Updated Environmental Impact Assessment

India: Chennai Metro Rail Investment Project Balance Corridor 5

Main Report

April 2024
Revision 01

Prepared by Chennai Metro Rail Limited (CMRL) for Project Lenders.

CURRENCY EQUIVALENTS

(as of 1st April 2024)

Currency unit	–	Indian rupees (₹)
₹1.00	=	$0.012
$1.00	=	₹83.39

ABBREVIATIONS

ADB	:	Asian Development Bank
AIIB	:	Asian Infrastructure Investment Bank
CBTC	:	Communication Based Train Control
CGWB	:	Central Ground Water Board
C&D Waste	:	Construction and Demolition Waste
CMA	:	Chennai Metropolitan Area
CMDA	:	Chennai Metropolitan Development Authority
CMRL	:	Chennai Metro Rail Limited
CMWSSB	:	Chennai Metro Water Supply and Sewerage Board
CPCB	:	Central Pollution Control Board
CMP	:	Comprehensive Mobility Plan
CMFRI	:	Central Institute of Mining and Fuel Research
CRZ	:	Coastal Regulation Zone
EHS	:	Environmental, Health, and Safety
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Plan
EMoP	:	Environmental Monitoring Plan
ESF	:	Environment and Social Framework
ESP	:	Environment and Social Policy
ESHS	:	Environment, Social, Health and Safety
FTA	:	Federal Transit Administration
GoI	:	Government of India
GoTN	:	Government of Tamil Nadu
GC	:	General Consultants
GRM	:	Grievance Redress Mechanism
IMD	:	India Meteorological Department
JICA	:	Japan International Cooperation Agency
KLD	:	Kilo Litres Per Day
MoEF&CC	:	Ministry of Environment, Forests and Climate Change
MDBs	:	Multilateral Development Banks
MRTS	:	Mass Rapid Transit System
NDB	:	New Development Bank
NAAQS	:	National Ambient Air Quality Standards
NBWL	:	National Board of Wildlife
NGT	:	National Green Tribunal
PAP	:	Project Affected Persons
RDSO	:	Railway Design & Standards Organization
RAP	:	Resettlement Action Plan
SIPCOT	:	State Industries Promotion Corporation of Tamil Nadu
SPV	:	Special Purpose Vehicle
SIA	:	Social Impact Assessment
TNCZMA	:	Tamil Nadu Coastal Zone Management Authority
TBM	:	Tunnel Boring Machine
TNPCB	:	Tamil Nadu Pollution Control Board
WHO	:	World Health Organization

WEIGHTS AND MEASURES

^{0}C	-	degree Celsius
dB(A)	-	A-weighted decibels
ha	-	hectare
km	-	kilometer
km/h	-	kilometer per hour
kWe	-	kilowatt-electric
kV	-	Kilo volt(s)
kVA	-	kilo Volt-Amps
kW	-	kilowatt
m	-	meter
mm	-	millimeter
MVA	-	Megavolt Ampere
MW	-	Megawatt
m^3	-	cubic meter
m^3/hr	-	cubic meters per hour
mg/L	-	milligrams per liter
m/s	-	meters per second
MTPA	-	metric tons per annum
MW	-	megawatt
ppm	-	parts per million
ppt	-	parts per thousand
rpm	-	revolutions per minute
µg/m^3	-	microgram per cubic meter

NOTES

(i) The fiscal year (FY) of the Government of India ends on 31 March. FY before a calendar year denotes the year in which the fiscal year ends, e.g., FY2023 ends on 31 March 2023.

(ii) In this report, "$" refers to US dollars.

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EXECUTIVE SUMMARY

1. Chennai, the capital city of the state of Tamil Nadu, is part of the Chennai Metropolitan Area (CMA) that is home to over 8.65 million people and plays a vital role in the economy of South India.[1] Like other metropolitan areas in the country, CMA is currently facing the challenges of accelerated urbanization growth that have considerably strained the area's transportation system. The increase in economic activities has boosted the regional economy and job creation, which in turn necessitates improvement in ease of travel and connectivity.

2. Chennai Metro Rail Limited (CMRL), a joint venture of the Government of India (GoI) and the Government of Tamil Nadu (GoTN) with equal equity ownership, is responsible for implementing, operating, and maintaining the city's metro system. CMRL developed the Comprehensive Mobility Plan for CMA in 2015 and identified three corridors (corridors 3, 4, and 5) for the second phase of the Chennai Metro Rail to alleviate CMA's transportation capacity constraints.

3. GoI requested the Multilateral Development Banks[2] (MDBs) to assist the implementation of 23 elevated metro stations and viaducts of approximately 30.002 km length, between CMBT Metro Station (excluded) to Sholinganallur Metro Station (excluded). This section Chennai Mofussil Bus Terminus (CMBT) to Sholinganallur hereafter referred as Balance Corridor 5 (BC5). This section forms part of Chennai Metro Rail Corridor 5 sharing 4 stations (namely Alwar Thirunagar, Valasaravakkam, Karambakkam and Alapakkam) in common with Corridor 4; allowing interchange with Corridor 3, Corridor 1 and Corridor 2 of Phase I Metro, MRTS and connecting with suburban railway system. Remaining section of the Corridor 5 from Madhavaram to CMBT which is being financed by Japan International Cooperation Agency (JICA) constitutes one of the Associated Facilities to Balance Corridor 5.

