring indicators below: - monitoring of participation in consultations, - monitoring of grievances from vulnerable groups, - monitoring of accessibility issues, with monthly, quarterly, and semi-annual reporting depending on indicator characteristics.	Contractor	PIU / BMRCL	Part of overall project cost
14	Cultural Heritage	Construction: (-) No cultural heritage sites are known along the alignment, but chance finds may occur.	• If ASI-protected cultural property is discovered, obtain legal clearance from relevant authorities before construction.	Contractor	PIU / BMRCL	Part of overall project cost
15	Landscape	Construction: (-) The proposed corridor mainly follows existing roads and urban metro alignments, where landscape characteristics have already been altered. Stations and structures will be similar to existing ones. (-) Poor management of construction sites or improper waste disposal may cause temporary nuisance to local residents.	• Maintain construction sites, temporary facilities, and access roads in a clean condition and strictly manage solid waste to prevent landscape disturbance. • Document the condition of roads and infrastructure before construction, and restore them to at least their original condition after completion. • Operate grievance procedures in a timely and transparent manner, and implement additional measures if complaints or risks arise.	Contractor	PIU / BMRCL	Part of overall project cost

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
16	Existing Social Infrastructure and Services (incl. Basic Infrastructure)	Pre-construction / Construction: (-) "No Objection Certificates (NOC)" from concerned departments are required; non-compliance with conditions may lead to legal action against the project entity. (-) Temporary/permanent relocation of utilities may temporarily affect local communities. (-) In congested areas, community access to social services such as hospitals, schools, and religious facilities may be temporarily restricted.	• Survey all public utilities and their locations in advance to avoid damage. • Ensure public services are maintained during construction and continue after completion. • Install traffic guidance and warning signs, and provide detours where necessary to maintain safe access to critical facilities such as hospitals and schools. • Conduct consultations with municipalities and stakeholders to disseminate project plans and impacts. • Engage vulnerable people (women, elderly, poor households, single parents, persons with disabilities) to reflect their concerns and ensure benefits are shared. • Ensure safe and uninterrupted access to temples and religious facilities during construction, including temporary diversions and appropriate signage.	Contractor	PIU / BMRCL	Part of overall project cost
17	Working Environment (incl. Occupational Safety)	Pre-construction / Construction: (-) Inadequate maintenance of vehicles/machinery or lack of protective equipment may result in occupational accidents. (-) Heavy equipment and construction materials may generate dust and noise, affecting worker health.	• Develop and implement a Safety, Health and Environment (SHE) Manual. • Conduct regular health check-ups for workers. • Provide proper training, maintenance, and safety measures to prevent accidents. • Comply with working hour regulations and ensure adequate rest periods. • Regularly maintain vehicles and machinery to prevent breakdowns and accidents. • Supply PPE to protect workers from dust, noise, vibration, and extreme weather. • Conduct regular safety training to reinforce hazard awareness and safe practices. • Develop and implement emergency response plans for accidents. • Introduce advanced construction management techniques and strict safety standards to minimize risks during viaduct works.	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)
18	Community Health, Safety and Security	Pre-construction / Construction: (-) Local communities along the corridor may be affected by traffic and pollution from land preparation and construction activities. (-) Residents may be at risk of accidents near construction sites and access roads.	• Conduct regular consultations with local communities. • If grievances arise, identify causes, devise countermeasures, and disclose them. • Use slogans and other tools to disseminate health and safety measures to communities. • Operate a GRM to respond to complaints. • Risks of gender-based violence (GBV), sexual exploitation, and abuse (SEA) associated with the	Contractor	PIU / BMRCL	Part of contract cost (borne by Contractor)

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
			influx or increase of construction workers will be mitigated through the operation of the grievance redress mechanism (GRM), proper management of workers' camps, and awareness-raising activities within the local communities. • Provide information on health and safety risks—including detours for vehicles and pedestrians—promptly and through multiple media. • Monitor, record, report, and disclose accidents around construction sites and temporary facilities. • For measures on air, water, noise, vibration, waste, and public access, refer to respective sections.			
Others						
19	Cross-border Impacts and Climate Change	Construction phase: (-) Temporary emissions of greenhouse gases are expected due to construction activities. (-) Tree felling will result in the loss of the ability to convert carbon dioxide into oxygen. (+) Compensatory afforestation will enhance oxygen supply and CO_2 absorption in the atmosphere. (-) Extreme weather events may affect construction material performance, paint quality, and soil stability.	• Conduct awareness-raising and tree planting campaigns. For every tree felled, plant 10 saplings. • Implement appropriate measures to protect workers from heat stress. • Distribute water regularly and ensure drinking water availability. • Provide rest shelters during summer to mitigate heat impacts. • Incorporate green building elements at the design stage, considering material management, waste generation, and water demand.	Contractor	PIU / BMRCL	Part of contract cost (borne by contractor)
Operation Stage						
Pollution						
1	Air Pollution	Operation stage: (-) Around stations, localized deterioration of air quality may occur due to increased traffic volume from passengers, intensified commercial activities, and operation/maintenance activities. (-) Additional road lanes may help alleviate congestion within the project section, but if existing lanes cannot accommodate the additional traffic flow, congestion may occur at the ends of the section.	• Ensure smooth integration of the metro with other public transport systems to minimize reliance on private vehicles. • Develop pedestrian-friendly zones around stations, including wide sidewalks, crosswalks, and clear signage. • Plan and implement maintenance works so as not to obstruct traffic and pedestrian flows. • Carry out regular maintenance of substations, depots, and other associated facilities.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost
2	Water Pollution	Operation stage: (-) Wastewater is expected to be generated within metro facilities from stations, depots, offices, and train cleaning.	• Introduce water-saving devices such as low-flow faucets to minimize wastewater generation. • Install wastewater treatment facilities at stations and depots, and promote reuse of treated water. • Provide training to staff on water conservation.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
3	Waste	Operation stage: (-) Improper handling of waste generated from stations, depots, and maintenance activities may deteriorate the surrounding environment.	• Ensure appropriate disposal of operational waste, including e-waste and battery waste, at certified recycling facilities. • Provide training to staff on waste management. • Promote material reuse such as metal recycling and minimize waste generation.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost
4	Soil Contamination	Operation stage: (-) Improper management of solid waste and wastewater generated at stations and depots may contaminate surrounding soil.	• Develop green belts and landscaping. • Implement waste collection and management measures. • Conduct regular site inspections to confirm compliance with soil contamination prevention measures.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost
5	Noise and Vibration	Operation stage: (-) Noise generated from metro operations, station activities, vehicular traffic, and maintenance works, along with expanded commercial activities, may affect surrounding residents and sensitive receptors. (-) Increased vibration levels from metro operation and traffic may cause ground-borne vibration (GBV) impacting nearby buildings and structures.	• Conduct noise monitoring near residential areas and sensitive receptors. • At locations where complaints arise, introduce low-noise technologies such as wheel re-profiling, rail grinding, and resilient pads. • Manage station announcement volumes and comply with noise standards. • Conduct vibration monitoring near residential areas and sensitive receptors. • At complaint sites, implement anti-vibration measures such as wheel re-profiling, rail grinding, speed control, elastic fasteners, and buffer pads. •A combined noise and vibration assessment shall be conducted considering both metro operation and adjacent road-traffic flows, particularly at elevated shared viaduct sections. If the combined simulation indicates potential exceedance of national or international standards at sensitive receptors, appropriate mitigation measures — such as installation of noise barriers, low-noise track/wheel technologies, rail grinding, speed regulation, or other engineering controls — shall be implemented. These measures shall be reflected in the updated EMP and EMoP.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost
6	Odor	Operation stage: (-) Inappropriate operation and maintenance of sewage treatment plants (STPs) treating domestic wastewater at metro stations may generate unpleasant odors.	• Regularly clean and collect waste at stations and depots. • Ensure proper and regular operation and maintenance of STPs installed at metro stations, depots, and other facilities.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost
Natural Environment						

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
7	Ecology	Operation stage: (-) Operation of facilities may affect habitats and behaviors of flora and fauna, including species listed as threatened on the IUCN Red List, such as the Bonnet Macaque. Specifically, Bonnet Macaques (Macaca radiata, VU) may face habitat fragmentation, behavioral disturbance, and increased human-wildlife conflict (e.g., foraging on garbage, feeding, aggressive interactions) due to noise, vibration, light pollution, and increased traffic from metro and road operations.	• Restore native vegetation in disturbed areas to minimize human-macaque interactions. • Establish and maintain green corridors and canopy bridges to prevent habitat fragmentation, ensure safe crossing of metro and double-deck road sections, and reduce roadkill risk. • Plant and maintain native fruit-bearing trees (e.g., Ficus species) around stations, viaducts, and buffer zones to restore foraging habitats. • Conduct continuous awareness campaigns for local residents (ban on feeding, strict waste management). • Establish a rapid response team to address human-wildlife conflict using non-lethal methods. • Conduct monitoring for 5 years post-operation to track distribution, population, and behavioral changes of macaque groups. • Collaborate with research institutions and the Forest Department to review findings and introduce additional measures as needed.	PIU / BMRCL	PIU / BMRCL	Approx. INR 3,020,000 (including initial 3-year post-operation monitoring)
8	Hydrology	Operation stage: (-) Due to increased impervious paved surfaces from the double-deck elevated structure, local flooding may occur if the drainage channel capacity is insufficient.	• Advanced drainage systems must be introduced to prevent inundation and reduce flood risk. • Flood control during operation: all above-ground structures are designed above the 100-year flood level, and station entrances are provided with step-ups/downs or temporary flood barriers.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost
9	Topography and Geology	Operation stage: (-) Earthquakes and liquefaction may impact railway facilities and operations, posing safety risks to staff, passengers, and residents.	• Facilities are designed to withstand seismic loads based on regional seismic hazard assessment. • Comprehensive emergency response measures, including disaster management plans, are applied to prepare for earthquakes and liquefaction.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost
Social Environment						
10	Working Environment (including Occupational Health and Safety)	Operation stage: (-) During operation and maintenance activities, accidents or injuries may occur due to inadequate maintenance of vehicles and equipment, or insufficient training. (-) Inequities in employment opportunities, wages, and working conditions may arise among workers.	• BMRCL shall fully respect labor rights and establish procedures to comply with national legal requirements. • Develop and implement Occupational Health and Safety (OHS) and emergency response plans, and strictly enforce preventive safety and security protocols.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost
11	Community Health, Safety and Security	Operation stage: (-) Passenger intrusion onto railway tracks may affect metro safety.	• Install Platform Screen Doors (PSDs) and CCTV to prevent passenger access to the tracks.	PIU / BMRCL	PIU / BMRCL	Part of overall project cost

Number	Item	Potential Impact	Mitigation Measures	Implementing Agency	Responsible Agency	Cost
		(-) During operation, unpredictable events may lead to accidents or injuries. (-) Elevated roads may affect the privacy of residents in surrounding areas.	• Deploy security personnel at stations to monitor passengers at entry points. • Install warning signs to control unauthorized access. • Provide clearly designated emergency exits, evacuation systems, and alarm/announcement systems. • Install pedestrian crossings at appropriate locations with clear markings. • Publicly disclose information promptly in the event of operational interruptions. • In designing and constructing elevated roads, take due consideration of the privacy of nearby residents. In areas where residential houses are located close to the alignment, particular attention should be paid to potential light pollution caused by metro operations at night.			

Source: JST

9.2 Details of Mitigation Measures

9.2.1 Pre-construction and Construction Phase

(1) Pollution Prevention

1) Air Quality

During construction, air quality impacts will mainly arise from increases in PM_{10} on haul roads and emissions from vehicles and construction machinery. The following measures shall be adopted to minimize air pollution:

- The Contractor shall take all necessary precautions to minimize the release of fugitive dust during activities such as excavation, grading, land clearing, and waste handling. No visible dust plumes shall be allowed to remain beyond the site boundary for prolonged periods without prior notice.
- The Contractor shall use construction equipment designed to minimize air pollution and shall retain evidence of such design/specifications for inspection by the Employer.
- All transport vehicles and construction equipment shall comply with emission standards prescribed by statutory authorities of the Government of India/State Government. The Contractor shall conduct periodic inspections and undertake corrective actions, including replacement where necessary, to ensure operation within permissible limits.
- Loads of dust-generating materials (e.g., soil, aggregates, construction debris) transported from the site shall be covered. All trucks carrying unconsolidated materials shall be tarpaulin-covered and loaded with adequate freeboard to prevent spillage from tailgates or sideboards.
- Stockpiles shall be properly maintained by the Contractor until excavated material is reused for backfilling or as directed by the Employer; dust suppression shall continue even during work stoppages.
- Materials shall be stored and handled to minimize dust generation.
- Keep material quantities at daily minimums and apply water spray to suppress dust. During dry and windy conditions, routine dust suppression methods shall be used to prevent off-site migration.
- Apply water spraying as needed during handling of excavated soils/debris and during demolition. Water trucks, supply and dispensing arrangements shall be available at all times. Where necessary, use dust screens and apply additional measures near sensitive receptors.
- Provide wheel-wash pits or tyre-washing facilities at exits of batching yards and construction bases.
- Such facilities shall use high-pressure water jets directed at the wheels to remove soil and mud completely.
- Construction Traffic and Congestion Management:
  To minimize air-quality deterioration caused by construction-related traffic, the Contractor

shall implement traffic management and congestion mitigation measures in coordination with the traffic police and relevant municipal authorities. These measures shall include scheduling material transport during off-peak hours, optimizing routing and consolidating deliveries to reduce the number of vehicle trips, establishing designated haul routes that avoid sensitive receptors, implementing temporary traffic regulations (e.g., lane management, speed control, and deployment of flagmen), and providing advance information to road users and local communities. The effectiveness of these traffic-related measures shall be reviewed and reflected in the Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP).

- In addition, once the detailed design stage confirms the final structural and operational conditions for both metro operations and adjacent road traffic on the double-deck viaduct, a quantitative assessment of the combined impacts of air quality will be undertaken. The outcome of this assessment will be used to refine the construction-phase air pollutions -mitigation measures and will be reflected in the EMP and the EMoP.

2) Water Quality Protection

- Sewage shall be managed through appropriate sewage treatment systems. Prior to commencement, the Contractor shall prepare a Sewage/ Wastewater Management Plan.
- Groundwater quality monitoring results, including fluoride (F^-), will be shared with the Karnataka State Pollution Control Board (KSPCB) and relevant water-resource authorities. Any guidance provided by these agencies—such as additional monitoring, precautionary communication, or community advisories—will be incorporated during project implementation.

3) Waste Management

i. Construction & Demolition (C&D) Waste

- Store C&D waste in designated, secure areas.
- The Contractor is responsible for segregation, storage, and disposal in line with KSPCB and BBMP norms.
- Do not mix C&D waste with municipal solid waste or hazardous waste.
- Dispose only at KSPCB-authorized C&D processing facilities.
- Ensure disposal within 15 days or when quantities reach 15 tonnes, whichever is earlier.
- Promote reuse/recycling for backfilling, road sub-base, and landscaping.

ii. Surplus Excavated Soil (Muck)

- Transport excavated soil to authorized low-lying areas or government-approved sites (BDA/BBMP).
- Coordinate in advance with land-owning agencies.
- Encourage reuse for embankments, parks, and lake rejuvenation.
- Dust suppression by water spraying, minimizing drop heights, and covering stockpiles with tarpaulin.

- Stabilize stockpiles on slopes using toe walls, geotextiles, or retaining structures.
- Use GPS-enabled vehicles and waste manifests to prevent illegal dumping.

iii. Hazardous Waste

- Includes used oil, solvents, batteries, and paint waste.
- Classify and manage per Hazardous & Other Wastes (Management & Transboundary Movement) Rules, 2016.
- Store in labeled, impervious, secure locations with spill prevention.
- Display boards indicating waste type, quantity, and date.
- Limit on-site storage to within 90 days; maintain auditable records.
- Dispose only through KSPCB-authorized recyclers/TSDF (with Form-10 documentation).
- Keep used oil in sealed containers; return empty drums to suppliers.

4) Potable Water, Sanitation, Solid Waste & Odour Control

All stations shall be provided with adequate potable water and sanitation (RO drinking water; gender-responsive and accessible toilets). Sewage shall be connected to BBMP sewer networks or treated on-site by STPs; septic sludge shall be safely collected/disposed by authorized vendors. Station solid waste shall be segregated into biodegradable, non-biodegradable, and sanitary waste for daily collection and processing. Organic waste shall be sent to BBMP composting facilities; recyclables to authorized vendors. Awareness campaigns shall promote cleanliness.

During construction, wastewater from batching yards and wheel-washing shall be settled and reused, following a zero-liquid-discharge approach. RO reject and filtered water shall be reused for dust suppression, cleaning, and landscaping; groundwater recharge may be undertaken where feasible. To control odour, sewer lines shall be properly vented and sealed; STPs and storage tanks shall be fitted with bio-filters and serviced regularly. Any odour incidents shall be addressed promptly.

To avoid accumulation of putrescible waste and related nuisances, BMRCL shall enforce strict waste and sanitation protocols in line with CPCB/BBMP guidelines. All construction camps shall have hygienic toilets, septic tanks, and scheduled desludging. Solid waste shall be source-segregated, stored in covered bins, and dispatched to authorized facilities at regular intervals. Periodic inspections and monitoring will ensure compliance with environmental and public-health standards, minimizing odour emissions and safeguarding worker welfare and nearby communities.

5) Soil and Groundwater Contamination Prevention

Oil and grease from construction machinery shall be collected and disposed of properly. Prevent runoff from entering groundwater or surface water. Provide oil traps in heavy equipment areas to recover hydrocarbons; install siltation basins upstream of outlets to reduce suspended loads in stormwater. Implement erosion and sediment control (silt fences, mulching, temporary vegetative cover, stabilized site entrances) to prevent sediment entry into storm drains and water bodies.

6) Noise Control

Elevated sections shall adopt ballastless track with double-layer rubber pads to reduce noise and vibration, and noise barriers up to rail height shall be installed. Apply suitable structural design and equipment layout at noise sources and use anti-vibration mounts/dampers. The Contractor shall deploy state-of-the-art acoustic controls and effectively enclose noisy equipment. Provide ear muffs to workers and install temporary noise barriers/enclosures for excessive sources. Manage day/night work to comply with standards; if exceedances occur, immediately implement corrective measures (e.g., relocation or shutdown). Transport vehicles shall have appropriate silencers. Operate noisy equipment primarily in daytime and monitor noise per CPCB standards. Prior to construction, undertake detailed noise assessment to identify receptor-specific mitigation.

In addition, once the detailed design stage confirms the final structural and operational conditions for both metro operations and adjacent road traffic on the double-deck viaduct, a quantitative assessment of the combined noise impacts will be undertaken. The outcome of this assessment will be used to refine the operation-phase noise-mitigation measures and will be reflected in the Environmental Management Plan (EMP) and the Environmental Monitoring Plan (EMoP).

7) Vibration Control

As vibration typically arises from wheel–rail interaction, minimize through reduction of surface irregularities, installation of under-sleeper/under-rail pads, and providing separation between rail seats and concrete base. For construction activities (e.g., piling) that may induce vibration, conduct multiple measurements and interpret impacts on nearby buildings/structures. Engage accredited monitoring agencies for analysis.

(2) Natural Environment

1) Ecology

a) Tree Felling and Compensatory Plantation

A total of 6,828 trees will be affected by this project. Affected trees will be transplanted, felled, or pruned as determined by the Tree Expert Committee (TEC) through on-site verification and deliberation. Final approval for felling is granted by the Deputy Conservator of Forests (DCF), BBMP, through the issuance of a Tree Clearance Order.

For Package 1 (JP Nagar – Mysore Road section), an official felling permission (Official Memorandum No. DCF/PR.642/2025-26) was issued by the BBMP Forest Wing on September 1, 2025. Based on field verification by the TEC, 686 trees were identified for retention, 406 for transplantation, and 1,092 for felling in this section.

Following TEC recommendations, BMRCL will prepare and implement a tree transplantation and compensatory plantation plan, subject to approval by the Forest Department. For each felled tree, at least ten saplings will be planted, and the survival of transplanted trees and saplings will be monitored

for five years. Replacement planting will be conducted annually for any dead transplants or saplings. Transplanted trees will be relocated to BBMP-designated receiving sites (e.g., KSRP Residency, land behind KSRP Convention Centre), where they will be maintained and monitored for a minimum of five years.

Compensatory plantation will enhance the city's green cover and contribute to dust and noise attenuation as well as urban landscape improvement. The cost of plantation will be included in the Environmental Management Plan (EMP) budget. Native shrubs and groundcover will be planted in the medians beneath elevated structures to form green belts, improve the streetscape, and mitigate environmental impacts.

b) Biodiversity Conservation Measures

- Undertake plantation along the metro alignment and around stations to improve landscape and micro-climate, enhance groundwater recharge, and reduce air/noise pollution.
- Prohibit groundwater abstraction (borewells) in parks, gardens, and urban forests.
- Protect retained trees with metal/brick tree guards and maintain during construction.
- Avoid high-noise night works; where unavoidable, provide noise barriers, particularly near parks and urban forests.
- Verify that no key bird nesting occurs on trees slated for transplant.
- As social surveys confirmed Bonnet Macaque (Macaca radiata, VU on IUCN Red List) at three locations, a species-specific Conservation Plan has been prepared: pre-construction additional surveys, canopy bridges where required, planting of native food trees (e.g., Ficus), community awareness, non-lethal deterrence, rapid response team, and periodic monitoring, including five years post-operation. These measures shall be integrated into site-specific EMP/EMoP; BMRCL will supervise and report quarterly (construction) and semi-annually (operation).

2) Hydrology

Conduct hydrological assessments to evaluate potential effects of pier foundations near storm drains/low-lying areas on surface and groundwater. Reuse dewatering flows from pile boring for recharge or construction purposes. Undertake pre-monsoon desilting and provide temporary bypasses to maintain drainage. Minimize the number of piers within drains and align pier geometry with flow. Avoid construction during monsoon to the extent practicable. BMRCL will obtain approvals from BBMP, BWSSB, and flood-management authorities and install temporary cofferdams/controls to prevent silt inflow. These measures aim to safeguard Bengaluru's drainage system and mitigate flood risk.

3) Erosion Control

Implement temporary erosion and sediment control to prevent soil loss, drain siltation, and pollution of nearby water bodies. As Phase 3 predominantly consists of elevated viaducts and localized pier foundations, exposed areas will be limited. No large-scale earthworks or vegetation clearance shall

proceed without BMRCL's prior approval. Stabilize excavated areas promptly with silt fences, straw bales, and geotextiles; cover with tarpaulin during monsoon or dry windy periods. Phase earthworks and apply grading, mulching, and turfing for permanent slope protection. BMRCL will monitor compliance, especially near drains, lakes, and residential areas. Discharge of untreated runoff to drains is prohibited; all work sites shall install sedimentation basins and silt traps.

(3) Social Environment

1) Land Acquisition

Refer to the Resettlement Action Plan (RAP).

2) Livelihoods and Community Engagement

BMRCL engages with affected communities through stakeholder consultations to address concerns and promote inclusive development. Local employment, skill development, and local procurement shall be prioritized to support livelihood opportunities. A Grievance Redress Mechanism (GRM) will operate for real-time resolution.

3) Vulnerable Groups

Particular attention shall be given to women, elderly persons, persons with disabilities, low-income households, and informal workers. Station designs will incorporate accessibility features such as tactile paving, ramps, and lifts. Marginalized groups shall be included in consultations, and their needs reflected in mitigation and access plans.

4) Chance-Find Procedures (Archaeology/Heritage)

If cultural property or protected remains are discovered, works shall stop immediately and the Department of Archaeology & Museums, Government of Karnataka, shall be notified. Work will resume only after obtaining approvals under ASI/State heritage laws.

5) Visual Amenity and Housekeeping

Maintain high housekeeping standards at construction sites, batching yards, and worker camps. A dedicated sanitation/housekeeping team shall handle daily cleaning and waste removal. Key actions include:

- Prohibit dumping of spoil/debris on public roads.
- Transport sand/soil/materials in covered trucks to prevent spillage and dust.
- Properly stack and store steel, cement, and construction materials.
- Provide silt traps and spill-control in hazardous-material storage zones.
- Clean toilets, drains, and living areas regularly.
- Enforce compliance by all subcontractors.

6) Water Use

- Use BWSSB potable water for construction and station operations.
- Do not abstract groundwater (borewells) without permits as per the Karnataka Groundwater Act.
- Install rainwater harvesting (RWH) systems at all elevated stations and depots.
- Convey roof/platform runoff through internal downpipes to recharge pits or storage tanks.
- Provide recharge structures in medians/green belts.
- Treat station greywater in STPs and reuse for landscaping.
- Provide RO-treated drinking water for workers with periodic quality testing.

7) Existing Utilities and Social Infrastructure

- Conduct detailed utility detection using GPR and trial pits prior to any works.
- Coordinate diversions of power/telecom/water/sewer with BESCOM, BWSSB, BBMP, BSNL and private operators.
- Avoid permanent disruption of essential services; implement temporary bypasses swiftly.
- Ensure safe access to hospitals, schools, and markets through: pedestrian diversions; temporary foot overbridges; traffic marshals and signage.
- Ensure safe and continuous access to major temples and religious facilities during construction, recognizing their cultural and social importance for local communities. Temporary access routes shall be provided where required, along with clear signage, traffic marshals, and pedestrian-safety measures, in consultation with temple committees and local residents.
- Communicate schedules and impacts through stakeholder consultations.

8) Child Rights and Safety

- Provide noise barriers and vibration controls near schools.
- Schedule high-noise works (piling/cutting) outside school hours.
- Coordinate with schools during exams/events to minimize impacts.
- Provide signage and traffic marshals to protect children near work sites.

9) Communicable Diseases

- Conduct medical camps and health awareness programmes in worker camps.
- Ensure first-aid kits, safe drinking water, and sanitation.
- Prefer local hiring to reduce health risks associated with labour in-migration.
- Undertake regular vector control (e.g., fumigation) against mosquitoes.

10) Occupational Health and Safety

- All works shall comply with BMRCL's SHE Manual aligned to ISO 45001 and relevant Indian OHS legislation.
- Key measures:

  - Provide PPE (helmets, gloves, safety harnesses, etc.) to all workers.
  - Conduct fire/evacuation/emergency response drills and trainings.
  - Implement daily/periodic inspections and safety audits.
  - Report incidents to BMRCL and labour authorities.
  - Ensure safety for working at height, lifting operations, and machinery use.
  - Enforce electrical safety audits and confined-space procedures.
  - Implement traffic management with reflective vests, cones, and signage.
- Sanitation: clean toilets/urinals with septic tanks or portable STPs; scheduled desludging and disinfection.
- Canteen/Rest Areas: hygienic catering; rest rooms with fans for heat-stress relief.
- Security: deploy guards at sites and camps, with accountability to BMRCL and police.

11) Community Health and Safety

- Provide a toll-free GRM and on-ground response staff.
- Communicate in real time via SMS, notices, and community meetings.
- Clearly mark and publicize traffic diversions.
- Record, report, and disclose any community-involved accidents.

(4) Others

1) Road Safety

- Provide safe, well-lit pedestrian diversions with signage.
- Install fencing/barricades around active work zones.
- Ensure high-visibility vests for all workers.
- Engage a traffic consultant to design diversion plans and monitor traffic flow.

2) Climate Resilience

- Heat-stress measures: drinking water points, shaded rest areas, shift rotations.
- Tree plantation for carbon offsets and increased canopy.
- Green-building features at stations (energy efficiency, solar PV, RWH).

3) Traffic Management

- Adopt balanced cantilever and precast segment methods to minimize road occupation and on-site work volume.
- Stage construction to maintain traffic flow.
- Coordinate with Bengaluru Traffic Police for real-time traffic control.

9.2.2 Operation Phase

(1) Pollution Prevention

1) Air Quality

- BMRCL will promote integrated and sustainable mobility to reduce vehicle exhaust and improve urban air quality.
- Strengthen last-mile connectivity through electric buses, e-rickshaws, bicycle sharing, and pedestrian-only links.
- Optimize feeder services in coordination with BMTC and private operators.
- Provide park-and-ride facilities at major stations to discourage private car use in congested areas.
- Conduct periodic emission audits of support vehicles (staff buses, maintenance fleets) to ensure compliance with Bharat Stage-VI norms.
- Localized dust/fumes from maintenance activities (e.g., welding, grinding) shall be controlled through dust collectors, PPE, and adequate ventilation.
- Since the elevated road will operate on the upper deck above the metro alignment, cumulative air-quality impacts—such as emissions from road traffic in addition to metro-related activities—have been considered. The air-quality assessment and mitigation measures presented in this EIA therefore reflect the combined operational impacts of both the road and metro components.

2) Water Quality

- Water conservation and pollution prevention are integral to sustainable operations.
- Provide STPs at all depots and major stations for treatment of blackwater.
- Reuse treated effluent for landscaping, cleaning, and cooling to reduce freshwater demand.
- Install water-efficient fixtures (low-flow taps, sensor flush) at all stations.
- Implement strict spill-prevention procedures in maintenance areas.
- Groundwater quality monitoring results, including fluoride (F^-), will be shared with the Karnataka State Pollution Control Board (KSPCB) and relevant water-resource authorities. Any guidance provided by these agencies—such as additional monitoring, precautionary communication, or community advisories—will be incorporated during project implementation.

3) Solid Waste Management

- Implement a system-wide waste management programme at all stations and depots.
- Provide colour-coded bins at suitable locations:
  - Green: biodegradable (e.g., food waste, paper)
  - Blue: recyclables (plastics, metals, glass)
  - Red: sanitary waste and household hazardous fractions
- Collect waste daily and hand over to BBMP for scientific disposal/recycling.

- Conduct awareness campaigns (digital displays, posters, announcements) to promote segregation by users.

4) Hazardous Waste Management

- Manage hazardous wastes from maintenance (used oil, batteries, e-waste, solvents) in accordance with KSPCB and 2016 Rules.
- Store safely in labeled, impervious containers with spill controls.
- Display waste type, quantity, and date at storage locations.
- Dispose only through KSPCB-authorized recyclers against Form-10 documentation.
- Prohibit open burning and illegal dumping.

5) Soil Contamination Prevention

- Use bunded storage for fuels, oils, and chemicals at depots.
- Provide spill kits and absorbents at high-risk locations.
- Establish green belts/planting along viaducts and around stations for stabilization and amenity.
- Conduct periodic soil tests near maintenance areas.

6) Noise Control

- Prioritize noise mitigation in residential and mixed-use areas.
- Provide noise barriers along elevated sections near schools, hospitals, and residences.
- Reduce rolling noise using resilient track fastenings and wheel dampers.
- Undertake regular rail/vehicle maintenance to prevent squeal and uneven wear.
- Operate PA systems at regulated volumes.
- Monitor at sensitive receptors quarterly and ensure compliance with CPCB limits (65 dB day/55 dB night).
- In addition, once the detailed design stage confirms the final structural and operational conditions for both metro operations and adjacent road traffic on the double-deck viaduct, a quantitative assessment of the combined noise impacts will be undertaken. The outcome of this assessment will be used to refine the operation-phase noise-mitigation measures and will be reflected in the Environmental Management Plan (EMP) and the Environmental Monitoring Plan (EMoP).

7) Vibration Control

- Mitigate wheel-rail vibration using resilient fastenings and under-rail pads.
- Maintain smooth rail profiles and precise track geometry to minimize dynamic forces.
- Monitor vibration during trial running and annually thereafter.
- Consider low-amplitude/high-frequency vibration in design to protect adjacent structures.
- Although the ODA loan covers only the metro component, the elevated road and metro will operate on a shared double-deck viaduct. Therefore, vibration levels experienced by roadside

receptors are influenced by both metro operation and road-traffic operation. The vibration assessment and proposed mitigation measures in this EIA have been prepared considering such cumulative impacts arising from both components.

(2) Natural Environment

1) Ecology

(Against the possible impacts on Indian flying foxes)

- Implement wildlife-friendly night-time lighting (shielding, directional lighting, minimizing light spill) near trees that may be used by Pteropus giganteus for foraging or temporary roosting.
- Avoid removal of large canopy trees wherever possible, especially if pre-construction surveys confirm bat activity.
- Based on nocturnal surveys, introduce additional measures such as buffer zones or restriction of night-time works if bat presence is confirmed.
- These measures will be incorporated into the updated EMP and EMoP.

2) Hydrology and Flood Resilience

- Given Bengaluru's urban-flood history, hydrological safety is a priority.
- Station/depot design shall consider the 1-in-100-year flood level and historical inundation data.
- Do not obstruct storm drains (rajakaluves); avoid narrowing by appropriate pier placement.
- Provide adequate freeboard and place electrical equipment at higher elevations for protection during heavy rainfall.
- Integrate schemes with BBMP drainage to avoid flow impediments.

3) Geology and Seismic Safety

- Bengaluru lies in Seismic Zone III (moderate risk).
- All structures shall be designed per IS 1893 and NBC 2016.
- Enhance resilience through flexible joints, ductile detailing, and base isolation where applicable.
- The Disaster Management Plan (DMP) shall include earthquake response, automatic train protection, and evacuation procedures.

(3) Social Environment

1) Rainwater Harvesting (RWH)

- Mandate RWH at all stations and depots to address groundwater depletion.
- Convey roof/platform runoff via downpipes to recharge pits or storage tanks.
- Provide built-in ducts in piers to direct runoff to soakaways in medians/green belts.
- Monitor recharge efficiency annually.

2) Community Health and Safety

- Maintain continuous engagement to uphold community trust and safety.

- Operate a GRM with toll-free number, mobile app, and on-ground staff for real-time response.
- Record and review incidents in/around stations; document any community-involved injuries.
- Conduct safety campaigns on platform behaviour, emergency exits, and evacuation drills.

(4) Others

1) Road Safety

- To reduce accidents and improve mobility:
  - Provide pedestrian subways/FOBs linking stations to major destinations.
  - Install medians to prevent unauthorized crossings.
  - Provide speed calming, signage, and zebra crossings at intersections near stations.
  - Ensure continuous, well-lit sidewalks and cycle tracks.

2) Climate Resilience and Awareness

- BMRCL shall lead climate adaptation efforts:
  - Heat-stress measures: drinking water kiosks, shaded waiting areas, ventilated rest spaces.
  - Urban forestry: extensive plantation along the alignment prioritizing native species.
  - Awareness programmes on climate change, water conservation, and sustainable commuting.

3) Public Transport Integration and Access

c) Multimodal Integration (MMI)

- Establish integrated hubs aggregating metro, bus, auto, taxi, and bicycle stands.
- Provide real-time displays for bus arrivals and shared mobility.
- Designate feeder-bus priority lanes near station entrances.

d) Non-Motorized Transport (NMT)

- Provide continuous, barrier-free sidewalks with tactile guidance for the visually impaired.
- Install bicycle parking and bike-share docks at key nodes.
- Provide multilingual wayfinding.

4) Intersection Traffic Management

- To ease congestion and enhance safety:
  - Provide regulated bus bays to avoid haphazard stopping.
  - Synchronize signals near stations to smooth peak flows.
  - Deploy traffic marshals during peak hours at high-volume stations.

9.3 Disaster Management

A disaster refers to an unforeseen event due to structural failure, fire, accidents, natural hazards (heavy

rain, lightning, high winds), or man-made threats. As Phase 3 comprises elevated/at-grade sections only, the Disaster Management Plan (DMP) focuses on protecting viaducts, stations, rolling stock, and passengers under surface conditions.

Anticipated key risks include:

- Cracks/settlement of piers and girders
- Fire in rolling stock or station premises
- Electrical failures or OHE malfunctions
- Flooding/inundation during monsoon
- Crowd-related incidents
- Accidents during construction or operation

These require preventive monitoring, preparedness, and coordinated emergency response.

9.3.1 Preventive Measures

Prevention is the first line of defence. On identification of early signs (vibration, cracking, equipment malfunction), immediate corrective actions are required. The engineering team shall:

- Maintain repair materials, jacking systems, and emergency support equipment.
- Conduct periodic inspections of piers, bearings, and girders using drones and visual checks.
- Monitor foundation stability, especially during monsoon.
- Provide fire-resistant materials and lightning protection at all stations and electrical rooms.

9.3.2 Reporting Protocol

Define clear criteria for classifying an event as a "disaster." When declared:

- Increase monitoring/inspection frequency immediately.
- The BMRCL Safety Officer/Project Director shall notify stakeholders of key information, including:
    - Emergency exits from elevated stations and FOBs
    - Ground-level safe assembly areas near stations
    - Nearest hospitals/emergency centres (e.g., MS Ramaiah, Bowring & Lady Curzon, Victoria)
    - Evacuation routes and status of lifeline shutdowns

9.3.3 Communication Systems

Reliable communication is vital during emergencies. Phase 3 shall be equipped with:

- Public Address (PA) and Passenger Information Display Systems (PIDS) at all stations/entrances
- Emergency intercoms at stations and platforms
- Redundant communication links (optical fibre with wireless backup) connecting stations, OCC, and emergency services
- Coordinated crisis communication with BBMP, Traffic Police, Fire Services, BESCOM, and KSDMA

- Mobile command vehicles for on-site incident management during major events

9.3.4 Emergency Action Committee (EAC)

To ensure integrated response, a city-level EAC chaired by the BBMP Commissioner will be constituted. Members include:

- BMRCL Safety/Operations Officers
- Bengaluru Traffic Police
- Fire & Emergency Services
- Karnataka State Health Services
- KSDMA representative
- BESCOM (Power)
- BWSSB (Water)
- Local MLAs/Councillors
- Experienced NGOs (e.g., Red Cross, SEEDS)

(1) Drills and Public Awareness

- Conduct biannual drills (fire, evacuation, crowd control) for all BMRCL staff, security, and contractors.
- Simulate real-life scenarios at elevated stations with Fire/Medical teams.
- Public awareness via posters, announcements, and social media on:
  - Use of emergency exits/intercoms
  - Evacuation behaviour on alarms
  - Safety during monsoon and power outages

(2) Closure of Emergency

- The EAC Chair, in consultation with BMRCL and emergency agencies, will officially declare closure.
- Notify the public via SMS, station announcements, media, and digital boards.
- Re-entry only after safety clearance and restoration of critical services.

9.4 Emergency Measures

The Emergency Measures Plan for BMRCL Phase 3 aims to safeguard passengers and staff and enable rapid response during incidents such as fire, power failure, or structural accidents. As all sections are elevated/at-grade, the focus is on viaducts, station facilities, and surface operations; underground structures are out of scope. The plan identifies vulnerable points, preventive actions, and notification protocols, ensuring coordination among BMRCL, Fire Services, Police, and other agencies.

9.4.1 Emergency Lighting

- Provide battery-backed emergency lighting at all stations, platforms, stairways, and entrances.

- Maintain at least 25% illumination for ≥2 hours during power failure.
- Arrange lighting on both platform sides and along evacuation routes.
- Use LED with backup batteries; integrate into central monitoring.
- Inspect all emergency lights monthly.

9.4.2 Fire Protection

- Comply with NBC 2016, BIS standards, and KFES regulations.
- Fire resistance: ≥2 h for elevated stations/ancillary buildings; ≥4 h for electrical rooms, control panels, and equipment rooms.
- Prohibit timber; use flame-retardant composites.
- Electrical safety: ELCBs/overload protection on all circuits; LSZH cables network-wide.
- Enforce no-smoking and ban storage of combustible waste; store combustibles in fire-rated cabinets.
- Smoke control: provide ventilation/smoke extraction in enclosed concourses; smoke curtains/down-stands at stairs and escalators.
- Water supply for firefighting: minimum 30-minute storage; fire pumps (1,100 L/min, 21 m head) with diesel standby; hydrants and hose reels.
- Fire extinguishers (powder/CO_2) for electrical fires in electrical rooms, panels, ticketing areas, and inside rolling stock.

9.4.3 Fire Prevention and Safety

- Non-combustible/ flame-retardant finishes; rolling stock with fire-retardant seats, LSZH cables, and heat sensors.
- Store combustibles in designated warehouses with signage/ventilation.
- Install automatic fire detection and alarm systems in rooms >750 m².
- Place portable extinguishers every 30 m along platforms.
- Provide smoke compartments and fire doors (FD-120) on evacuation routes.

9.4.4 Fire Alarm and Detection

- Install KFES/NBC-compliant fire alarm systems in all stations, depots, and control rooms.
- Detectors: smoke, heat, linear heat sensing cables, and beam detectors for large spaces.
- Manual call points at hydrants, platform ends, station entrances, and control rooms.
- Provide audible/visual alarms (bells/strobes).
- Central fire control panel in Station Master's room with remote operation of pumps and ventilation.KFES

9.4.5 Firefighter Access and Smoke Exhaust

- Subdivide non-public areas into compartments ≤1,500 m² with 2-hour fire-rated walls/doors.
- Protect public areas with smoke control and detection.
- Provide dedicated firefighter entrances and road access for appliances.

- Minimum stair width 1.0 m; risers ≤18 cm; provide roof access at elevated structures.
- Provide station ventilation and smoke exhaust (exhaust fans, louvers, fresh air intakes).

9.4.6 Emergency Doors and Evacuation

- Provide emergency end-doors in rolling stock for egress onto viaducts/maintenance walkways.
- Provide side emergency windows/hatches for alternate escape.
- Provide evacuation walkways ≥750 mm on both sides of viaducts with handrails and lighting.
- Install emergency intercoms in trains and stations linked to the control room.
- Publicize evacuation procedures via signage and announcements.

10. Monitoring Plan

10.1 Monitoring Plan

The following table presents the monitoring programme for pre-construction, construction, and operation phases.