4. The capital cost of Balance C5 including taxes and duties (as on December 2018) is estimated at USD 1,037 million, USD 107.51 million as compensation for land and structures, and Resettlement & Rehabilitation (R&R). It is estimated that the project will be implemented over a period of 53 months from the date of award of civil works. CMRL will take full responsibility of the implementation of Corridor 5.

5. As per provisions of the EIA Notification 2006 and its subsequent amendments by the Ministry of Environment, Forests and Climate Change (MoEF&CC), Railways and Metro Rail Projects are exempted from requirements of Environmental Clearance (EC). However, as the alignment passes through Nanmangalam Reserved Forest (RF) between Velakallu and Medavakkam 1 (formerly Medavakkam Koot Road), the forest clearance (FC) of alienation of forest land to non-forest use is required and has been obtained **(copy enclosed in Annexure-13).** Further, the requisite tree felling permissions have been obtained from the respective District Green Committee (DGC) prior to felling of trees under the Project.

6. As per MDBs' Environmental and Social Policies[3], this project has been categorized as 'A' (for environmental safeguards) due to the significant impacts anticipated and remains Category A. The environmental impact assessment (EIA) was conducted accordingly in March 2021 which has been updated in 2024. The EIA report

[1] Indian National Census, the Census Organization of India, 2011.Based on the Second Master Plan, the current Metropolitan area is expected to have a population of 126 lakhs by 2026 (Source: Comprehensive Mobility Plan, 2019)

[2] Asian Development Bank (ADB) and Asian Infrastructure Investment Bank (AIIB).

[3] ADB's Safeguard Policy Statement (SPS) 2009, and AIIB's Environmental and Social Framework (ESF).

comprising baseline data on existing conditions of physical and ecological environment including biodiversity assessment, with the identified and anticipated environmental impacts and proposed mitigation measures, has been prepared in accordance with the GoI's legislative framework and MDBs' Environmental Safeguard requirements. This EIA report has been updated covering environmental impacts and mitigation measures associated with the changes in design and alignment of Balance Corridor-5.

7. The implementation of the Balance Corridor 5 is expected to generate environmental and socio-economic benefits in terms of reducing air pollution from replacing diesel-fueled transportation and from traffic congestion and serving the growing travel demand.

8. As per the proposed alignment and design details, standard Gauge (1435mm) will be adopted with a minimum track center distance of 4000 mm, 16-ton maximum axle load capacity and a design speed of 80 kmph. The elevated station is generally located on the road median at 140 m long and 24 m wide and is a three-level structure, with a minimum vertical clearance of 5.50 m under the concourse. To reduce the physical and visual impact of the elevated station, stations have been made transparent with minimum walls on the sides. The signaling system shall be adopted for Balance C5 in line with the remaining section of Corridor 5 (JICA Section). Rolling stock is of light weight stainless steel/aluminum body for energy efficiency. Universal accessibility has been reflected in the design following international best practices. Green building features like rainwater harvesting, solar energy panels at elevated stations' roofs, parking areas (wherever technically feasible), will be considered in station design.

9. The terrain along Balance C5 alignment is mostly flat, no more than 3 m above mean sea-level (MSL). The soil along the alignment is clayey, sandy and hard rock. Balance C5 alignment is located about 2km from the Guindy National Park, however, the wildlife clearance is not required but project activities will strictly follow the guidelines issued by MoEF&CC regarding the prohibited, regulated and permitted activities and consultations with the Tamil Nadu Forest Department (TNFD). The alignment is approximately 1km away from Nanmangalam Lake which is home to a number of bird species; it also runs along existing road passing through Pallikaranai marshland which is also home to a wide variety of birds and other fauna. The requisite forest clearance has been obtained for diversion of 1.569 Ha. forest land in the Nanmangalam Reserve Forest (RF) for the construction purpose vide letter no *F. No. 4-TNB080/2022-CHN/267* dated 02nd March 2023 (Attached as Annexure 13). 259 trees are felled, and 145 trees are transplanted (as of December 2023) along Balance Corridor 5.

10. Despite the seemingly abundant sources of water, Chennai suffers continuously from water stress since the entire basin is dependent on rainfall. Water samples has been collected from 7 locations and tested for its quality as per the IS 10500:2012 (drinking water standard).The outcome of the analysis shows most of the key water quality parameters are well within the prescribed permissible limits except for Total Dissolved Solids (TDS) at Global Hospital, turbidity at Global Hospital, calcium at MIOT Hospital and Medavakkam junction, Aluminium at Global Hospital, Kalpana Hospital at Adambakkam, Madipakkam Koot Road and Velakallu bus, hardness at MIOT Hospital, Medavakkam junction and Global Hospital and mercury at Alwarthirunagar and MIOT Hospital.