Table10-1: Pre-Construction Monitoring Plan

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
(i) Pollution								
1	Air Pollution	The contractor shall take all necessary preventive measures to minimize the emission of fugitive dust arising from excavation, leveling, land development, and waste disposal	Monitoring survey: $PM_{2.5}$, PM_{10}, NO2, CO	National Ambient Air Quality Standards (18 November 2009 and subsequent amendments)	27 locations identified in the baseline survey	Once prior to construction	BMRCL / Contractor (through NABL-accredited laboratory)	INR 19,832 per sample; total INR 1,070,928
2	Water Quality	The contractor shall prepare and implement a Construction Water Management Plan with the approval of the Environmental Specialist. The contractor shall also submit a list of abstraction points and types of water sources to be used for construction. In particular, water quality monitoring shall be conducted for lakes and water bodies that may receive drainage during the construction and operation stages, in order to implement appropriate mitigation measures.	Sampling survey: pH Sodium Potassium Chloride Nitrogen Phosphorus Organic matter Heavy metals (Mercury, Cadmium, Arsenic, Cyanide, Lead, Chromium) Oils and grease	CPCB standards (BIS 10500:2012)	Water bodies along the corridor: 14 surface water locations and 27 groundwater locations identified in the baseline survey	Once prior to construction	BMRCL / Contractor (through NABL-accredited laboratory)	Surface water: INR 9,904 per sample; Groundwater: INR 12,016 per sample Total: Surface water INR 277,312; Groundwater INR 648,864
3	Waste	The contractor shall prepare a comprehensive Waste Management Plan in accordance with local regulations for segregation and disposal of solid and hazardous waste. In addition, a 3R (Reduce, Reuse, Recycle) Plan shall be prepared to promote reuse and recycling to minimize waste generation.	Implementation status of the Comprehensive Waste Management Plan and the 3R Plan for soil/construction and demolition waste	-	All construction sites	-	-	-
4	Soil Contamination	A comprehensive soil investigation shall be conducted prior to construction to identify existing contaminants and establish baseline concentrations of hydrocarbons, chemicals, and organic pollutants.	Sampling survey: pH Sodium Potassium Chloride Nitrogen Phosphorus Organic matter Heavy metals (Mercury, Cadmium, Arsenic, Cyanide, Lead, Chromium)	USEPA RSL	27 locations identified in the baseline survey	Once prior to construction	BMRCL / Contractor (through NABL-accredited laboratory)	INR 8,905 per sample; total INR 241,650

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
			Oils and grease Visual inspection of implementation of soil contamination prevention measures					
5	Noise and Vibration	A comprehensive noise survey shall be conducted prior to the commencement of construction to identify the need for noise barriers and other mitigation measures for sensitive receptors along the alignment.	Visual observation	-	Construction sites and temporary facilities / project areas	Once prior to construction	Contractor	-
			Sampling survey: Leq and Lmax (both day and night) Visual inspection of installation status of required facilities	Noise Regulation Rules (2000)	- 32 locations identified in the baseline survey - Residential buildings and sensitive receptors located near roadside construction sections where traffic diversion, acceleration, and deceleration occur. - Houses situated close to major roadways adjacent to construction sites, particularly those identified as sensitive in the baseline survey.	Once prior to construction	BMRCL / Contractor (through NABL-accredited laboratory)	INR 14,400 per sample; total INR 460,800
		Conduct vibration monitoring along the proposed alignment and at sensitive receptors	Sampling: Vdb	FTA Guidelines (daytime and nighttime)	32 locations identified in the baseline survey	Once prior to construction	BMRCL / Contractor	INR 20,000 per sample; total INR 640,000
6	Land Subsidence	Conduct detailed survey of buildings and residences along the proposed alignment	Survey	-	Buildings and residences along the proposed alignment	Once prior to construction	BMRCL / Contractor	-
(ii) Natural Environment								

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
7	Ecology	Priority shall be given to preserving trees as far as possible by incorporating modifications in construction activities. Where preservation is not feasible, transplantation is recommended.	Monitoring items: Status of tree-felling permit acquisition Number of trees planted / Planned number of trees	-	Project site and plantation areas	Once prior to construction	BMRCL / Contractor	INR 80,000 per survey; total INR 160,000
		Install fences and signage around protected forests, parks, and other sensitive areas to clearly demarcate boundaries, prevent unauthorized access, and restrict construction activities.	Visual inspection of installation status of required facilities Concerns and issues raised by local residents	-	Areas adjacent to protected forests and parks	Once prior to construction	BMRCL / Contractor	-
		Study on Indian flying foxes/ *Pteropus giganteus*	Presence of Indian flying foxes (roosting/foraging activity) Method: - Nocturnal spotlight/visual surveys - Lighting spill measurement (lux)	-	Areas where potential roosting/foraging activity is expected (near parks, large trees, green belts)	Pre-construction and annually during early operation	BMRCL / Contractor	-
8	Hydrology	Conduct a comprehensive survey to assess potential impacts of construction on regional hydrology, including surface water and groundwater levels, flow patterns, and groundwater depth.	Visual observation of flood protection measures and drainage facilities Observation of surface water flow Measurement of groundwater and surface water levels Concerns and issues raised by local residents	-	Drainage channels crossed by the proposed alignment, construction sites and surrounding areas	Once prior to construction	BMRCL / Contractor	-
9	Topography and Geology	Conduct a detailed geological survey prior to construction to identify natural landforms, soil composition, rock structures, fault lines, and potential seismic activity. This information is essential for safe and effective structural design.	Visual inspection of soil erosion, topsoil removal, and spoil accumulation	-	Construction sites	Once prior to construction	Contractor	-
(iii) Social Environment								
10	Livelihood and Living	Ensure continuous access to local businesses and avoid significant disruption to commercial activities. Conduct consultations with affected business operators, employees, and other	Feedback and grievances from local residents	-	Local residents affected by the project	Once prior to construction	BMRCL / Contractor	-

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
		stakeholders so that their concerns are considered in decision-making processes and timely information is provided.						
11	Vulnerable Groups	Conduct consultations with local residents including vulnerable and marginalized groups such as women, the elderly, the poor, single parents, and persons with physical or social disabilities, ensuring that their concerns are considered and addressed. Special attention shall be given to enable them to benefit from and access opportunities provided by the project. In addition, provide channels through the Grievance Redress Mechanism (GRM) for residents to raise concerns.-	- Number of consultations with vulnerable groups (women, elderly, poor households, persons with disabilities, single parents). - Number of grievances received from vulnerable groups and resolution rate. - Participation rate of women and vulnerable groups in project-related meetings. - Number of accessibility-related issues identified and corrected (e.g., barrier-free access at stations).	-	Local residents affected by the project	- Monthly reporting during construction for stakeholder engagement indicators. - Quarterly reporting for grievance redress indicators. - Semi-annual reporting for gender/ESI inclusion outcomes (participation, accessibility improvements).	BMRCL / Contractor	-
12	Cultural Heritage	If any ASI-protected cultural property is discovered, BMRCL shall follow due process to obtain approval from the competent authority under applicable legislation prior to commencement of construction.	Record of ASI-protected cultural property (if applicable)	-	Construction sites	As required	BMRCL / Contractor	-
13	Landscape	Record the condition of roads and infrastructure prior to the commencement of construction, and upon completion restore temporary access and community infrastructure to at least the pre-construction condition.	Visual inspection	-	Construction sites	Once prior to construction	Contractor	-
			Status of waste management Status of information dissemination to local community	-	Construction sites	-	BMRCL / Contractor	
14	Existing Social Infrastructure and Services (including basic	Conduct a detailed survey of all public utilities prior to construction and carry out trial excavations to prevent damage. In addition, conduct consultations with local residents including vulnerable and marginalized groups such as women, the	Status of utility interruptions Feedback and grievances from local residents	-	Project affected area	Once prior to construction	BMRCL / Contractor	-

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
	infrastructure)	elderly, the poor, single parents, and persons with physical or social disabilities, ensuring that their concerns are considered. Special attention shall be given to enable them to benefit from and access opportunities provided by the project. Furthermore, provide a platform through the GRM for residents to raise concerns.						
15	Working Conditions (including Occupational Safety)	Prepare and implement a Safety, Health and Environment (SHE) Manual.	-	-	All construction sites	-	Contractor	-

Source: JST

Table10-2: Construction Phase Monitoring Plan

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
(i) Pollution								
1	Air Pollution	The contractor shall not allow fugitive dust generated from transport, handling, construction, or storage activities to remain in the atmosphere beyond the site boundary for extended periods without prior notice to the Employer. The contractor shall use appropriate designs and equipment to minimize or control air pollution, retain evidence of such specifications and equipment, and make these available for inspection by the Employer. Transport vehicles and other equipment shall comply with emission standards prescribed by the Central or State Government of India. The contractor shall conduct regular inspections and undertake corrective actions such as repair or replacement as necessary to ensure that operations remain within permissible standards at all times. When transporting debris, soil, or other dust-generating materials, adequate freeboard shall be maintained and loads shall be covered to prevent spillage from tailgates or sideboards. Temporary stockpiles shall be properly maintained until reuse or as directed by the Employer, and dust suppression activities shall continue even during work stoppages. Materials shall be stored to minimize dust generation, quantities shall be kept to the minimum necessary on a daily basis, and water sprinkling shall be	Visual observation; ambient air quality conditions and dust generation/deposition	-	Construction sites and temporary facilities / project areas	Weekly visual inspection until completion of construction	Contractor	-
			Confirmation of ambient air quality conditions and dust generation/deposition during the construction stage Sampling survey: $PM_{2.5}$, PM_{10}, NO_2, CO	National Ambient Air Quality Standards (18 November 2009)	27 locations identified in the baseline survey	Weekly 24-hour monitoring until completion of construction	Contractor BMRCL / Contractor (through NABL-accredited laboratory)	Total cost: INR 102,809,088 (to be borne by the Contractor)

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
		carried out. During dry periods, dust suppression shall be implemented daily, and additional measures shall be taken on dry and windy days to prevent off-site dispersion. Water shall be sprinkled at construction sites as necessary to suppress dust from excavation, debris, and demolition. Sprinklers, water spraying systems, and water supply equipment shall be maintained on-site at all times and used for dust suppression when required. Dust screens shall be installed where necessary, with additional measures implemented near sensitive receptors. Wheel-washing pits or vehicle cleaning facilities shall be installed at exits of construction yards and asphalt plants, where high-pressure water jets shall be used to remove soil and dirt from vehicle wheels.						
2	Water Pollution	The contractor shall, at his own cost, arrange for an adequate supply and storage of water required throughout the construction period. The contractor shall submit to the DE and BMRCL a list of water sources to be used for this project, indicating the location and type of each source for construction water. Water shall be abstracted only from approved sources, and prior to final decision, the contractor shall consult with the DE Environmental Specialist to avoid any adverse impacts on other water users. The contractor shall take all necessary precautions to minimize wastage of water during construction activities. In particular, water quality monitoring and corresponding mitigation measures shall be implemented for lakes and water bodies that may receive drainage during the construction stage.	Water quality (visual inspection and sampling survey: pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorus, Organic matter, Heavy metals [Mercury, Cadmium, Arsenic, Cyanide, Lead, Chromium], Oils and grease)	CPCB (BIS 10500:2012)	Water bodies along the corridor: 14 surface water locations and 27 groundwater locations identified in the baseline survey	Visual inspection: weekly until completion of construction / Sampling: monthly	BMRCL / Contractor (through NABL-accredited laboratory)	To be borne by the Contractor Total cost: Surface water INR 6,655,488; Groundwater INR 15,572,736
3	Waste	Implement a comprehensive Waste Management Plan to segregate and dispose of solid and hazardous waste in accordance with local regulations. Implement a 3R (Reduce, Reuse, Recycle) Plan to promote recycling and reuse and reduce waste generation. Construction and demolition (C&D) waste shall be disposed of at designated C&D waste recycling facilities. Hazardous waste shall be stored on impervious flooring with containment measures to prevent leakage, spillage, or breakage. Waste shall only be disposed of through authorized recyclers, ensuring proper management and disposal from the site. Surplus earth generated at the site shall be disposed of at disposal sites in layered form and mechanically compacted.	Visual inspection	-	All construction sites	Weekly inspections until completion of construction	Contractor	To be borne by the Contractor
			Quantity of C&D waste including soil Implementation status of the Comprehensive Waste Management Plan and soil/C&D 3R (Reduce, Reuse, Recycle) Plan Records of C&D waste	-	All construction sites	Monthly until completion of construction	BMRCL / Contractor	

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
			disposal (including transport and disposal sites) Feedback and grievances from local residents					
4	Soil Contamination	Conduct comprehensive soil testing during construction to identify existing contaminants, and if contamination is detected, prepare a remediation plan. All waste shall be disposed of in accordance with environmental regulations, and in case of leakage or spillage, the Emergency Response Plan and the Health and Safety Management Plan shall be implemented immediately. Grease and oil shall be stored on impervious PCC flooring, and frequent inspections shall be conducted to confirm the implementation of preventive measures.	Sampling survey: pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorus, Organic matter, Heavy metals (Mercury, Cadmium, Arsenic, Cyanide, Lead, Chromium), Oils and grease / Visual inspection of implementation of soil contamination prevention measures	USEPA RSL	27 locations identified in the baseline survey	Monthly until completion of construction	BMRCL / Contractor (through NABL-accredited laboratory)	To be borne by the Contractor Total cost: INR 11,599,200
5	Noise and Vibration	In elevated sections, ballastless track structures shall be supported on dual rubber pads to reduce noise and vibration. In addition, noise barriers (parapets) shall be installed up to track height to lower noise levels. Appropriate design measures shall be incorporated in structural design and equipment layout, and elastic supports or dampers shall be used to control and reduce noise at the source. The contractor shall ensure that all power machinery and equipment used in construction are effectively silenced using the latest technologies (including silencers). Ear muffs shall be provided to workers. Noise screens or enclosures shall be installed at locations where excessive noise is generated. Construction noise by the contractor and subcontractors shall not exceed permissible limits at any time, day or night. In case of violation, equipment shall be immediately relocated or adjusted, or other appropriate measures taken, including temporary or permanent discontinuation of use, to maintain noise levels below standards. Material transport vehicles shall be equipped with proper silencers. The operation of construction machinery shall be carefully scheduled and restricted to daytime hours only, with noise monitoring carried out in accordance with CPCB standards.	Visual observation	-	Within and around construction sites and temporary facilities	Weekly until completion of construction	Contractor	To be borne by the Contractor
			Sampling survey: Leq and Lmax (day and night) Visual observation of installation of required facilities	Noise Regulation Rules, 2000	32 locations identified in the baseline survey - Residential buildings and sensitive receptors located near roadside construction sections where traffic diversion, acceleration, and deceleration occur.	Weekly 24-hour monitoring until completion of construction	BMRCL / Contractor (through NABL-accredited laboratory)	To be borne by the Contractor Total cost: INR 88,473,600

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
					Houses situated close to major roadways adjacent to construction sites, particularly those identified as sensitive in the baseline survey.			
		To minimize impacts, adopt low-vibration construction methods such as bored piling using hydraulic rotary rigs instead of impact hammers or driven piles. Construction machinery shall be well maintained and selected for low-vibration performance, and simultaneous operation of heavy equipment shall be avoided. Sensitive facilities such as hospitals and schools shall be protected by temporary barriers and advance notification of vibration-inducing works. Works shall be restricted to daytime, and vibration monitoring devices shall be installed near vulnerable structures; immediate corrective actions shall be taken if thresholds are exceeded.	Visual observation of installation of required facilities	-	Construction sites	Weekly until completion of construction	Contractor	To be borne by the Contractor
			Sampling survey: Vdb	FTA Guidelines (daytime and nighttime)	32 locations identified in the baseline survey	Monthly 24-hour monitoring until completion of construction	BMRCL / Contractor	To be borne by the Contractor Total cost: INR 30,720,000
7	Land Subsidence	Monitor the condition of buildings and residences during construction.	Survey	-	Buildings and residences along the proposed alignment	Throughout the construction period	BMRCL / Contractor	To be borne by the Project / Contractor
(ii) Natural Environment								
8	Ecology	Construction activities shall be modified as a priority to preserve trees as far as possible; where preservation is not feasible, transplantation is recommended. Tree cutting shall be limited to those that obstruct construction, and shall be carried out only with permission from the State Forest Department and written approval from BMRCL. Trees not designated for cutting shall not be damaged during construction. Each felled tree shall be compensated by planting at least 10 saplings, or as required by TEC or Forest Department conditions. Saplings shall be native species and planted within the project impact area. Survival of the saplings shall be monitored for three years, and dead saplings shall be replaced. Compensatory plantation shall contribute to expansion of urban green cover. Surplus	Status of tree-felling permit acquisition / Number of trees planted vs. planned	-	Project sites and plantation areas	Monthly until completion of construction	BMRCL / Contractor	Total cost: INR 3,840,000

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
		construction materials or wastewater, including paints and plaster, shall not be dumped around trees. Where excavation occurs near tree roots, measures shall be taken to prevent drying. Trees shall be transplanted to pre-approved suitable sites wherever possible, and if a transplanted tree dies, it shall be compensated by planting at least 10 saplings per tree. Ornamental plants shall be planted in two rows along the central median.						
		It is desirable to avoid activities generating excessive noise during nighttime. Around sensitive areas such as protected forests and parks, fences and signage shall be installed to clearly demarcate boundaries, prevent unauthorized access, and restrict construction activities. The contractor shall ensure that transplanted trees do not contain nests of important species. If impacts on fauna are detected, appropriate mitigation measures shall be implemented in consultation with expert institutions.	Visual inspection of installation of required facilities Feedback and concerns from the public	-	Areas adjacent to protected forests and parks	Once annually during construction, continuing until completion	BMRCL / Contractor	To be borne by the Project / Contractor
9	Hydrology	Conduct a comprehensive assessment to identify potential impacts of construction on local hydrology, including evaluation of surface water and groundwater levels, flow patterns, and groundwater depth. Reduce the number of piers within drainage channels and adopt cone-shaped pier designs. Implement a surface and groundwater monitoring program, with regular measurement of water levels and water quality in wells near construction sites.	Status of flood prevention and drainage facilities Visual observation of surface water flow, measurement of groundwater and surface water levels, feedback and concerns from the public	-	Drainage channels, construction sites and surrounding areas	Once prior to construction and twice annually during construction, depending on site conditions	BMRCL / Contractor	-
10	Topography and Geology	Conduct detailed geological surveys during construction to understand natural landforms, soil composition, rock strata, fault lines, and potential seismic activity in the area. This information is essential for safe and effective structural design. Incorporate all permanent erosion control structures into the project.	Visual inspection: erosion, topsoil removal, and spoil collection	-	Construction sites	Annually until completion of construction	Contractor	To be borne by the Contractor
(iii)Social Environment								
11	Livelihoods and Living	Ensure continuous access to local businesses so that commercial activities are not significantly disrupted. Conduct consultations with relevant stakeholders (such as business owners and employees) to ensure that their concerns are reflected in decision-making processes and that necessary information is provided in a timely manner.	Feedback and grievances from local residents	-	Communities in the project impact area	As required, continuing until completion of construction	BMRCL / Contractor	To be borne by the Project / Contractor

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
12	Vulnerable Groups	Prioritize the use of local materials and local contractors to stimulate the local economy and create employment opportunities for vulnerable residents.	the employment recruitment ratio for socially vulnerable groups	-	Communities in the project impact area	As required, continuing until completion of construction	BMRCL / Contractor	To be borne by the Project / Contractor
13	Cultural Heritage	In the event that an ASI-protected monument is discovered, BMRCL shall complete the procedures to obtain approval from the competent authority, in accordance with applicable laws, before the commencement of construction.	Records of ASI-protected monuments (where applicable)	-	Construction sites	As required, continuing until completion of construction	BMRCL / Contractor	To be borne by the Project / Contractor
14	Landscape	Maintain cleanliness inside and around construction sites, temporary facilities, and access roads, and strictly manage solid waste to minimize adverse impacts on landscape. Implement the grievance redress procedure promptly and transparently, and take supplementary measures if complaints or risks are identified.	Visual inspection	-	Construction sites	Weekly until completion of construction	Contractor	To be borne by the Project / Contractor
			Status of waste management Status of information disclosure to local residents	-	Construction sites	Monthly until completion of construction	BMRCL / Contractor	
15	Existing Social Infrastructure and Services (including basic infrastructure)	Ensure uninterrupted operation of utility services during construction and after project completion, with all proposals designed to maintain continuous functionality. During construction, provide safe access to sensitive facilities such as hospitals and schools by deploying traffic marshals and warning signs, and establish diversions as necessary in response to traffic congestion. Closely coordinate with concerned municipalities and stakeholders, ensuring adequate information disclosure and consultation on construction schedules and potential impacts. Consult with local residents, including women, the elderly, the poor, single parents, and physically/socially vulnerable groups, to ensure that their concerns are addressed. Particular consideration shall be given to enabling them to benefit from the project. In addition, the Grievance Redress Mechanism (GRM) shall function as a means for local residents to voice concerns and have their issues considered.	Feedback and grievances from local residents	-	Project impact area	From the time grievances arise until completion of construction	BMRCL / Contractor	To be borne by the Project / Contractor
16	Working Environment (including occupational safety)	Prepare and implement a Safety, Health and Environment (SHE) manual. Conduct regular health check-ups for workers. Implement appropriate training, maintenance, and safety measures to prevent accidents. Strictly comply with working hours regulations and ensure adequate rest periods.	Visual inspection of the cleanliness and safety of working environments at construction sites and temporary facilities	-	All construction sites	Weekly until completion of construction	Contractor	To be borne by the Project / Contractor

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
		Regularly maintain all vehicles and machinery to prevent breakdowns and accidents. Provide workers with appropriate PPE to protect them from air pollution, noise, vibration, and extreme weather conditions. Conduct regular safety training for all workers to raise awareness of potential hazards and safe working practices. Prepare and implement an emergency response plan to ensure prompt action in case of accidents. Apply advanced construction planning and management techniques to minimize risks associated with elevated viaduct works. Establish strict safety rules for heavy equipment operation, including regular inspections and operator training.	Regular health check-ups Feedback and grievances from workers	-	All construction sites	Every 3 months until completion of construction / From the time grievances arise until completion of construction	BMRCL / Contractor	
17	Community Health, Safety and Security	Engage regularly with community stakeholders, and in case of complaints, immediately identify the cause, evaluate existing measures, and disclose the results. Raise awareness among local residents and the public regarding potential project impacts and related health and safety measures through slogans and other means, capture community concerns, and address them appropriately to resolve grievances. Operate the Grievance Redress Mechanism (GRM) and widely disseminate information on community health and safety risks, such as vehicle and pedestrian diversions, promptly through various media. Monitor accidents involving local residents occurring at construction sites, temporary facilities, and surrounding areas, and record, report, and disclose fatal accidents, treatable injuries, disabling injuries, and near-miss incidents. Mitigation measures related to pollution (air, water, noise, vibration, waste) and public transport access are specified separately under each item.	Feedback and grievances from local residents	-	Project impact area	From the time grievances arise until completion of construction	BMRCL / Contractor	To be borne by the Project / Contractor
(iv) Others								
18	Transboundary Impacts and Climate Change	Conduct awareness campaigns and tree plantation activities.	Status of plantation initiatives and provision of rest facilities / Availability of adequate drinking water	-	Project impact area	As feasible, continuing until completion of construction	BMRCL / Contractor	To be borne by the Project / Contractor

Source: JST

Table10-3: Operation Phase Monitoring Plan

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
(i) Pollution								
1	Air Pollution	• Ensure smooth connectivity between the metro and other public transport modes to minimize dependence on private vehicles. • Develop pedestrian-friendly zones around stations by providing wide sidewalks, crosswalks, and clear signage. • Carry out maintenance activities in a planned manner to avoid disruption to traffic and pedestrian flow. • Conduct regular maintenance of related facilities such as substations and depots.	Sampling survey: $PM_{2.5}$, PM_{10}, NO_2, CO	National Ambient Air Quality Standards (18 November 2009)	27 locations identified in the baseline survey	Weekly 24-hour monitoring for 5 years after commencement of operation	BMRCL / Contractor (through NABL-accredited laboratory)	Total cost: INR 25,702,272
2	Water Pollution	• Introduce water-saving fixtures to minimize wastewater generation. • Install wastewater treatment facilities at stations and depots, and promote reuse of treated water. • Provide training for staff on water resource conservation. • Ensure that the water quality of lakes and water bodies that may receive drainage during operation is not adversely affected.	Sampling survey: pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorus, Organic matter, Heavy metals (Mercury, Cadmium, Arsenic, Cyanide, Lead, Chromium), Oil and grease, Fluoride (F^-)	CPCB (BIS 10500:2012)	Water bodies along the corridor: 14 surface-water sites and 27 groundwater sites identified in the baseline survey, including lakes that may receive drainage from the double-deck viaduct.	Monthly for 5 years after commencement of operation	BMRCL / Contractor (through NABL-accredited laboratory)	Total cost: SW INR 1,663,872, GW INR 3,893,184
3	Soil Contamination	Conduct soil testing during the operation stage.	Sampling survey: pH, Sodium, Potassium, Chloride, Nitrogen, Phosphorus, Organic matter, Heavy metals (Mercury, Cadmium, Arsenic, Cyanide, Lead, Chromium), Oil and grease / Visual inspection of implementation of soil contamination prevention measures	USEPA RSL	27 locations identified in the baseline survey	Monthly for 5 years after commencement of operation	BMRCL / Contractor (through NABL-accredited laboratory)	Total cost: INR 2,899,800
4	Noise and Vibration	• Conduct noise monitoring near residential areas and other sensitive receptors. • At locations where complaints arise, implement low-noise technologies such as wheel reprofiling, rail grinding, and the use of vibration-damping rubber pads. • Control the volume of station announcements	Sampling survey: Leq, Lmax (day and night) / Visual observation of installation of required facilities	Noise Regulation Rules, 2000	In addition to the 32 baseline locations, representative ramp/approach sections where acceleration and	In addition, long-term follow-up assessments shall be conducted at approximately 10 years and 15 years after	BMRCL / Contractor (through NABL-accredited laboratory)	Total cost: INR 22,118,400

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
		to ensure compliance with noise standards. • At complaint-prone locations, implement vibration control measures such as wheel reprofiling, rail grinding, speed regulation, installation of elastic fastenings, and vibration-absorbing pads. • In addition, once the detailed design stage confirms the final structural and operational conditions for both metro operations and adjacent road traffic, an additional quantitative assessment of the combined noise and vibration impacts will be conducted. The results will be used to refine the operation-phase mitigation measures and will be incorporated into the Environmental Management Plan (EMP) and the Environmental Monitoring Plan (EMoP). • Representative ramp areas will be included as monitoring locations to assess noise/vibration associated with acceleration and deceleration movements. Long-term monitoring (10-year and 15-year reassessment) will also be conducted to reflect projected traffic growth.			deceleration of vehicles occur shall be included as additional monitoring points during operation.	commencement of operation to capture potential changes in traffic volume and resulting noise/vibration levels.		
		• Conduct vibration monitoring near residential areas and other sensitive receptors. • During the operation stage of the elevated metro, vibration is primarily generated by train movement on the viaduct. To mitigate this, the track design shall incorporate floating slab tracks, elastic fastenings, and elastomeric bearings to attenuate vibration and prevent its transmission to surrounding structures. • Continuous welded rails and regular wheel and rail grinding shall be implemented to maintain smooth contact surfaces and reduce vibration caused by impact. • Metro vehicles shall be equipped with advanced bogies and secondary suspension systems to minimize vibration transmission. • Speed restrictions may be imposed along sections adjacent to vibration-sensitive facilities such as hospitals, heritage structures, and research institutions.	Sampling survey: Vdb	FTA Guidelines (daytime and nighttime)			BMRCL / Contractor	Total cost: INR 7,680,000

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
		• Regular vibration monitoring shall be conducted along the corridor, and a preventive maintenance program for tracks, bearings, and rolling stock shall be implemented to prevent vibration increase due to deterioration. • In addition, public concerns related to vibration and structure-borne noise shall be addressed through appropriate consultation and mitigation measures.						
(ii) Natural Environment								
5	Ecosystem	• Restore native vegetation in disturbed areas to minimize human interaction with bonnet macaques. • Establish and maintain green corridors and arboreal pathways (canopy bridges) to prevent habitat fragmentation and enable safe crossings of metro and double-deck viaduct sections, thereby reducing the risk of roadkills. • Plant and maintain native fruit-bearing trees (e.g., Ficus spp.) around stations, elevated structures, and buffer zones to restore foraging habitats. • Conduct continuous awareness programs for local residents to discourage feeding of wildlife and promote proper waste management. • Establish a rapid response team to address human–wildlife conflicts using only non-lethal methods. • Continue monitoring for five years after commencement of operation to track changes in troop distribution, population size, and behavior. • Collaborate with research institutions and the Forest Department to review monitoring results and implement additional mitigation measures as needed.	• Monitoring survey of planted and transplanted trees, survival assessment survey, condition assessment survey, and inspection survey	-	Project sites and plantation areas	Monthly for 5 years after commencement of operation	BMRCL / Contractor	Total cost: INR 960,000
6	Hydrology	In areas with high groundwater levels, metro facilities are designed to collect infiltrated groundwater and reuse it within the premises. Conduct a comprehensive assessment to identify potential impacts of construction on local hydrology, including surface water and	Visual observation of surface water flow	-	Drainage channels, construction sites, and surrounding areas	Second year after commencement of operation	BMRCL / Contractor	To be borne by the Contractor

No.	Impact Item	Mitigation Measures	Method / Parameters	Monitoring Standards	Monitoring Location	Period and Frequency	Implementing Agency	Cost (INR)
		groundwater levels, flow patterns, and groundwater depth.						
7	Topography and Geology	Implement appropriate measures to ensure the safe and stable condition of ground and geological features along the alignment during operation. As required, BMRCL will determine the need for additional ground-condition investigations or remedial actions if any signs of erosion, settlement, or abnormal geological conditions are detected.	• Visual inspection of erosion, settlement, or slope instability • Additional geological surveys if required, based on BMRCL assessment • Documentation of any ground-related abnormalities and follow-up actions	-	Construction sites	To be determined by BMRCL based on operational needs (no fixed annual schedule)	BMRCL / Contractor (as instructed by BMRCL)	Within the budget of the implementing entity, as determined by BMRCL
(iii) Social Environment								
8	Labor Conditions (including Occupational Health and Safety)	• BMRCL shall fully respect labor rights and establish procedures to ensure compliance with national legal requirements. • An Occupational Health and Safety (OHS) Plan and Emergency Response Plan shall be developed, and preventive safety and security protocols shall be strictly implemented.	Workers' Feedback and Grievances	-	Project sites	During operation, as necessary	BMRCL	To be borne by the Project / Contractor
9	Community Health, Safety, and Security	• Install Platform Screen Doors (PSDs) and CCTV to prevent passengers from entering the tracks. • Deploy security personnel at stations to monitor passengers at entry points. • Install warning signs to control unauthorized access. • Provide clearly designated emergency exits, evacuation systems, and alarm/announcement systems. • Install pedestrian crossings at appropriate locations with clear markings. • Publicly disclose information promptly in the event of operational interruptions. • In the design and construction of elevated roads, take due consideration of the privacy of nearby residents. In areas where residential houses are close to the alignment, design measures shall also be taken to mitigate potential light pollution caused by night-time metro operations.	Utility Disruption / Community Feedback and Grievances	-	Project-affected areas	-	BMRCL	To be borne by the Project / Contractor

Source: JST

10.2 Monitoring Form

In accordance with the above Monitoring Plan, the Monitoring Form to be used by the implementing agencies for carrying out monitoring activities is provided in the annexed document (Annex1). The Monitoring Form for this Project has been designed to cover all phases — pre-construction, construction, and operation — and to comprehensively address environmental and social aspects (such as air quality, water quality, noise and vibration, waste management, natural environment, social environment, traffic and safety, and climate change response). The format enables the systematic recording of parameters including standards, measurement results, frequency, responsible entities, and the status of grievance handling.

Furthermore, the Monitoring Form will also be used in the course of regular reporting to JICA on this Project's progress in relation to its financial cooperation, as described in the following section 13 "Institutional Arrangements." This ensures that the implementing agency, contractors, and supervising consultants maintain consistent records using a common format, thereby securing transparency and uniformity in reporting.

11. Implementation Costs for the Environmental Management Plan and Environmental Monitoring Plan

The estimated costs required for the implementation of the Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP) are presented in the table below.

Table11-1: Estimated Costs for the Implementation of the Environmental Management Plan and Environmental Monitoring Plan

SN	Item	Amount in Lakhs	
		Line 3-1	Line 3-2
1	Compensatory Afforestation[1]	718.80	169.00
2	Environmental Monitoring (Construction Phase)	1970.13	626.56
3	Training and Extension[2]	36.63	24.73
4	Environment Division[2]	75.48	75.48
5	Depot		
a.	Effluent Treatment Plant (ETP) [2]		50.00
b.	Green Belt Development		
	Sub-Total	2801.04	945.77
6	Miscellaneous 10%	280.10	94.58
	Grand-Total	**3081.14**	**1040.35**

Note 1 – Of the total number of affected trees, it is estimated that approximately 65% will be felled, 15% transplanted, and 20% pruned. In addition, for trees that are felled, a plantation ratio of 1:10 has been considered, with an estimated cost of INR 2,000 per sapling for procurement and planting.

Note 2 – This amount is quoted from the Final DPR of Bangalore Metro Phase 3 alignment (at the stage when only the metro was initially planned).

Source: JST

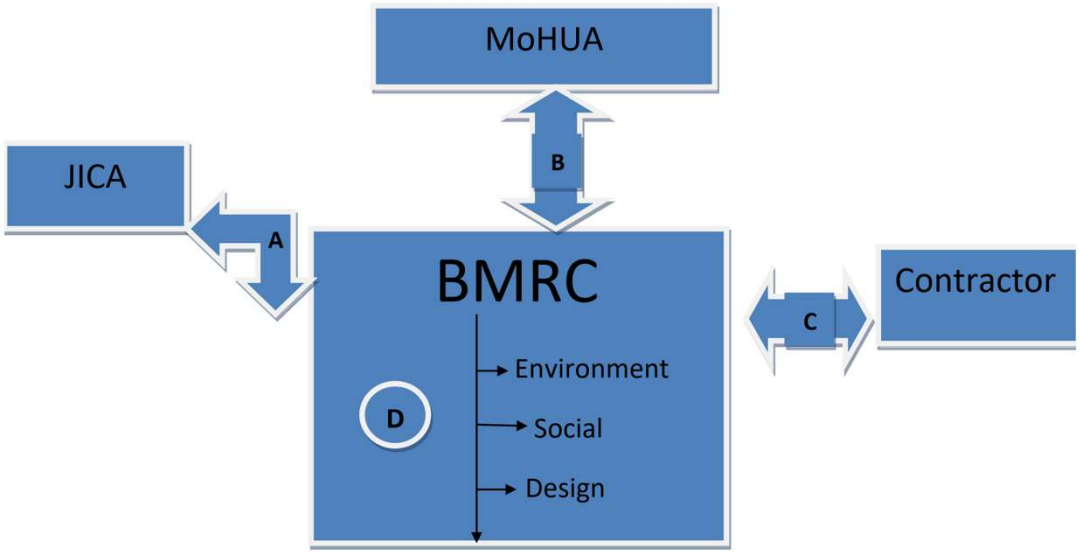
12. Institutional Arrangements

12.1 Institutional Framework for Implementation of the Environmental Management Plan (EMP)

The Bangalore Metro Rail Corporation Limited (BMRCL) shall play the central role in the implementation and updating of the Environmental Management Plan (EMP). While the contractors are responsible for carrying out the EMP, its supervision shall be undertaken by the Environment and Social Safeguard Specialist of BMRCL. BMRCL shall also conduct regular internal monitoring.

It should be noted that the entire team of both the contractor and BMRCL is expected to cooperate in supporting the implementation of the Environmental and Social Management Plan. External monitoring shall be conducted by an independent agency.

The figure below illustrates the inputs required by BMRCL in order to comply with JICA's requirements, as well as to report on compliance to the Ministry of Housing and Urban Affairs.



A: BMRCL shall report to JICA on a quarterly basis regarding progress, environmental monitoring, and related matters.
B: BMRCL shall report to the Ministry of Housing and Urban Affairs (MoHUA) concerning grievances.
C: For grievance redress, BMRCL shall serve as the responsible body, while the contractor shall act as the implementing body.
D: The relevant departments of BMRCL shall maintain records and coordinate with JICA regarding grievances.
Source: JST

Figure12-1: Implementation Structure for EMP Implementation

JICA plays a significant role by providing financial and technical support to BMRCL, thereby facilitating the advancement of the Project. The Ministry of Housing and Urban Affairs (MoHUA) supervises BMRCL, providing administrative guidance and policy direction. Within BMRCL, the Environment Department monitors compliance with environmental regulations to ensure that the Project adheres to applicable laws and standards. The Social Cell of BMRCL works in coordination to manage social impacts and to respond to concerns raised by local communities. Construction contractors are responsible for executing

construction activities in accordance with BMRCL's plans and specifications, while adhering to environmental safeguards. In addition, the Design and Supervision Team oversees the design stage and monitors construction works to ensure compliance with safety and operational standards. Collectively, these stakeholders form an integrated network that supports the successful and sustainable implementation of the BMRCL Project.

With regard to the double-deck viaduct under this Project, although the road portion of construction and operation formally falls under the jurisdiction of the Bruhat Bengaluru Mahanagara Palike (BBMP), it has been agreed between BMRCL and BBMP that BMRCL will take sole responsibility for the construction and maintenance of the entire viaduct, including the road portion. Accordingly, BMRCL shall bear unified responsibility for mitigation and monitoring of environmental and social impacts related to the double-deck viaduct and associated facilities, including those arising from the road portion.

12.2 Key Institutions and Responsibilities for EMP Implementation

The following summarizes the roles and responsibilities for the implementation, supervision, and monitoring of the Environmental and Social Management Plan (ESMP). Marserve is designated as the Supervision Organization, while the contractors shall serve as the Implementation Organization for the Environmental Monitoring Plan (EMoP). This arrangement ensures that environmental measures are effectively implemented and monitored throughout all phases of the Project.

Table12-1: Roles and Responsibilities of Key Institutions

Organization	Responsibility
BMRCL	・ Carry out quality control and review of the EMP. BMRCL is responsible for overall checking of the quality of work undertaken by contractors for mitigating and minimizing environmental and social impacts during the pre-construction, construction, and operation phases. Mitigation measures shall be taken to minimize adverse impacts of project activities. A quality control Management Information System (MIS) will be prepared to regularly monitor the quality of sub-projects undertaken during project execution. ・ Inspect the implementation status of the EMP, provide recommendations, and determine whether additional measures are required. ・ Review the performance of contractors, and if the measures taken are found not to comply with the EMP, notify the contractor and require full compliance with the requirements of the EMP in both letter and spirit. ・ Responsible for submitting compliance reports to JICA, including quarterly and semi-annual progress reports. ・ Guide and supervise the preparation and implementation of Labour, Environment and Social Commitment Plans, ensure their finalization, consultations with relevant stakeholders, and disclosure by BMRCL.
Contractor	・ Develop a project-specific EMP as part of the construction method statement prior to the commencement of works, and submit it to BMRCL for review and approval. ・ Submit monthly reports during the construction period on environmental and social issues, mitigation measures, and results. In case of unforeseen problems, consult with BMRCL. ・ Ensure that construction works are carried out in compliance with the approved EMoP and site-specific EMP. ・ Control and minimize environmental impacts. ・ Ensure that all staff and workers understand the procedures and their roles in the environmental management program. Maintain environmental hygiene.

Source: JST

The measures included in the Environmental Management Plan (EMP) shall be adhered to by the project proponent and incorporated as an integral part of the contract of the contractors employed under this Project. The mitigation measures proposed for the operation phase shall be integrated into the regular maintenance

and monitoring schedule.

With regard to the double-deck viaduct under this Project, although the road portion of construction and operation formally falls under the jurisdiction of the Bruhat Bengaluru Mahanagara Palike (BBMP), it has been agreed between BMRCL and BBMP that BMRCL will assume unified responsibility for the construction and maintenance of the entire viaduct, including the road portion. Accordingly, BMRCL shall bear sole responsibility for the mitigation and monitoring of environmental and social impacts associated with the double-deck viaduct and its ancillary facilities, including those arising from the road portion.

13. Stakeholder Consultations with Local Communities

13.1 Stakeholder Analysis

The local stakeholders relevant to environmental and social considerations in this Study are as follows. Their opinions will be gathered through individual meetings, Stakeholder Meetings (SHMs), and Focus Group Discussions (FGDs), and their views will be considered for incorporation into the Project.

Table13-1: Stakeholders Anakysis

Stakeholder	Relevance to the Project
Ministry of Environment, Forest and Climate Change (MoEFCC)	National authority responsible for environmental matters.
Expert Appraisal Committee (EAC) at Centre level	Central agency responsible for EIA procedures. Supervisory authority for Category A projects, with the mandate to issue TOR/EIA and Environmental Clearance (EC).
Central Pollution Control Board (CPCB)	National authority responsible for pollution control. Holds the obligation to monitor pollution conditions after issuance of EC.
State Pollution Control Boards (SPCBs)	State-level agencies responsible for pollution control. Inspect pollution prevention measures and monitor their effectiveness.
Ministry of Housing and Urban Affairs (MoHUA)	Parent ministry of BMRCL.
Government of Karnataka	State government having jurisdiction over the Project area. Responsible for environmental and social matters within the state, with authority to issue project-related permits and approvals. Undertakes land acquisition procedures under KIADA.
Bangalore Development Authority (BDA)	Authority managing the Bengaluru Metropolitan Area (BMA), which is the Project area.
Bruhat Bengaluru Mahanagara Palike (BBMP)	Project proponent for road projects, responsible for infrastructure development and implementation in the city core. Acts as implementing agency for the flyover section, including preparation of project plans, technical studies, as well as ESIA/RAP.
Bangalore Metro Rail Corporation Limited (BMRCL)	Project proponent for the metro, responsible for preparation of project plans, technical studies, and ESIA/RAP.
Transport-related associations	Existing transport operators (e.g., autorickshaw unions) have expressed concerns about business opportunities during construction and operation of the Project.
Other industry associations	Other transport-related and non-transport industry associations expressing concerns regarding Project impacts.
Residents, shops, and institutions along the alignment	Expected to have concerns and interests regarding construction and operational impacts, as well as business opportunities.
NGOs / CBOs	Non-governmental organizations and community-based organizations engaged in environmental protection and support for vulnerable groups, expected to have concerns and interests regarding Project impacts.

Source: JST

13.2 Implementation Policy

The objective of these consultations was to provide information on the environmental and social impacts during the planning stage, to solicit views from local residents and stakeholders, and to reflect these inputs

in the Project's environmental and social considerations. The consultations were organized by BMRCL and conducted in accordance with the principles of transparency, inclusiveness, and attention to vulnerable groups, as stipulated in the JICA Guidelines for Environmental and Social Considerations (2022).

In line with the JICA Guidelines, stakeholder consultations for this Project were held twice: at the scoping stage and at the Draft Final Report (DFR) stage, as summarized below.

Table13-2: Implementation Policy for the First ESIA Stakeholder Meeting under this Study

Item	Details
Notification Date	15 July 2025 (notification for consultations at 5 venues from 21–23 July); 6 August 2025 (notification for re-consultations at 2 venues on 18 August)
Notification Method	Through newspaper advertisements, BMRCL website, social media, posters displayed around the venues, and SMS messages to local residents
Date of Implementation	21–23 July (5 venues); 18 August (2 venues for re-consultation)
Venues	Five venues along the proposed alignment: Regional Institute of Co-operative Management (Padmanabhanagar), SDK Party Hall (BSK 3rd Stage), Sri Suryodhaya Kalyana Mantapa (Vijayanagar), Anu's Party Hall (Nagarabhavi), and Marigold Function Hall (Sanjayanagar); and as re-consultation, Sri Siddalingeshwara Kalyana Mantapa (Banashankari) and BMRCL Head Office (Shanthinagar)
Participants	A total of 166 participants attended the 5 venues from 21–23 July. For the re-consultations at 2 venues on 18 August, a total of 60 participants attended. Participants included affected residents, shopkeepers, NGOs, resident associations, civic groups, students and academic representatives, engineers, and government officials
Explanation and Discussion	Explanations were provided on the proposed alignment and alternatives, and on the method for identifying key environmental and social impact items. Participants expressed concerns about land acquisition and tree cutting, while also voicing expectations for improved transport convenience
Remarks	In the initial 5 venues, two of them recorded low attendance and issues with the consultation method were pointed out. Therefore, two replacement re-consultations were organized at alternative venues.

Source: JST, Minutes prepared by BMRCL

Table13-3: Implementation Policy for the Second ESIA Stakeholder Meeting under this Study

Item	Details
Notification Date	29 August 2025
Notification Method	Through newspaper advertisements, BMRCL website, and posters displayed at public facilities
Date of Implementation	13–17 September 2025 (5 venues)
Venues	Five venues along the proposed alignment: GNR Kalyana Mantapa (Jayanagar), Regional Institute of Co-operative Management (Padmanabhanagar), Anu's Party Hall (Nagarabhavi), Urban Zilla Panchayath Office (Banashankari), and BMRCL Head Office (Shanthinagar)
Participants	Approximately 70 participants on average at each venue, including affected residents, shopkeepers, NGOs, civic groups, academic representatives, and government officials
Explanation and Discussion	Based on the DFR, the results of the environmental impact assessment and proposed mitigation measures were presented. Participants expressed concerns about tree cutting and compensatory plantation, noise, vibration and dust control, and transparency in land acquisition and compensation. At the same time, expectations were voiced for traffic decongestion and improved convenience of public transport.
Remarks	Consultations were successfully conducted at all five venues as scheduled, and minutes of meetings were prepared by BMRCL. Compared with the first stakeholder consultations, the combination of traditional media (newspaper advertisements and posters) and smartphone-based communication (WhatsApp, SMS and other social media) was found to be more effective in raising awareness and securing participation, reflecting the widespread use of smartphones in Bengaluru.

Item	Details
	Based on this experience, BMRCL will continue to use a multi-channel approach that actively utilizes smartphone-based tools while also maintaining newspaper and poster notifications so that stakeholders without smartphones are not excluded.

Source: JST, Minutes prepared by BMRCL

13.3 First Stakeholder Meeting (Scoping Stage)

13.3.1 Notification and Public Information

The first stakeholder consultations (scoping stage) were held at five venues across Bengaluru from 21–23 July 2025, with a total of 166 participants. Although the JICA Guidelines for Environmental and Social Considerations (2022) do not stipulate a fixed number of days for advance notice, they recommend allowing sufficient time for public awareness. In this case, a newspaper announcement was published on 15 July, resulting in six days of notice prior to the first meeting on 21 July.

- Newspaper announcement: *New Indian Express* (15 July)
- Website: Posted on the official BMRCL website
- Around venues: Posters and banners displayed
- Others: Direct communication with some community representatives, social media (X, official WhatsApp channel)

At SDK Party Hall (11 participants) and Sanjayanagar (12 participants), attendance was very low. In Sanjayanagar, concerns were raised about the short notification period, weekday scheduling, unsuitability of the venue, and absence of senior BMRCL officials. Some participants requested that the meeting be declared invalid. Consequently, it was decided to conduct re-consultations at these locations.

Re-consultations were organized on 18 August 2025 at Banashankari (morning) and BMRCL Head Office, Shanthinagar (afternoon). In advance of these, notifications were issued more than ten days prior, including a newspaper announcement on 6 August.

- Newspaper announcements: Deccan Herald, Kannada Prabha (6 August)
- Website: BMRCL official website
- Resident notification: SMS messages sent to affected households
- Around venues: Posters displayed
- Social media: X and BMRCL's official WhatsApp channel

Notices were provided in both English and Kannada, with explanatory materials prepared in English and oral presentations delivered in Kannada.

13.3.2 Schedule, Venues, and Participants

- Held from 21–23 July at five venues in Bengaluru, with a total of 166 participants (numbers per venue recorded in the Minutes of Meeting).
- At SDK Party Hall (11 participants) and Sanjayanagar (12 participants), attendance was significantly low. In Sanjayanagar, participants demanded invalidation of the meeting due to "insufficient notice" and "unsuitable venue." As a result, re-consultations were held on 18 August

at Banashankari and BMRCL Head Office.

- Participants included community representatives, Resident Welfare Association (RWA) members, representatives of religious institutions, NGOs, civic groups, and media representatives. The participation of women and elderly residents was also confirmed.
- The re-consultation on 18 August was attended by 56 participants at Banashankari and 4 participants at BMRCL Head Office.

13.3.3 Explanation Provided

BMRCL presented the following information:

- Project overview (alignment, structures, construction period)
- Environmental impacts (tree felling and transplantation, compensatory plantation plan, considerations for cultural and religious properties)
- Social impacts (land acquisition, compensation, potential resettlement)
- Draft Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP)
- Grievance Redress Mechanism (GRM) procedures

13.3.4 Consultation Process

- Conducted in English and Kannada, with sufficient time allocated for Q&A.
- Special attention was given to ensuring opportunities for women and elderly participants to express their views.
- Attendance sheets were prepared at each venue to record participants.

13.3.5 Key Opinions, Questions, and BMRCL Responses (by Venue)

Table13-4: Key Opinions, Questions, and Responses from BMRCL during the First Consultation

Venue / Date	Key Opinions / Questions	BMRCL Response	Follow-up
Padmanabhanagar (21 July) 40 participants (Male:36, Female:4)	Request for 15-day advance notice, weekend scheduling, prior distribution of PPT materials, and initiation of compensatory plantation in advance	Agreed to provide 15-day advance notice and hold meetings on weekends; compensatory plantation to start prior to construction; third-party audit to be considered	Improvement of notification methods; inclusion of audit and community plantation in EMP
SDK Party Hall (21) 11 participants (Male:11, Female:0)	Objections to the necessity of the double-deck structure; proposal for ORR alternative route; dissatisfaction with short notification period	Design team to review; future meetings to have 15-day advance notice and be held on weekends	Re-consultation organized due to low attendance and expressed dissatisfaction
Vijayanagar (22 July) 53 participants (Male:45, Female:8)	Proposal for alignment change (Prasanna Theater–Magadi Rd); request to return unused land and convert it into parks	Design team to review; parking arrangements to be coordinated with BBMP; improvement of materials promised	Disclosure of DPR and enhanced coordination with urban planning authorities
Nagarabhavi (22 July) 50 participants (Male:46, Female:4)	Request to utilize ORR; demand for disclosure of final alignment; concerns about impacts on religious institutions	ORR option already examined; current alignment decided based on composite evaluation; religious institutions to be preserved with due consideration	Disclosure of final alignment; cultural property considerations to be reflected in design

Venue / Date	Key Opinions / Questions	BMRCL Response	Follow-up
Sanjayanagar (23 July) 12 participants (Male:8, Female:4)	Claim that the meeting was "invalid" (insufficient notice, unsuitable venue, weekday scheduling, absence of senior officials); request for disclosure of tree-felling list	Commitment to provide 15-day advance notice, weekend scheduling, and participation of senior officials in future; list of tree-felling permits to be disclosed	Re-consultation organized, same as SDK Party Hall

Source: JST, Minutes prepared by BMRCL

Table13-5: Re-consultations (18 August, 2 venues)

Venue / Date	Key Opinions / Questions	BMRCL Response	Follow-up
Banashankari (Morning session on August 18) 56 participants(Male:46, Female: 10)	Proposal to change the ramp location at Dalmia Circle	Referred to the design department; no tree cutting without TEC approval	Review by design department
BMRCL Head Office (Afternoon session on August 18) 4 participants (Male:4, Female:0)	Concerns about survival rate of transplanted trees (75%), adoption of bamboo, and impacts on schools and hospitals	Transplantation expected at 75% survival rate; 1:10 compensatory plantation to be implemented; bamboo introduction to be considered based on expert opinion; most social infrastructure located on public land and addressed	Reflected in EMP and DPR; strengthened coordination with RWAs

Note: The reconvened consultations were held to complement the first meetings conducted on July 21 at SDK Party Hall and on July 23 at Sanjayanagar, both of which had low attendance and where participants requested improvements in the consultation format. The venues for the reconvened meetings were selected to ensure accessibility for stakeholders who had attended or were expected to attend the initial consultations at SDK Party Hall and Sanjayanagar.

Source: JST, Minutes prepared by BMRCL

13.3.6 Follow-up

The participants' opinions were forwarded to the Design Department and the Environmental & Social Department, to be reflected in the EMP/EMoP and improvements of the GRM. Regarding the request for disclosure of the DPR, BMRCL responded that it is "planned for disclosure." The minutes of meetings prepared by BMRCL (for both the first consultation and the re-consultation) are attached as Annex 2 to this report.

13.4 Second Stakeholder Consultation (DFR Stage)

13.4.1 Notification and Information Dissemination

The second consultation (DFR stage) was held from 13 to 17 September 2025 at five venues in Bengaluru, with an average of about 70 participants at each venue.

While the JICA Guidelines do not prescribe a specific number of days for notification, they recommend that a sufficient notification period be ensured. For this project, a public notice was issued on 29 August, securing a 15-day notification period before the first meeting (13 September).

- **Newspaper Notice:** *Deccan Herald*, *Kannada Prabha* (dated 29 August)
- **Website:** Published on the official BMRCL website
- **Around the venues:** Posters displayed

- **Others:** Direct communication with local representatives and RWAs, and via social media (X, official BMRCL WhatsApp channel)

Notifications were issued in both English and Kannada; the explanatory materials were prepared in English, and oral presentations were delivered in both English and Kannada.

13.4.2 Schedule and Venues

The consultations were conducted by BMRCL, based on the public notices, at the following venues and dates.

Table13-6: Dates and Venues of the Second Stakeholder Consultation

No.	Venue	Date	Time	Number of participants
1	GNR Kalyana Mantapa, Jayanagar	13 Sept 2025	10:30 AM	31（Male 25, Female 6）
2	Regional Institute of Co-operative Management, Padmanabhanagar	13 Sept 2025	2:30 PM	27（Male 20, Female 7）
3	Anu's Party Hall, Nagarabhavi	14 Sept 2025	10:30 AM	40（Male 36, Female 4）
4	BMRCL Head Office, Shanthinagar	16 Sept 2025	10:30 AM	24（Male 20, Female 4）
5	Urban Zilla Panchayath Office, Banashankari	17 Sept 2025	10:30 AM	27（Male 20, Female 7）

Source: JST, Minutes prepared by BMRCL

13.4.3 Profile of Participants

- **Total Participants**: 149 persons (121 men, 28 women)
- **Affiliation:** Project-affected residents, shop owners, RWAs (Resident Welfare Associations), NGOs, civil society organizations, students/academics, and government officials
- **Consideration for Vulnerable Groups:** Venues were selected to ensure access by public transport. Prior notification was disseminated not only through newspapers and the website, but also via RWAs and social media (SNS).

13.4.4 Explanation and Discussion Content

During the consultation, BMRCL explained the project outline as well as the results of the Environmental Impact Assessment (EIA) based on the DFR and the proposed mitigation measures.

- **Environmental Impacts:** Tree cutting and compensatory plantation, noise and vibration during construction, and air quality/dust management.
- **Social Impacts:** Compensation policies for land acquisition and measures for small businesses affected by the project.
- **Community Feedback:** Concerns were expressed regarding tree cutting, dust control, and transparency in compensation. At the same time, many participants expressed expectations for reduced traffic congestion and improved convenience of public transport.

13.4.5 Method of Consultation

The second consultation was conducted in both English and Kannada, similar to the first consultation, with attention given to ensuring sufficient time for Q&A and fairness in opportunities for participants to speak.

13.4.6 Key Opinions/Questions and Responses by BMRCL (Summary by Venue)

Table13-7: Key Opinions/Questions and Responses from the Second Stakeholder Consultation

Venue / Date	Key Opinions / Questions	BMRCL Responses	Follow-up
Jayanagar (9/13, 31 participants)	・ Request for disclosure of overall environmental impacts and the EIA; - Introduction of renewable energy and water pollution prevention measures; - Clarification on environmental monitoring system and reference to best practices (other cities, LCA); - Noise and vibration mitigation measures	・ EIA is under preparation, to be disclosed on the official website once finalized; - Considering solar and other renewable energy; water protection measures to be incorporated in design; - Environmental monitoring to be carried out by BMRCL with third-party involvement; - Life Cycle Assessment (LCA) reflected in design and mitigation; installation of noise barriers; - Construction time restrictions and vibration control technologies to be introduced	・ Disclosure of EIA and monitoring information to be shared on BMRCL's official website
Padmanabhanagar (9/13, 27 participants)	・ Request for disclosure of baseline data; - Traffic congestion management in areas with high density of pubs; - Questions on necessity of double-deck; demand for direct distribution of MoM; - Request for transplantation within the local area; - Selection of deep-rooted and fruit-bearing species; - Queries on plantation around lakes and planting intervals; - Request for disclosure of transplantation sites via Google Maps; - Request for survival rate monitoring	・ - Baseline data will be disclosed on official website; - Coordination with traffic police for phased construction; double-deck under review considering technical and environmental aspects; - MoM to be distributed via official channels; - Replantation to be conducted within the local area using native species; - Fruit-bearing species will be prioritized; - Plantation around lakes considered; spacing to follow horticulture standards (5m); - Transplantation site information to be disclosed online; - Monitoring of survival rate to be established and disclosed	・ Progressive disclosure of data and updates on tree management plan via official website
Nagarabhavi (9/14, 40 participants)	・ Proposal for alternate route via ORR (avoiding 80ft road); - Questions on number of transplanted trees; - Demand for disclosure of accurate route information; - Request for participation of senior management in meetings; - Demand for review of double-deck sections; - Point raised that ORR route could save 1,400 trees	・ Route alternatives comprehensively assessed in DPR; current alignment confirmed; - Number of transplanted trees to be verified with Forest Department and disclosed on BBMP website; - Final alignment per DPR, available on BMRCL website; - Senior management to participate in future consultations; - Double-deck sections under consideration based on demand and cost factors; - ORR route was considered, but current alignment chosen due to land acquisition and other constraints	・ Disclosure of transplantation numbers and route details on official website
Shanthinagar (9/16, 24 participants)	・ Request for strict compliance with 3R principle; - Demand for prompt implementation of compensatory	・ 3R principle to be followed under guidance of Forest Department and expert committee; - Compensatory	・ Implementation of compensatory

Venue / Date	Key Opinions / Questions	BMRCL Responses	Follow-up
	plantation; improvement of transplanted tree survival rates; - Request for involvement of tree expert committee at design stage; - Request for citizen site visits to compensatory plantation sites; - Demand for full disclosure of DPR; - Request for revised DPR after double-deck approval; - Queries on response to IISc technical evaluation report	plantation to be implemented promptly; survival rate to be improved with watering and soil treatment; - Expert committee already engaged from design stage; - Citizen site visits to be arranged; - DPR to be disclosed upon approval; revised version to also be disclosed; - IISc report under review and concerns will be addressed	plantation; disclosure of DPR and response to IISc report
Banashankari (9/17, 27 participants)	· Request for CO_2 reduction measures; - Pollution prevention in construction zones; - Strengthened C&D waste reduction and recycling; - Request for installation of noise barriers and adoption of low-noise technologies; - Questions on contribution to air quality improvement; - Request for biodiversity and wildlife protection measures	· CO_2 reduction through energy efficiency and renewable energy adoption; - Pollution prevention via sediment control, sewage treatment, and proper disposal of construction waste; - Segregation, reuse, and recycling of C&D waste; installation of noise barriers and similar measures planned; - Metro expected to reduce automobile dependency, thereby improving urban air quality; - Sensitive areas will be avoided, and greenery restored through plantation	· Reflection of emission reduction, pollution prevention, and biodiversity protection measures in EMP

Source: JST, Minutes prepared by BMRCL

13.4.7 Follow-up

The opinions and questions raised during the second consultation, along with BMRCL's responses, were forwarded to the Design Department and the Environment and Social Department, and will be reflected in improvements to the EMP/EMoP and the GRM.

- **Disclosure of EIA and data**: The EIA report, baseline data, transplantation site information, and plantation plans are scheduled to be disclosed on the official website.
- **Plantation and compensatory measures**: Compensatory plantation and post-transplantation management systems will be strengthened in collaboration with RWAs and local communities.
- **Traffic management and noise control**: Congestion mitigation measures in coordination with traffic police, installation of noise barriers, and restrictions on construction hours will be incorporated into the EMP.
- **DPR and transparency**: The revised DPR following approval of the double-deck structure will be disclosed, and citizen visits to compensatory plantation sites will be considered.
- **Response to IISc Report (technical evaluation by the Indian Institute of Science)**: Observations on sustainability will be thoroughly reviewed and, as necessary, incorporated into design and mitigation measures.

The contents of this follow-up will be reflected in the Environmental and Social Considerations Chapter of the DFR and utilized for further improvements during the design stage.
The minutes of the second stakeholder consultation prepared by BMRCL are attached as Annex 3.

14. Grievance Redress Mechanism (GRM)

14.1 Prevention of Grievances

For the smooth implementation of both construction and operation, it is important to minimize grievances to a manageable level.

Most grievances arise due to misunderstandings, lack of information, delays in communication, inconsistencies, or inadequate disclosure. To prevent this, the Contractor and the Project Proponent shall provide sufficient and timely information to the affected communities.

- Provide information on project operations and their impacts in an understandable form and language, at appropriate places and in a timely manner.
- Use appropriate communication channels and media.
- Conduct meaningful consultations and dialogue with the community throughout the project implementation period.
- Enhance the capacity of project staff and provide adequate information to field staff.
- Where necessary, engage community facilitators who understand local dynamics and processes, have negotiation and conflict resolution skills, and are capable of building trust with the local community.

The Contractor and the Project Proponent shall ensure that reports from field staff on interactions with local communities are effectively conveyed to senior management, in order to prevent grievances from escalating.

14.2 GRM Operation Team

BMRCL is the responsible organization for addressing environmental and social issues. Internally, responsibilities are divided between the **Environment Cell** and the **Land Cell**. The Environment Cell deals with grievances related to pollution control and other environmental concerns, while the Land Cell is responsible for grievances related to land acquisition, tree cutting, and associated issues.

14.3 Anticipated Grievances

During the construction stage, although the Contractor is responsible for implementing the EMP under the contractual environmental clauses, grievances from citizens are still anticipated in the following areas:

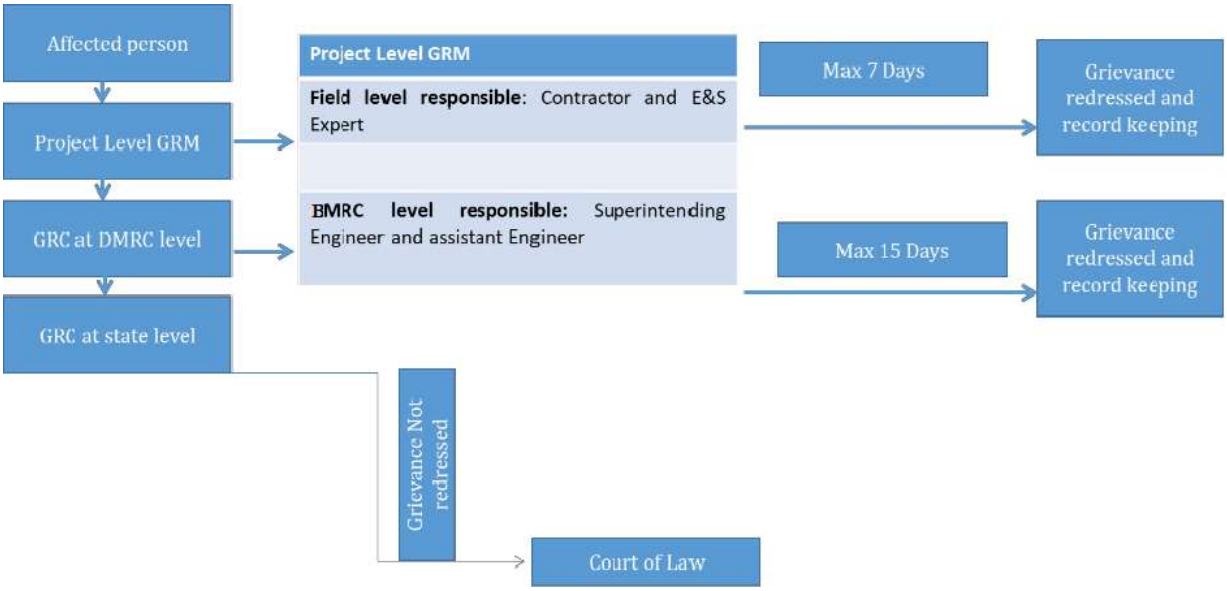
- **Environmental impacts:** dust, flooding, noise (blasting, piling, concrete breaking), vibration (disturbance to livelihood or damage to structures), deterioration in the quality or quantity of groundwater and surface water.
- **Environmental concerns:** opposition to tree cutting, loss of open spaces.
- **Public safety:** loss of access, risks to life and safety, and road damage due to heavy machinery.

To ensure prompt grievance handling and an effective mechanism, BMRCL has established the following procedures.

14.4 Grievance Redress Procedure

Grievances will be addressed at the following levels. If resolution cannot be achieved at one level, the grievance will be escalated to the next (Project level, BMRCL level, State Government level, and finally judicial level).

- **Project level:** The first responsibility for grievance handling lies with the Contractor and the Environmental and Social (E&S) Expert. At this level, a maximum of 7 days is allowed for resolution and record-keeping.
- **BMRCL level:** If unresolved, the grievance will be escalated to BMRCL, where the Superintending Engineer and the Assistant Engineer will be responsible. At this stage, a maximum of 15 days is provided for resolution and documentation.
- **State Government level:** If the grievance remains unresolved, the affected persons may seek resolution through the State Government.
- **Judicial level:** After exhausting all internal mechanisms, final recourse may be sought through the courts.



Source: JST

Figure14-1: Grievance Redress Process

The GRM is operated within BMRCL's existing legal and cultural framework, and it is recognized that the system includes project-level redress mechanisms. Contact details of the designated staff are always made public and are available for grievance submission and resolution.

Most project-related grievances are expected to be minor and site-specific. Therefore, the majority of grievances will be received directly by BMRCL's designated officer stationed at the site, who will attempt amicable resolution at the field level. The designated officer reports both resolved and unresolved cases to BMRCL, and any unresolved grievances are escalated to higher levels. All offline grievances are recorded in a **Grievance Register** maintained at site level, and are periodically consolidated, analyzed, and reported at city level.

Specific procedure:

1. Grievances may be registered online, through a toll-free number (1800-425-12345), or via chatbot.
2. Upon receipt, the responsible officer records the date and time, name, contact details, and nature of the grievance, and informs the complainant of the expected timeframe for resolution. If the officer cannot resolve the issue within the stipulated period, they are responsible for escalating it to BMRCL.
3. The grievance process follows the GRM flow chart and consists of the following steps:

a. **Registration:** The first step is for the Social Contact Person/Institution to receive the grievance from the complainant. The complainant is expected to fill out and submit a *Grievance Registration Form*, and the officer issues an acknowledgment within two working days.

b. **Verification:** The grievance is assessed to confirm whether it is project-related and whether it can be addressed at that stage. Depending on the findings, it may be quickly referred to the next level, to traditional authorities, or to law enforcement agencies. As part of verification, an assessment of the costs and severity of risks or losses is carried out.

Processing: In this stage, options for resolution are examined and decided. Relevant parties are convened, and the Social Contact Person mediates to collect proposals from each side and attempt initial resolution. If the complainant wishes to pursue the issue further, the Social Contact Person determines which institution should review and resolve it. This processing step must be completed within five days from the start of the investigation.

Implementation and Case Closing: The Social Contact Person refers the case to the competent authority responsible for implementing the GRM at that stage. This may be the Chair of the Grievance Redress Committee (GRC) or a designated officer within BMRCL directly responsible for the nature of the grievance. Proper documentation of the case facilitates an appeal process if the complainant is dissatisfied, or serves as an enforceable record if the complainant is satisfied.

The outcome of grievance handling is communicated to the complainant and other relevant parties. Possible outcomes include rejection of the claim, recommendation of compensation, or an apology from the management.

14.5 Grievance Filing and Record-Keeping

14.5.1 Filing of Grievances

BMRCL has established a GRM that is accessible through a unified helpline number, IVRS, social media, and other channels. External individuals and organizations affected by Metro Phase 3 may submit concerns and grievances through the following means:

- Entry in the *Complaints/Suggestions/Thanks Register* at Customer Care Centers in each metro station.
- Email submission to **helpline@BMRCL.org** (also accessible via the "Grievances" link on the official BMRCL website: https://english.bmrc.co.in/).

- 24-hour IVRS helpline (**155370**).
- SMS or social media platforms (Twitter, Facebook, Instagram, etc.).
- Submissions at the BMRCL office reception, through government portals, or by letter addressed to BMRCL.

In addition, specific grievance channels are available for vulnerable groups (e.g., women, the elderly) and for particular types of grievances (e.g., missing persons, trespassing, helplines for women, children, and persons with disabilities, as well as for general commuters and tourists).

14.5.2 Acknowledgement of Receipt

When a complaint, suggestion, or commendation is received, an acknowledgment is issued as follows:

- Written complaints submitted at stations: a receipt is given to the complainant.
- Complaints by email: an immediate acknowledgment/interim response is sent, followed by a final reply upon resolution.
- 24-hour IVRS helpline: a grievance number is issued.

14.5.3 Grievance Processing Routes

When grievances are submitted by residents, they follow two principal routes: **Assistance Route** or **Compensation Route**. In both cases, the ultimate objective is the effective resolution of grievances.

Assistance Route:

- Grievances seeking assistance are first addressed by BMRCL's field staff.
- If unresolved, they are escalated to the Grievance Redress Committee (GRC).
- The GRC reviews and proposes a resolution, upon which the grievance is closed.

Compensation Route:

- Grievances seeking compensation are referred to the Competent Authority.
- If the complainant is dissatisfied with the decision, they may appeal through the judicial system.
- Final resolution is provided by the courts, after which the grievance is considered closed.

14.5.4 Disposition of Grievances

When a grievance is received, the necessary action is considered. Where referral to relevant authorities is required, a request for a response is made, and the complainant is notified of this through an interim reply. After receiving a report from the concerned authority, a final reply is issued to the complainant. In other cases, appropriate actions are taken and responses provided accordingly.

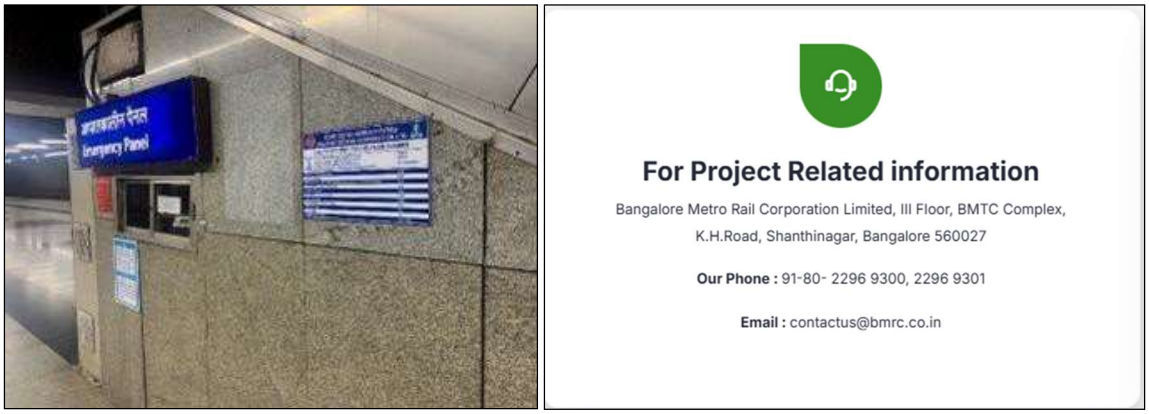
14.5.5 Disclosure of the GRM

The GRM is publicized to citizens through multiple methods:

- Posters displayed inside Bengaluru Metro trains.

- Notices at metro station platforms.
- Guidance on grievance channels provided on the official BMRCL website (https://english.bmrc.co.in/contact/).
- Information at customer service counters in each station.

At construction sites, contact information of designated staff is always posted so that the GRM can be accessed for submission and processing of grievances.

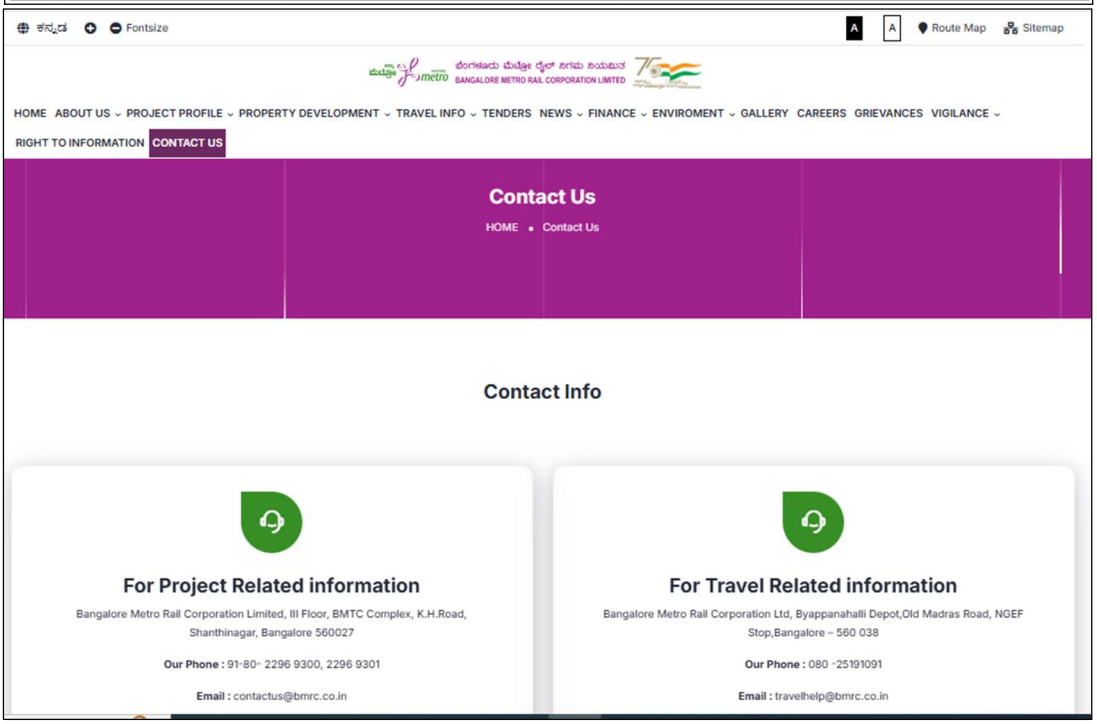


Source: BMRCL

Figure14-2: Bengaluru Metro Online Grievance Redress Mechanism

Contact Us

Sl. No	Name of Officer	Functional area	Contact No.
1	Director (Project & Planning)	Civil Construction, Underground & Tunneling, Utility shifting, Station constructions etc.	080-22969206
2	Director (RSE)	Rolling Stock, Electrical,Signalling & Telecommunication.	080-22969231
3	Chief Vigilance Officer	Vigilance matters related to BMRCL.	Phone: 080-22969387
4	General Manager(Land Acquisition)	Civil Land acquisition, Rehabilitation	BMRCL – Land Section Opposite to Chinnaswamy Stadium Gate 10 Mahatma Gandhi Road Bangalore - 560027. 080-22969396
5	Chief Public Relations Officer	Public Relations	080-22969300
6	For more information on Bangalore Metro Rail Project under the RTI Act,	RTI Act	Sri Padmaraju (PIO), BMRCL, Phone No: 080-22969200 / 080-22969400.
7	Property Development & Connectivity Division		3rd,4th & 5th Floor, Deepanjalinagar Site Office Beside Deepanjalinagar Metro Station Mysuru Road, Deepanjalinagar Bengaluru -560026 Phone No: 080 – 22969280 / 22969274
8	Metro Travel Related Queries, O&M Division	For any Complaints related to Stations / Security Issues / Travel / Recharge / Tokens, passengers may kindly Contact	080 -25191091
9	Manish - Line1 (Purple Line) and Srinivasmuruthy - Line2 (Green Line)	Only for Lost and Found Queries	Manish +91 8277889988 Srinivasmuruthy 080-25191232 / 080-22162232



Source: Banaglore Metro Website (https://english.BMRCL.co.in/contact/)

Figure14-3: Bengaluru Metro Online Grievance Redress Mechanism

ENVIRONMENTAL MONITORING FORMAT (DRAFT)

<Pre-Construction and Construction Phase>

1. Permits and Consultations

SN	Activities involved	Clearance Required	Authority/ Agency to Coordinate	Responsible Party	Requirements	Due date of permit issued	Obtaining Status
1	Site Clearance	Tree Cutting	Tree Expert Committee (TEC)	BMRCL	Permit	Before commencement of construction / prior to removal of trees (As per Karnataka Tree Preservation Act, 1976 Sec. 8 & Rule 4)	
2	Laying of double decker flyover with Metro line	Alignment is crossing National and State Highway	NHAI, PWD	BMRCL	Co-ordination	Before excavation or foundation work within RoW (As per National Highways Act, 1956 & Karnataka Highways Act, 1964 – prior NOC required)	
3		Project Alignment crossing railway line	Railways Department	BMRCL	Co-ordination	Before starting structural work near railway boundary (As per Indian Railways Works Manual – NOC prior to commencement of any work within 30 m of RoW)	
4		Road Cutting, NOC for Right of Way (ROW)	NHAI, PWD	Contractor/ BMRCL	Co-ordination	Before any road cutting or trenching activity (As per Karnataka Municipal Corporation Act, 1976, Sec. 288; prior permission mandatory)	
5		Canal Crossing, Intake Structure and Minors/ Majors Distributaries	Irrigation Department	BMRCL	Co-ordination	Before diversion or any work in canal buffer area (As per Karnataka Irrigation Act, 1965 Sec. 22 – NOC prior to any	

						interference with irrigation structure)	
6		Temporary Traffic Diversion for alternate Route and diversion of traffic	District Traffic, Police/ PWD	Contractor/ BMRCL	Co-ordination	At least 15 days prior to diversion implementation (As per Indian Motor Vehicles Act, 1988 & local police traffic regulation rules)	
7		Shifting of Electric utility services, RoW	Bangalore Electricity Supply Company Limited (BESCOM)	Contractor/ BMRCL	Co-ordination	Before excavation near existing line; application 30 days prior (As per Electricity Act, 2003 Sec. 68; BESCOM procedure manual)	
8		Shifting of Telecom utility services, RoW	Telecom	Contractor/ BMRCL	Co-ordination	Before shifting work; NOC application minimum 15 days before activity (As per Indian Telegraph Right of Way Rules, 2016, Rule 8)	
9		Park and Residential Area	BBMP	BMRCL	Co-ordination	Before entry or any activity within park/residential zone (As per Karnataka Municipal Corporation Act, 1976 Sec. 288; prior NOC)	
10	Source of Water	Water Requirement	Bengaluru Jal Board/ other source	BMRCL	Permission in case of Bengaluru Jal Board	Before extraction or supply connection (As per BWSSB Act, 1964; permission required prior to use)	
11	Source of Water for Construction Work	Domestic Water requirement for Construction	Other Source	Contractor	-	Before commencement of construction using borewell/tanker (As per CGWA guidelines – prior permission if groundwater extraction)	
12	Labour License	Mobilization of labours at site	Labour Commissioner	Contractor	License taken by Contractor	Within 15 days of commencing work employing >10 labourers	

						(As per Contract Labour (Regulation & Abolition) Act, 1970 Sec. 12(2))	
13	Consent to Establish & Operate (CTE & CTO)	Erection of Batching Plants, Diesel Generator, etc.	Karnataka Pollution Control Board	Contractor	NOC	CTE before establishment; CTO before operation of plant (As per Water Act 1974 & Air Act 1981, Rule 25)	
14	Identification of C&D Waste Disposal Site	Disposal of Muck generated	Land Owning Agency	BMRCL	NOC	Before start of civil work (As per Construction & Demolition Waste Management Rules, 2016, Rule 7)	
15	High Tension (HT) and Low Tension (LT) Lines	HT and LT lines passing though project alignment	Power Grid/ Respective Electrical Departments	Contractor/ BMRCL	NOC	Before excavation near lines; NOC prior to shifting (As per Electricity Rules, 2005, Rule 80)	
16	Demolition of building	For demolition of existing building	Land Owning Agency	BMRCL	NOC	Before demolition work starts (As per Karnataka Municipal Corporation Building Bye-laws 2003, Rule 21)	
17	Use of Vehicle and Equipment	Pollution under Control (PUC) Certificate	Department of Transport	Contractor	NOC	Before vehicle deployment at site; renewed every 6 months (As per Central Motor Vehicle Rules, 1989, Rule 115(7))	

Monitoring Item	**Monitoring Results during Reporting Period（In the case of consultations with local stakeholders, describe whether there are records of the consultations, the dates, the number of participants, etc.）**
Ex.: Implementation status of local stakeholder consultations	

2. Pollution Control

2-1. Air Quality

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken	Frequency
Visual Inspection; Status of ambient air quality, dust generation/ deposition			

Monitoring Item	Unit	Measured Value		Average	Country's Standards (NAAQS, 2009)	Referred Int'l Standards (WHO)	Remarks (Measurement Point, Frequency, Method, etc.)
		Min.	Max.				
PM_{10}							
$PM_{2.5}$							
NO_2							
CO							

2-2. Ground Water Quality

Monitoring Item	Unit	Measured Value		Country's Standards (IS: 10500 2012)	Referred Int'l Standards (WHO)	Remarks (Measurement Point, Frequency, Method, etc.)
		Min.	Max.			
pH						
Sodium						
Potassium						
Chloride						
Nitrogen						
Phosphorus						
Organic matter						
Heavy metal						

Oil & Grease						

2-3. Surface Water Quality (Effluent / Wastewater / Ambient Water Quality)

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken	Frequency
Visual Inspection			

Monitoring Item	Unit	Measured Value		Country's Standards (CPCB Standards)	Referred Int'l Standards (WHO)	Remarks (Measurement Point, Frequency, Method, etc.)
		Min.	Max.			
pH						
Sodium						
Potassium						
Chloride						
Nitrogen						
Phosphorus						
Organic matter						
Heavy metal						
Oil & Grease						

2-4. Waste

Monitoring Item	Monitoring Results during Report Period	Frequency
C&D Waste generated and disposed per month (qty) and record of C&D waste delivering process and disposal sites and this procedure		
Soil generated and disposed per month (qty) and record of delivering process and disposal		
Status of implementing Soil/ C&D Waste 3 R (reduce, reuse, recycle) plan		
Status of implementing comprehensive wastemanagement plan		

Voices and complaints from the local community(number)		

3 R plan: A minimum of 20% of C&D recycled products shall be used for external development and road works for finishing contracts.

2-5. Soil Contamination

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken	Frequency
Visual Inspection			

Monitoring Item	Unit	Baseline Value	Measured Value	Country's Standards	Referred Int'l Standards (WHO)	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
Sodium						
Potassium						
Chloride						
Nitrogen						
Phosphorus						
Organic matter						
Heavy metal						
Oil & Grease						

2-6. Noise / Vibration

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken	Frequency
Visual Inspection			

Monitoring Item	Unit	Baseline Value	Measured Value	Country's Standards	Referred Int'l	Remarks

		Leq	LMax	Leq	LMax		Standards (WHO)	(Measurement Point, Frequency, Method, etc.)
Noise level (daytime)	dB(A)							
Noise level (night time)	dB(A)							
Vibration level	VdB							

2-7. Ground Subsidence

Monitoring Item	Summary of Monitoring Report	Measures to be Taken	Frequency
Conduct of survey, if required.			

※A survey will be conducted by civil team when the risk of ground subsidence is found according to the detailed survey by the contractor before construction. Summary of the monitoring report will be submitted by the contractor.

2-8. Odour

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken	Frequency
Complaint on odour			

3. Natural Environment (Biodiversity, Ecosystem)

3-1. Afforestation

Item	Accumulated Results	Remarks
Number of trees planted (A)/ Number of trees planned to be planted (B) (A/B)		

(A): accumulated number of trees which are already planted so far for phase 1 and Phase 2

(B): accumulated number of affected trees which have to be planted based on permission of Forest Department

3-2. Ecology Monitoring

Monitoring Item	Monitoring Results during Report Period/ response	Measures to be Taken	Remarks
Visual observation of necessary facilities			

3-3. Geology/Topography

Monitoring Item	Monitoring Results during Report Period (Incidence)	Measures to be Taken, (if required)	Remarks
Visual inspection Soil Erosion, Topsoil removal, Debris material collection			

4. Social Environment

4-1. Livelihood

Monitoring Item	Response	Measures to be Taken, (if required)	Remarks
Voices and complaints from localcommunities			

4-2. Social Vulnerability

Monitoring Item	Response	Measures tobe Taken, (if required)	Remarks
Voices and complaints from localcommunities			

4-3. Cultural Heritage

Monitoring Item	Monitoring Result during Report Period	Measures tobe Taken, (if required)	Remarks
Record of ASI protected monument is encountered, if any			

4-4. Landscape (House Keeping)

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks
Visual Inspection			
Status of waste management			
Status of information dissemination to local community			

4-5. Water Use

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks
Status of obtaining permit, if required (number)			
Voices and complaints from local communities (number)			

4-6. Utility and Social Infrastructure

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks
Status of utility interruption(number)			
Voices and complaints from local communities,			

4-7. Children's Right

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks
Site observation (number)			
Voices and complaints from local communities, (Number)			

4-8. Infectious Disease for Workers

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks

General health check-up			
Status of adequate facilities at sites			
Voices and complaints from local communities (numbers)			

4-9. Worker's health and safety

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks
Status of ensuring a clean and safe work environment at each construction site or temporary facility:			
General health checkup			
Voice and complaints from the workers			

4-10. Community Health and Safety

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks
Voice and complaints from the workers			

5. Others

5-1. Road Safety

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks
Voice and complaints from the local community			

5-2. Climate change

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks
Plantation details			

Status of providing resting facilities, provision of sufficient drinking water			

5-3. Public/ Traffic Access

Monitoring Item	Monitoring Result during Report Period	Measures to be Taken, (if required)	Remarks
Voices and complaints from the local community			

6. Complaint Reception Status

Number and content of Complaints	Responsible organization	Current situation

<Operation Phase>

1. Pollution Control

1-1. Air Quality

Monitoring Item	Unit	Measured Value		Average	Country's Standards (NAAQS 2009)	Referred Int'l Standards (WHO)	Remarks (Measurement Point, Frequency, Method, etc.)
		Min.	Max.				
PM_{10}							
$PM_{2.5}$							
NO_2							
CO							

1-2. Ground Water Quality (IS: 10500)

Monitoring Item	Unit	Measured Value		Country's Standards (IS:10500)	Referred Int'l Standards (WHO)	Remarks (Measurement Point, Frequency, Method, etc.)
		Min.	Max.			
pH						
Sodium						
Potassium						
Chloride						
Nitrogen						
Phosphorus						
Organic matter						
Heavy metal						
Oil & Grease						

1-3. Surface Water Quality (effluent / Wastewater / Ambient Water Quality)

Monitoring Item	Unit	Measured Value		Country's Standards (CPCB Standards)	Referred Int'l Standards (WHO)	Remarks (Measurement Point, Frequency, Method, etc.)
		Min.	Max.			
pH						
Sodium						
Potassium						
Chloride						
Nitrogen						
Phosphorus						
Organic matter						
Heavy metal						
Oil & Grease						

1-4. Waste

Monitoring Item	Monitoring Result	Frequency
Waste generated and disposed per month (qty)		
Record of disposal including delivering process		
Voices and complaints from the local community (number)		

1-5. Soil Contamination

Monitoring Item	Unit	Baseline Value	Measured Value	Country's Standards	Referred Int'l Standards (WHO)	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
Sodium						
Potassium						
Chloride						
Nitrogen						
Phosphorus						
Organic matter						
Heavy metal						

Oil & Grease						

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken	Frequency
Visual Inspection			

1-6. Noise / Vibration

Monitoring Item	Unit	Baseline Value		Measured Value		Country's Standards	Referred Int'l Standards (WHO)	Remarks (Measurement Point, Frequency, Method, etc.)
		Leq	LMax	Leq	LMax			
Noise level (day time)	dB(A)							
Noise level (night time)	dB(A)							
Vibration level	VdB							

2. Natural Environment (Biodiversity, Ecosystem)

2-1. Hydrology

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken, (if required)	Remarks
Visual observation ofsurface water flow			
Visual observations of seepage water			
Visual observation of necessary facilities for drainage and flood protection			

2-2. Geology/Topography

Monitoring Item	Monitoring Results during Report Period (Incidence)	Measures to be Taken, (if required)	Remarks
Applying status of emergency response plan			

3. Social Environment

3-1. Water Use

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken, (if required)	Remarks
Status of installing RWH, water meters, awareness campaign			
Voices and complaints from local communities (number)			

3-2. Worker's Health and Safety

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken, (if required)	Remarks
Status of implementing OHS and ERP			
General health checkup			
Voice and complaints from the workers			

OHS: Occupation of Health and Safety, ERP: Emergency Response Plan

3-3. Community health and Safety

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken, (if required)	Remarks
Voice and complaints from the workers			
Status of PSD, CCTV, security Personal, warning sign etc.			

4. Others

4-1. Road Safety

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken, (if required)	Remarks
Voices and complaints from the local community			

4-2. Climate Change

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken, (if required)	Remarks
Voices and complaints from the local community			

4-3. Public/ Traffic Access

Monitoring Item	Monitoring Results during Report Period	Measures to be Taken, (if required)	Remarks
Voices and complaints from the local community			

5. Complaint Reception Status

Number and Content of Complaints	Responsible Organization	Current Situation

Bangalore Metro Rail Corporation Limited (BMRCL)

Minutes of the Environmental Stakeholders Meeting

Phase-3 Public Consultation
Dates: 21st to 23rd July 2025

1. Meeting Details

Date	Venue	No. of participants attended	Location
21 July 2025	Regional Institute of Co-operative Management.	40	Padmanabhanagar
21 July 2025	SDK Party Hall.	11	BSK 3rd Stage
22 July 2025	Sri Suryodhaya Kalyana Mantapa	53	Vijayanagar
22 July 2025	Anu's Party Hall	50	Nagarabhavi
23 July 2025	Marigold Function Hall	12	Sanjayanagar
Total		**166**	

2. Key Points Raised by Stakeholders

General & Procedural Requests

- Provide 15 days' prior notice for future meetings.
- Conduct meetings on Sundays or public holidays to ensure better public participation.
- Circulate PowerPoint presentations beforehand and share them post-meeting.
- Meeting notices to be published via social media, BMRCL website, and shared with BBMP ward committees and RWAs.
- Fix a quorum for meetings; postpone if attendance is below threshold.
- Host at least one public consultation at BMRCL Head Office and another within the project area.
- Signed copies of MoM to be provided to attendees.

Transparency & Information Disclosure

- Publish on BMRCL website: Finalized DPR, Final EIA Report, Tree felling data, Proof and status of replantation and compensatory afforestation, Certified list of trees felled,

Timeline for final alignment decisions, Results of the vibration impact study, Contribution to groundwater recharge.

Environmental Concerns

- Begin compensatory afforestation before construction.
- Ensure replantation/relocation is done in the same locality to retain micro green spaces.
- Independent third-party audits for replantation efforts to be conducted and published.
- Involve NGOs and local communities in replantation.
- Invite BBMP tree committee to all EIA meetings.
- Avoid replantation in locations where tree survival is unlikely (due to severed roots).
- Specific request to save Shri Tamraparni Raghavendra Swamy Matha from alignment impacts.

Technical and Alignment Concerns

- Questions on the necessity of the Double-Decker structure in Vijayanagar.
- Proposal to realign from Prasanna Theater to Magadi Road to save local boulevard.
- Requests to align metro along Outer Ring Road (ORR) to minimize displacement.
- Query raised on the criteria behind choosing underground vs. overground stretches (cost, social, environmental weightage).

Community Engagement & Communication

- Display meeting banners in prominent local spots.
- Invite stakeholders to all replantation ceremonies.
- BMRCL Civil Engineering team should be present in future meetings.
- Display at sites: Contact points and complaint resolution timelines.

Site-Specific Concerns

- Unused properties should be returned or converted to public parks.
- Tree felling near Kadabagere Cross by BDA despite BMRCL's plantation.
- Complaints about vehicle parking near Attiguppe Metro Station.
- Contractors are unresponsive to public grievances.

Policy & Legal Recommendations

- Develop a policy for indemnifying property damage or injury during construction.
- Returning unused properties or allocating for public benefit.

3. Demands for Meeting Annulment (Sanjayanagar - 23 July 2025)

Attendees demanded the meeting be declared null and void citing:

- Not held on a public holiday
- Insufficient notice (less than 15 days)
- Venue not located near the project area
- Absence of senior BMRCL officials

4. Follow-Up Actions Suggested

- Ensure greater inclusivity in future meetings
- Document and track each public query and corresponding BMRCL response

- Schedule additional public meetings addressing areas with high concern
- Create summary dashboards for environment-related metrics on the BMRCL website

BMRCL's response to queries and concerns raised by stakeholders

Meeting Notice and Participation

Stakeholders emphasized the need for sufficient prior notice and holding meetings on holidays for better attendance. BMRCL acknowledges the concern and will make efforts to issue notices at least 15 days in advance and schedule meetings on public holidays where feasible.

Transparency and Information Sharing

There were requests to publish project details, alignment, and environmental documents online. BMRCL commits to enhancing transparency by updating the website with relevant documents, including the EIA report, DPR, and replantation status.

Environmental and Tree-related Concerns

Participants requested local replantation, early compensatory afforestation, and involvement of independent agencies. BMRCL reiterates its commitment to sustainable practices and will explore involving third-party verification and local replantation to the extent possible.

Alignment and Technical Suggestions

Suggestions were made regarding alternative routes to save green spaces and minimize displacement. While technical constraints determine alignment, all feedback is noted and will be shared with the engineering design team.

Public Engagement and Communication

The public requested better on-ground communication and inclusion of civic bodies in consultations. BMRCL will enhance signage at sites, increase public interface efforts, and involve local institutions where relevant.

Grievance Redressal

Concerns were raised about responsiveness at project sites. BMRCL will review grievance mechanisms and improve the responsiveness and visibility of contact points.

Meeting Validity and Requests for Repetition

Some attendees at the Sanjayanagar meeting requested the session be annulled due to short notice and venue concerns. BMRCL appreciates the feedback and will strive to adhere more closely to procedural expectations in the future.

Policy Suggestions

Suggestions were made for indemnity policies and post-project land use planning. These suggestions are valuable and will be discussed internally for appropriate incorporation.

Way Forward

BMRCL sincerely thanks all stakeholders for their time and constructive suggestions. As the project progresses, BMRCL remains committed to incorporating public feedback, enhancing transparency, and minimizing environmental and social impacts. Continued engagement

with local communities and civic organizations will form the cornerstone of our environmental management strategy.

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Bangalore Metro Rail Corporation Limited (BMRCL)

Minutes of the 1st Environmental Stakeholders Meeting

Phase-3 – Public Consultation on Environmental aspects
Date : 21.07.2025 to 23.07.2025

Sl. No	Venue	Date	Name of the Questioner	Questions Raised	BMRCL Response
1.	**Regional Institute of Co-operative Management, Padmanabhanagar**	**21-07-2025**	[redacted]	1. Meeting convened at Short notice- give at least 15 days' prior notice. 2. Circulate the PPT amongst the stakeholders beforehand. 3. Further public consultation meetings to be organized on a Sunday or a Public holiday to ensure large participation. 4. Compensatory afforestation to begin before the project starts	BMRCL will ensure that all future meetings are notified at least 15 days in advance through website, social media, BBMP ward committees and RWAs. Presentations will be circulated before and after meetings, and also uploaded to the BMRCL website. Future meetings will be scheduled on Sundays/holidays to enable wider public participation. Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate.
2.			[redacted]	5. Conduct an independent 3rd party survey of the	Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent

				re-plantation work. Publish proof of work on the BMRCL website. 6. Please invite stakeholders for all re-plantation ceremonies. 7. Locate spaces for re-planting/relocating of trees along the alignment and stations.	third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate. Alignment decisions are based on detailed technical, social, cost and environmental studies. Suggestions regarding alignment, double-decker structures, and heritage-sensitive areas will be forwarded to the design team for review, and the rationale will be published in the DPR.
3.	**Regional Institute of Co-operative Management, Padmanabhanagar**	**21-07-2025**	[redacted]	8. Representatives from the BMRCL Civil Engineering section to be present in the next meeting to answer technical questions/queries	BMRCL has taken note of the concern and will examine it further with relevant departments.
4.			[redacted]	9. At project sites, display points of contact and the Minimum time required to resolve complaints. 10. BMRCL must devise a policy regarding indemnity for damage to private property, life, or limb caused during metro construction.	Meeting notices and banners will be displayed in prominent local areas and announcements will be made on social media and the BMRCL website. Complaint redressal mechanisms will be strengthened with clear display of contact details and resolution timelines at all project sites. Contractors will be instructed to respond promptly to public concerns. BMRCL will prepare a clear indemnity and compensation framework for damage to private property, life, or limb caused during metro works.

5.	**SDK PARTY HALL BSK 3rd Stage**	**21-07-2025**		• Provide 15 days' prior notice for future meetings. • Conduct meetings on Sundays or public holidays to ensure better public participation. • Circulate PowerPoint presentations beforehand and share them post-meeting. • Meeting notices to be published via social media, BMRCL website, and shared with BBMP ward committees and RWAs.	BMRCL will ensure that all future meetings are notified at least 15 days in advance through website, social media, BBMP ward committees and RWAs. Presentations will be circulated before and after meetings, and also uploaded to the BMRCL website. Future meetings will be scheduled on Sundays/holidays to enable wider public participation.
6.	**SDK PARTY HALL BSK 3rd Stage**	**21-07-2025**		• Begin compensatory afforestation before construction. • Ensure replantation/relocation is done in the same locality to retain micro green spaces. • Independent third-party audits for replantation efforts to be conducted and published.	Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate.

				• Involve NGOs and local communities in replantation	
7.	**SDK PARTY HALL BSK 3rd Stage**	**21-07-2025**		• Questions on the necessity of the Double-Decker structure in Vijayanagar. • Proposal to realign from Prasanna Theater to Magadi Road to save local boulevard. • Requests to align metro along Outer Ring Road (ORR) to minimize displacement. • Query raised on the criteria behind choosing underground vs. overground stretches (cost, social, environmental weightage).	Alignment decisions are based on detailed technical, social, cost and environmental studies. Suggestions regarding alignment, double-decker structures, and heritage-sensitive areas will be forwarded to the design team for review, and the rationale will be published in the DPR.
8.	**SDK PARTY HALL BSK 3rd Stage**	**21-07-2025**		• Display meeting banners in prominent local spots. • Invite stakeholders to all replantation ceremonies. • BMRCL Civil Engineering team should be	Meeting notices and banners will be displayed in prominent local areas and announcements will be made on social media and the BMRCL website. Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and

				present in future meetings	reports/photos published on the website. NGOs and local RWAs will also be invited to participate.
9.	**SDK PARTY HALL BSK 3rd Stage**	**21-07-2025**		• Ensure greater inclusivity in future meetings • Document and track each public query and corresponding BMRCL response • Schedule additional public meetings addressing areas with high concern • Create summary dashboards for environment-related metrics on the BMRCL website	Alignment decisions are based on detailed technical, social, cost and environmental studies. Suggestions regarding alignment, double-decker structures, and heritage-sensitive areas will be forwarded to the design team for review, and the rationale will be published in the DPR. An environment performance dashboard (tree plantation, water conservation, carbon savings) will be published on the BMRCL website.
10.	**Sri Suryodhaya Kalyana Mantapa, Vijayanagar**	**22-07-2025**		1. Is Double–Decker necessary? 2. The Boulevard in Vijayanagar can be saved if the alignment is relocated to continue from Prasanna Theater to Magadi Road instead of taking a detour to Hosahalli Metro.	Alignment decisions are based on detailed technical, social, cost and environmental studies. Suggestions regarding alignment, double-decker structures, and heritage-sensitive areas will be forwarded to the design team for review, and the rationale will be published in the DPR.

11.			[redacted]	3. BMRCL must invite the General Public to give their preference for re-planation. 4. Tree re-plantation and relocation must happen in the same locality to preserve micro lung-space.	Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate.
12.	**Sri Suryodhaya Kalyana Mantapa, Vijayanagar**	**22-07-2025**	[redacted]	5. In the in PPT Presentations, use the photographs/plans of the locality where the meeting is convened. 6. BMRCL must come out with a policy to return unused properties to owners or create public parks. 7. Haphazard vehicle parking around Attiguppe Metro Station. BMRCL should plan better parking around metro stations.	Presentations will be circulated before and after meetings, and also uploaded to the BMRCL website. Parking management around metro stations will be improved in coordination with local authorities.
13.	**Sri Suryodhaya Kalyana Mantapa,**	**22-07-2025**	[redacted]	8. Publish proof of Re-plantation/Relocation work on the BMRCL website. 9. Revised DPR must be published on	Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local

	Vijayanagar			the BMRCL website. 10. BMRCL must involve the general public/NGO in re-plantation work.	RWAs will also be invited to participate.
14.	**Sri Suryodhaya Kalyana Mantapa, Vijayanagar**	**22-07-2025**		11. Near Kadabagere Cross, trees planted by BMRCL in the buffer zone have been felled by BDA. BMRCL to take action. 12. Even though BMRCL has taken contact details of property owners, Meeting intimations have not been sent.	Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate.
15.	**Sri Suryodhaya Kalyana Mantapa, Vijayanagar**	**22-07-2025**		Display meeting banners in vantage positions like cross-roads, market places etc. of the locality. 14. Give signed Minutes of the Meeting (MOM) to attendees. 15. Invite BBMP tree-committee to all EIA meetings.	Signed Minutes of Meeting (MoM) will be provided to participants in future consultations. Meeting notices and banners will be displayed in prominent local areas and announcements will be made on social media and the BMRCL website. Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate.
16.				1. BMRCL must publish	Alignment decisions are based on detailed technical,

	Anu's party hall, Nagarabhavi	**22-07-2025**		the finalized alignment on its Website. 2. Request to re-align the metro line along the existing ORR (500 mtrs apart).	social, cost and environmental studies. Suggestions regarding alignment, double-decker structures, and heritage-sensitive areas will be forwarded to the design team for review, and the rationale will be published in the DPR.
17.	**Anu's party hall, Nagarabhavi**	**22-07-2025**		3. Contractors on the site are not responsive to public complaints. 4. BMRCL must publish the timeline required for the finalization of alignment.	Alignment decisions are based on detailed technical, social, cost and environmental studies. Suggestions regarding alignment, double-decker structures, and heritage-sensitive areas will be forwarded to the design team for review, and the rationale will be published in the DPR. Complaint redressal mechanisms will be strengthened with clear display of contact details and resolution timelines at all project sites. Contractors will be instructed to respond promptly to public concerns.
18.	**Anu's party hall, Nagarabhavi**	**22-07-2025**		5. BMRCL must publish details of the "vibration study" on its website. 6. Publish compensatory afforestation on the BMRCL website.	Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate.
19.	**Anu's party hall, Nagarabhavi**	**22-07-2025**		7. Request to save Shri. Tamraparni Raghavendra Swamy Matha (plus code: 7J4VXGC4+6V). Mutt represented by Shri Ramanna,	Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to

				The Hindu Reporter (Retd), in the meeting. The representative said that the Mutt was constructed and consecrated 30 years ago. According to the representative, the alignment poses a risk to the frontage of the Mutt. 8. Complete compensatory afforestation before the beginning of the project.	participate. Alignment decisions are based on detailed technical, social, cost and environmental studies. Suggestions regarding alignment, double-decker structures, and heritage-sensitive areas will be forwarded to the design team for review, and the rationale will be published in the DPR. Concerns regarding heritage structures will be carefully reviewed and mitigation measures will be incorporated into project planning.
20.	**Marigold Function Hall, Sanjayanagar**	**23-Jul-2025**	[redacted]	1. One public consultation meeting must be held in the BMRCL head office and also closer to the project. 2. The Public demanded that this meeting be declared null and void for the following reasons: a) it was not held on a public holiday; b) Non-issuance of 15 days' prior notice	BMRCL will ensure that all future meetings are notified at least 15 days in advance through website, social media, BBMP ward committees and RWAs. Future meetings will be scheduled on Sundays/holidays to enable wider public participation.

				c) Not held in the project vicinity.	
21.	**Marigold Function Hall, Sanjayanagar**	**23-Jul-2025**		3. The public demanded why the higher officials of BMRCL were not present at the meeting. 4. A certified copy of the tree felled must be published on the BMRCL website. 5. Publish proof of compensatory afforestation on the BMRCL website.	Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate. Certified lists of trees permitted for felling, along with compensatory actions, will be published zone-wise on the website.
22.	**Marigold Function Hall, Sanjayanagar**	**23-Jul-2025**		6. Replanting must be done in the project area. 7. Translocating trees will not work due to surface-level removal, which will sever the mother root. 8. Issue 15-day notice of such meetings. Publish meeting notices on social media and the BMRCL website. Circulate meeting	BMRCL will ensure that all future meetings are notified at least 15 days in advance through website, social media, BBMP ward committees and RWAs. Meeting notices and banners will be displayed in prominent local areas and announcements will be made on social media and the BMRCL website. Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate.

			[redacted]	notices amongst BBMP ward committees and Resident Welfare Associations (RWAs).	
23.	**Marigold Function Hall, Sanjayanagar**	**23-Jul-2025**	[redacted]	9. Publish zone-wise and package-wise reports on trees enumerated for felling/ translocating. 10. Arrange to send PPT presentations to attendees after the meeting. 11. Replant /Translocate in the locality it is removed from.	Presentations will be circulated before and after meetings, and also uploaded to the BMRCL website. Compensatory afforestation will be initiated before construction wherever feasible. Re-plantation will be prioritized in the same locality, with independent third-party audits, and reports/photos published on the website. NGOs and local RWAs will also be invited to participate.
24.	**Marigold Function Hall, Sanjayanagar**	**23-Jul-2025**	[redacted]	12. What is BMRCL's contribution to the recharging of the water table under its project line (existing and proposed)? 13. All further presentations must have two sections: a) How the proposed project affects the overall environment of Bengaluru; b) How the proposed project	Presentations will be circulated before and after meetings, and also uploaded to the BMRCL website. BMRCL will adopt rainwater harvesting and recharge structures at stations to support groundwater recharge.

				segment affects the local environment.	
25.	**Marigold Function Hall, Sanjayanagar**	**23-Jul-2025**		14. BMRCL must fix the quorum for each meeting. If attendance is less than the stated quorum, it must be postponed. 15. Publish the following on the BMRCL website: a) Finalized DPR; b) EIA report. 16. In the next meeting, kindly add information as to why certain sections of the metro line is underground and certain others are overground, what the weightages given to cost, social, and environmental considerations.	A minimum quorum requirement will be defined and meetings with low participation will be rescheduled. Alignment decisions are based on detailed technical, social, cost and environmental studies. Suggestions regarding alignment, double-decker structures, and heritage-sensitive areas will be forwarded to the design team for review, and the rationale will be published in the DPR.

Bangalore Metro Rail Corporation Limited (BMRCL)

Minutes of Additional Environmental Stakeholders Meeting

Phase-3 – Environmental Public Consultation Date: 18th August 2025

Venue 1: Sri Siddalingeshwara Kalyana Mantapa, Banashankari, Benglauru
Venue 2 : BMRCL Coroporate office, Conference hall, Shantinagar, Bengaluru

Issued in Public Interest by BMRCL

1. Overview

The meeting was conducted to gather stakeholder inputs regarding the proposed metro alignment under Phase-3 and to provide clarifications from the BMRCL. The objective was to ensure transparency, foster environmental stewardship, and uphold social accountability in line with national policies and international frameworks, including those of JICA.

2. Stakeholder Feedback and BMRCL Responses

◆ Concern: Ramp Down near Dalmia Circle

Raised by: Ms. Prana Kumari

Issue: Suggested shifting the ramp till Bannerghatta Road (approx 300m) to avoid potential environmental impact and avoid traffic congestion.
Response: BMRCL appreciates the concern and will forward the suggestion to the Architecture and Planning Division for examination. It is reiterated that no trees will be felled without approval from the Tree Expert Committee (TEC), consisting of officials from BBMP and the Forest Department from GoK. Environmental due diligence is at the core of all BMRCL actions.

◆ Concern: Translocation Success & Bamboo Inclusion

Raised by: Mr. Prasanna

Issue: Requested survival statistics for translocated trees and proposed inclusion of bamboo in compensatory plantation.

Response: The survival rate for translocated trees is approximately 75%, and BMRCL undertakes compensatory plantation at a 1:10 ratio. The proposal to include bamboo is a resilient and eco-beneficial species. Inclusion of Bamboo is good suggestion, it shall be reviewed by ecological experts and forestry advisors.

◆ **Concern: Impacts on Social Infrastructure & Developer Compliance**

Raised by: Ms. Anupama

Issue: Expressed concern over the metro line affecting schools, parks, and hospitals. Raised issues about private developers not fulfilling environmental obligations.

Response: BMRCL clarifies that only 23% of affected land is privately owned, while the majority is government property. BMRCL's environmental compensations are monitored by both local and international agencies, including JICA. For issues involving private developers, residents are encouraged to approach the BBMP or appropriate regulatory bodies.

3. Addressing Concerns Raised by Mr. Dattatreya T. Devare

Based on JICA Guidelines for Environmental and Social Considerations (2022)

Mr. Devare has highlighted critical excerpts (via message, as the person was unavailable for the consultation) on:

a) The importance of meaningful consultation.
b) The need for timely and accessible disclosure of information.
c) The right of vulnerable social groups to be represented.
d) The requirement to prepare and share Minutes of Meetings (MoM).

The reference to the JICA Guidelines (2022) reinforces the shared values we hold regarding inclusive development and environmental responsibility.

In response:

a) Meaningful Consultation: We acknowledge that consultation is not a one-time event but a continuing dialogue. Efforts will be made to ensure notices are issued with ample lead time, held at convenient venues, and include local-language materials.
b) Information Disclosure: BMRCL has published project-related documents (EIA, DPR, afforestation records) on its official website. We remain open to expanding this to include updates on alignment changes, impact studies, and mitigation progress.
c) MoM Documentation: All stakeholder meetings are documented, and MoMs are being systematically compiled and published in the website. This very document serves to reinforce the commitment.
d) Engagement with Vulnerable Groups: We are improving mechanisms to ensure women, elderly, differently abled, and economically weaker

residents are adequately consulted. Partnerships with RWAs and civic bodies will be further strengthened to this end.

4. Access to Full DPR – Clarification

Mr. Dattatreya T. Devare requested access to the full Detailed Project Report (DPR). BMRCL has already made the Executive Summary of the DPR available to the public via the downloads section of its website (https://phase3laq.bmrc.co.in/).

Sharing the entire DPR online would be impractical due to its considerable size. However, BMRCL is committed to transparency and can provide access to the full DPR upon receiving a written application addressed to the Executive Director, Civil 3, BMRCL.

5. Future Prospects

Suggestions received will be shared with relevant technical and environmental departments. Upcoming consultations will prioritize transparency, advance notice, local access, and broader outreach. BMRCL will continue to align its best practices with the JICA environmental and social safeguards framework, ensuring both project sustainability and attaining public trust.

This MoM is issued in public interest and will be made available through the BMRCL website (https://phase3laq.bmrc.co.in/).

Sd/-

DGM (Land & SEMU)
BMRCL

Bangalore Metro Rail Corporation Limited (BMRCL)

Minutes of the Environmental Stakeholders Meeting

Phase-3 – Public Consultation
Date:
Venue:

Sl.No	Name of the Questioner	Questions Raised	Response by DGM (Land & SEMU)
1	[redacted]	1. Meeting convened at short notice – requested 15 days' prior notice. 2. Circulate the PPT beforehand. 3. Hold future consultations on Sundays or public holidays.	BMRCL acknowledges the importance of timely and inclusive consultation. Future meetings will be planned with a minimum of 15 days' notice and scheduled preferably on holidays for wider participation. Presentation material will be shared in advance where feasible.
2	[redacted]	1. Begin compensatory afforestation before the project starts. 2. Conduct third-party verification of replantation and publish results. 3. Invite stakeholders to replantation ceremonies. 4. Replantation to happen along	BMRCL is committed to environmental safeguards. Compensatory afforestation is prioritized in advance of construction. Third-party oversight is under review. Local stakeholder involvement will be

		alignment and stations.	encouraged where feasible.
3	[redacted]	1. Include BMRCL Civil Engineering team in future meetings. 2. Display complaint contact points and response time at project sites. 3. Indemnity policy for damage to life/property during construction.	BMRCL will ensure representation from technical teams in relevant meetings. Site-level signage will be improved to display grievance contacts and resolution timelines. A framework for indemnification is being reviewed under project safeguards.
4	[redacted]	1. Is Double–Decker necessary? 2. Suggests alternate alignment from Prasanna Theatre to Magadi Road to avoid boulevard impact.	Alignment decisions are made considering multiple factors including technical feasibility, cost, and social-environmental trade-offs. Suggestions are documented and referred to the engineering division for review.
5	[redacted]	1. Public preference for replantation. 2. Replant trees in same locality to protect micro-lung spaces. 3. Use local area photos in presentations. 4. Return unused land to owners or create parks.	Public inputs on replantation are welcome and will be encouraged. Localized replanting is prioritized where ecologically viable. Presentation content will increasingly use local references. Post-project land use will be

			coordinated with civic agencies.
6	[redacted]	1. Resolve parking issues around Attiguppe Metro Station. 2. Publish proof of replantation. 3. Publish revised DPR.	Suggestions have been noted. Parking management around metro stations is under review. Replantation status and revised DPR summaries will continue to be updated on BMRCL's official website.
7	[redacted]	Involve general public/NGOs in replantation.	BMRCL welcomes community and NGO involvement in replantation efforts. Channels for collaboration will be strengthened.
8	[redacted]	1. Trees planted near Kadabagere Cross were felled by BDA. 2. Property owners were not informed about the meeting.	BMRCL will coordinate with BDA to prevent such occurrences. We will also ensure improved stakeholder outreach and information dissemination for future meetings.
9	[redacted]	1. Use banners at visible public locations. 2. Distribute signed MoMs. 3. Invite BBMP tree committee to EIA meetings.	These suggestions are accepted. BMRCL will ensure meeting banners are placed prominently, and signed MoMs are shared with attendees. BBMP Tree Committee participation will be

			ensured in future EIA consultations.
10	[redacted]	1. Publish final alignment. 2. Re-align along ORR. 3. Improve contractor responsiveness. 4. Share timeline for final alignment. 5. Publish vibration study.	Final alignment and study outcomes are progressively being published on BMRCL's website. ORR-based alternatives have been evaluated; decisions are based on feasibility. Contractor performance will be monitored more rigorously.
11	[redacted]	1. Publish compensatory afforestation status. 2. Save Shri Tamraparni Raghavendra Swamy Matha (Plus Code: 7J4VXGC4+6V).	Afforestation reports are being updated online. The specific religious site has been noted and reviewed; alignment design will aim to minimize any impact to heritage and religious structures.
12	[redacted]	Complete compensatory afforestation before starting the project.	BMRCL is prioritizing early afforestation and environmental offsetting in alignment with project phases.
13	[redacted]	1. Hold meetings at BMRCL HQ and closer to project. 2. Meeting invalid due to short notice, non-holiday, and distant venue.	Future consultations will be held in or near project areas and with adequate notice. Feedback is acknowledged and will guide planning improvements.
14	[redacted]	1. Presence of senior BMRCL	Efforts will be made to ensure

		officials at meetings. 2. Publish certified tree felling records. 3. Publish afforestation proof.	senior officials attend key meetings. Tree felling and afforestation data is periodically updated on the official website.
15	[redacted]	1. Replant in same locality. 2. Translocation damages roots. 3. Give 15-day notice and notify RWAs and BBMP.	Localized replanting is prioritized where feasible. Translocation is handled using best practices under expert guidance. Communication outreach will be expanded including RWAs and ward-level engagement.
16	[redacted]	1. Publish package-wise tree data. 2. Share PPT after meetings. 3. Translocate trees to same locality. 4. Explain BMRCL's groundwater recharge efforts.	Tree enumeration data is being organized and will be shared online. PPTs will be circulated to attendees. Recharge initiatives are being explored under sustainable design measures.
17	[redacted]	1. All presentations must include citywide and local environmental impact. 2. Fix quorum for meetings.	Future presentations will incorporate broader and segment-specific environmental views. Establishing a quorum is under consideration to validate public consultations.
18	[redacted]	1. Publish final DPR and EIA. 2. Clarify why	Final reports are being shared on the website. The

		certain sections are underground and others elevated.	elevated/underground decisions are based on multiple criteria—cost, topography, land use, and environmental/social impact considerations.

Bangalore Metro Rail Corporation Limited (BMRCL)

Minutes of the 2nd Environmental Stakeholders Meeting

- Phase-3 – Public Consultation on Environmental aspects
- Date :13.09.2025 to 17.09.2025
- Date of public notification issued through News paper : 29.08.2025
- Methods used to inform public about the meeting : News paper advertisement, Namma Metro Website display, Banners in the public areas such as Parks, Govt Office.
- No change in location and dates as published and informed.
- Average 70 participants attended in each meeting
- Considering the social vulnerable, venues were decided based on easy accessibility and approach
- Presentation used during Meeting is attached for ready reference.

Sl.No	Venue	Date	Name of the Participant	Questions Raised	BMRCL Response
1	**GNR Kalyana Mantapa**	**13-09-2025**	[redacted]	1. What is the overall environmental impact of this project or policy? 2. Has an Environmental Impact Assessment (EIA) been conducted? Can we see the results?	An Environmental Impact Assessment (EIA) is under preparation and overall impacts and proposed mitigation measures are documented and the summary report will be published on the BMRCL website for public once completed.
2	**GNR Kalyana Mantapa**	**13-09-2025**	[redacted]	1. Are there renewable energy alternatives being considered or implemented? 2. What mitigation measures are in	Renewable energy options such as solar are being explored, and measures to prevent water contamination are included in the design.

			[redacted]	place to reduce harm to the environment? 3. Will the project impact local water sources (rivers, lakes, groundwater)?	
3	**GNR Kalyana Mantapa**	**13-09-2025**	[redacted]	Who is responsible for ongoing environmental monitoring?	A dedicated environmental monitoring team under BMRCL along with independent third-party agencies will oversee compliance.
4	**GNR Kalyana Mantapa**	**13-09-2025**	[redacted]	1. Can you provide case studies or examples of similar projects with successful environmental outcomes? 2. Have you conducted a lifecycle analysis of the project? 3. What is the exit strategy for minimizing long-term environmental harm?	Similar metro projects in other Indian cities have shown positive outcomes, and lifecycle analysis with mitigation strategies is integrated in project planning.
5	**GNR Kalyana Mantapa**	**13-09-2025**	[redacted]	1.Severe noise during the construction must be avoided, and also the vibration should be minimised. What are the mitigation measures are being taken by BMRCL?	Noise barriers, controlled construction timings, and vibration-dampening techniques will be implemented during construction.

6	**Regional Institute of Co-operative Management, Padmanabhanagar**	**13-09-2025**	[redacted]	1. Baseline data should be updated in the website and it should be transparent to the publics.	Baseline environmental data is included in EIA report will be updated on the official BMRCL website for public access and transparency.
7.	**Regional Institute of Co-operative Management, Padmanabhanagar**	**13-09-2025**	[redacted]	1.From JP Nagar to Saraki signal there are more than 20 pubs & Bars and how the traffic conjunction is reduced or maintained?	Traffic management plans including diversion routes, coordination with traffic police, and phased construction schedules will be implemented to minimize congestion near pubs & Bars.
8.	**Regional Institute of Co-operative Management, Padmanabhanagar**	**13-09-2025**	[redacted]	1. Is Double–Decker necessary? 2.MoM should be shared directly to the Stakeholders.	The necessity of double-decker alignment is being studied considering technical feasibility, cost, and environmental factors. Minutes of Meetings (MoM) will be shared with stakeholders through official communication channels.
9.	**Regional Institute of Co-operative Management, Padmanabhanagar**	**13-09-2025**	[redacted]	3. BMRCL must invite the General Public to give their preference for re-planation. 4. Tree re-plantation and relocation must happen in the same locality to preserve micro lung-space.	BMRCL will consider inviting public preferences during the compensatory plantation program, and efforts will be made to re-plant trees within the same locality to preserve micro lung-spaces.

10.	**Regional Institute of Co-operative Management, Padmanabhanagar**	**13-09-2025**	[redacted]	1.Horizontal root spreading trees should be avoided as compensatory plantation and also suggesting for deep root plantation mainly the fruit bearing plants.	Compensatory plantation will prioritize deep-rooted, native, and fruit-bearing species, while avoiding horizontal root spreading trees to ensure long-term ecological stability.
11.	**Regional Institute of Co-operative Management, Padmanabhanagar**	**13-09-2025**	[redacted]	1.Plantation should be done near lakes as it is helpful for other species and also helps in the storage of water. 2.What is the Distance between each plantation(translocation)	Plantation will be undertaken near suitable ecological zones including lakes wherever feasible. Spacing between plantation/translocation will follow horticulture guidelines, BMRCL maintains 5 meters depending on species.
12.	**Regional Institute of Co-operative Management, Padmanabhanagar**	**13-09-2025**	[redacted]	1. Google location should be shared with publics to visit the site where the translocation had done by BMRCL.	Details of translocation sites, including Google map locations, will be shared on the BMRCL website for public reference.

13.	**Regional Institute of Co-operative Management, Padmanabhanagar**	**13-09-2025**	[redacted]	1. Make a Statistical study on the plants to monitor the survival rates based on the locations.	A statistical monitoring system will be put in place to study plant survival rates across locations, and results will be periodically updated for transparency.
14.	**Anu's Party Hall**	**14-09-2025**	[redacted]	Change the alignment via ORR rather than 80ft road to reduce the traffic conjunction.	Alignment alternatives were studied during the Detailed Project Report (DPR) stage. The current alignment is finalized based on technical feasibility, social impact, and environmental considerations.
15.	**Anu's Party Hall**	**14-09-2025**	[redacted]	How many trees have been identified for translocation?	The exact number of trees identified for translocation will be shared after the joint inspection with the Forest Department, Tree Expert Committee and will be published in BBMP website for review.
16	**Anu's Party Hall**	**14-09-2025**	[redacted]	Give the exact information like where the metro alignment is designed, is it through ORR or at 80ft road.	The alignment has been finalized as per the approved DPR, and details of the route are available in the public domain on the BMRCL website.
17	**Anu's Party Hall**	**14-09-2025**	[redacted]	Involve ED & higher officers for the next Environment stakeholder meeting.	Senior officials including ED and higher management will be involved in future stakeholder meetings to address concerns directly.

18	**Anu's Party Hall**	**14-09-2025**		Is Double decker is necessary From Nagarabhavi to Sumanahalli via Ambedker college(80ft road)?	The requirement for double-decker alignment is being evaluated for the Nagarabhavi–Sumanahalli stretch considering traffic demand and cost efficiency.
19	**Anu's Party Hall**	**14-09-2025**		Is BMRCL is aware that if the metro is constructed through ORR rather than 80ft road more than 1400 trees can be saved?	Alternative alignments including ORR were studied. While ORR alignment may save more trees, the final decision considered multiple factors including land acquisition, social impact, and technical feasibility.
20	**Bangalore Metro Rail Corporation Ltd. Head Office. Shantinagar**	**16-09-2025**		3R's is appreciated. Is BMRCL is strictly following the '3R' Policy? (Retention, Relocation and Removal)	BMRCL is committed to the 3R Policy (Retention, Relocation, and Removal) and follows it strictly in consultation with the Tree Expert Committee and Forest Department.
21	**Bangalore Metro Rail Corporation Ltd. Head Office. Shantinagar**	**16-09-2025**		Compensatory plantation should not delay.	Compensatory plantation activities will be initiated promptly in coordination with concerned authorities to avoid any delays.
22	**Bangalore Metro Rail Corporation Ltd. Head Office. Shantinagar**	**16-09-2025**		Survival rate of the translocation plants should improve. what are the mitigating measures taken for the success rate of translocated trees.	Adequate post-translocation care including watering, soil treatment, and protective measures are undertaken to improve the survival rate of transplanted trees.

23	**Bangalore Metro Rail Corporation Ltd. Head Office. Shantinagar**	**16-09-2025**	[redacted]	Tree Expert Committee should be present during the alignment design to save more trees.	The Tree Expert Committee is consulted during alignment design and project execution to ensure maximum possible tree retention.
24	**Bangalore Metro Rail Corporation Ltd. Head Office. Shantinagar**	**16-09-2025**	[redacted]	1. Organize the visit for citizens where BMRCL had done the compensatory afforestation. 2. Full DPR is to be published in website to maintain the transparency. 3 Approval for Double Decker had approved on 4th Sept. The revised DPR Should be uploaded on website based Double decker. IISc. Reported that Double Decker is unsustainable project. What are the BMRCL concerns regarding this Report?	Citizen visits to compensatory afforestation sites will be organized in coordination with local stakeholders to ensure transparency. Full DPR will be made available by taking the approval of the competent authority and after checking the need of full DPR to be made available based on BMRCL confidentiality. Revision of DPR based on Double decker feasibility is noted and will be implemented. BMRCL is reviewing the IISc report carefully and all sustainability concerns will be addressed while balancing project feasibility and public need.

25	**Bangalore Metro Rail Corporation Ltd. Head Office. Shantinagar**	**16-09-2025**	[redacted]	Approval for Double Decker had approved on 4th Sept. The revised DPR Should be uploaded on website based Double decker.	Revision of DPR based on Double decker feasibility is noted and will be implemented. Full DPR will be made available by taking the approval of the competent authority and after checking the need of full DPR to be made available based on BMRCL confidentiality.
26	**Bangalore Metro Rail Corporation Ltd. Head Office. Shantinagar**	**16-09-2025**	[redacted]	IISc. Reported that Double Decker is unsustainable project. What are the BMRCL concerns regarding this Report?	BMRCL is reviewing the IISc report carefully and all sustainability concerns will be addressed while balancing project feasibility and public need.
27	**Zilla Panchayati Banashankari**	**17-09-2025**	[redacted]	What actions the organization taking to reduce carbon emissions?	BMRCL is adopting measures such as use of energy-efficient technologies, renewable energy integration, and sustainable construction practices to reduce carbon emissions.
28	**Zilla Panchayati Banashankari**	**17-09-2025**	[redacted]	What steps are being taken to prevent contamination in the project area?	Strict measures such as sedimentation control, proper sewage management, and safe disposal of construction materials are being implemented to prevent contamination.

29	**Zilla Panchayati Banashankari**	**17-09-2025**		What efforts are being made to reduce C&D waste and improve recycling programs at site?	Construction and Demolition (C&D) waste will be segregated, reused wherever feasible, and recycled in compliance with BBMP regulatory norms.
30	**Zilla Panchayati Banashankari**	**17-09-2025**		Will sound barriers or other noise dampening technologies be implemented along the route?	Noise barriers and other sound-dampening technologies will be provided along sensitive stretches to minimize noise pollution.
31	**Zilla Panchayati Banashankari**	**17-09-2025**		How does the Metro Rail project align with long-term air quality improvement goals in the city?	By reducing dependency on private vehicles and promoting mass rapid transport, the Metro project directly contributes to improving long-term air quality in the city.
32	**Zilla Panchayati Banashankari**	**17-09-2025**		What will be done to protect local wildlife and biodiversity during construction?	Bengaluru Metro project is not impacting to wildlife and considering the biodiversity protection measures include avoiding ecologically sensitive areas, controlled working hours, and plantation drives to restore green cover.

Environment Stake Holder Meeting Attendance Report

Sl No	Venue Location	Date	No of Males	No of Females	Total PAP's Attending
1	**GNR Kalyana Mantapa**	13-09-2025	25	6	31
2	**Regional Institute of Cooperative Management**	13-09-2025	20	7	27
3	**Anu's party hall Nagarbhavi**	14-09-2025	36	4	40
4	**Bangalore Metro Rail Corporation Ltd Head office**	16-09-2025	20	4	24
5	**Bengaluru Urban Zilla Panchayati**	17-09-2025	20	7	27
	Total		121	28	149

	
13-09-2025, am session	13-09-2025, pm session
	
13-09-2025, pm session	13-09-2025, pm session
	
14-09-2025, am session	14-09-2025, pm session
	
16-09-2025, am session	16-09-2025, am session

	
17-09-2025, am session	**17-09-2025, am session**