11. Ambient air quality (AAQ) monitoring has been conducted for the sensitive receptors along the Balance C5. The outcome of the AAQ results shows that Particulate Matter (PM10 and PM2.5), Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) were within the permissible level of National Ambient Air Quality Standards (NAAQS). Concentration of Carbon Monoxide (CO) exceeded the permissible level of NAAQS in all the monitoring locations but was within WHO guideline.

12. The Ambient Noise Levels monitored at 7 locations along the alignment were above the national and international permissible limits. Noise levels were also monitored at 10 sensitive locations belonging to the silence zone, with 50% slightly exceeding GoI standards of 50dB the daytime limit (none per WHO guideline of 55dB), and none exceeding 40dB the night-time limit. The predominant source of ambient noise at monitored locations is due to road traffic. All the monitoring stations are located on urban arterials and regional highways.

13. Peak VdB vibration level at 6 out of 8 monitored locations is found to exceed acceptable criteria for ground borne vibration prescribed by the Federal Transit Administration (FTA) USA and Railway Design and Standards Organization (RDSO) India which are more valid for operation of this project**.** However, the observed levels at all 8 locations ranging from 0.049 mm/sec to 2.090 mm/sec are well below the construction vibration damage criteria for blasting as per Indian authorities, the Directorate General of Mines Safety (DGMS) and that Central Institute of Mining and Fuel Research (CMFRI or CMRI) which are relevant only if blasting is undertaken during construction.

14. Based on the analysis of project and environmental settings, a detailed assessment of potential impacts with respect to project location and design, construction and operation has been carried out. For each of the anticipated adverse impacts, mitigation measures have been proposed as part of the Environmental Management Plan (EMP). The key positive environmental impacts of Balance C5 include reduced use of private vehicle leading to exhausted gas reduction; road congestion status; road safety improvements; increased accessibility and mobility, and a modest reduction in greenhouse gas emissions. The main residual negative impacts of Balance C5 include fugitive and point source dust emission, noise from construction and operation, disposal of large quantities of construction wastes, and occupation and community health and safety, which are mainly temporary and localized, and can be well managed through implementation of EMP and good international industry practice.

15. The main mitigation measures proposed are as follows: (i) to plant twelve saplings for each tree to be cut as against ten saplings ordered for infrastructure projects by the Honorable Madras High Court, with estimated compensatory afforestation cost in place accordingly; (ii) noise reduction measures (i.e. noise barriers at sensitive receptor locations); and (iii) reuse of excavated material where feasible and disposal of construction waste in a regulated manner. Balance C5 has taken into consideration the climate change effects of an anticipated continuous increase in ambient temperature, intensity of cyclones and storm surge, heavy precipitation events, and sea level rise in the future. The alignment being elevated inherently contributes to climate adaptation of flooding risks. Climate mitigation is integrated into Balance C5 design include: (i) using solar panels on station buildings, parking areas and station roofs to reduce the extensive use of grid-generated electricity supplied to the station for its operation and maintenance; (ii) through better station roof design, providing for rainwater harvesting by channeling rainwater through gutters and pipes to either harvesting pits in the ground or to recharge groundwater and (iii) using head-hardened rails of 1080 grade steel rails will result in better mechanical properties in terms of stiffness, higher lateral resistance, and better transmission of thermal stresses, and higher durability; and reduced maintenance resulting from practically unchanged track geometry over time and at almost any operating speed..

16. Various alternatives such as modes of transport, alignment, proposed design etc. have been considered and analyzed for its likely impacts on various environmental and social parameters. Additionally, an evaluation of potential environmental and social

impacts in terms of 'with' and 'without' project situation has been considered for the justification of Balance C5.

17. Meaningful public consultations were carried out with communities on the alignment during EIA preparation and will continue before start of implementation of Balance C5 and throughout its implementation. Public consultations highlighted opinions of participants on benefits of Metro in terms of reducing congestion on roads. The EIA report and its Executive summary (in Tamil & English) was disclosed at the CMRL and lenders' websites with hard copies displayed at the project site locations.

18. Grievance Redress Mechanism (GRM) has been constituted for Balance C5 which comprises the procedures to address grievances (i) first at the Project Implementation Unit level, (ii) second at Grievance Redress Committee (GRC), to ensure grievances from Project Affected Peoples (PAPs) and workers are addressed to facilitate timely project implementation. The GRC has been formed which has representatives from Contractors, General Consultant (GC), CMRL, local administration, and PAPs. Unsatisfied PAPs will have the option to escalate the grievances at any point of time.

19. An EMP with institutional arrangements, budgetary provisions, schedule for EMP implementation and its monitoring has been prepared, including appropriate mitigation measures, provisions related to occupational health and safety, labour camp and construction site management, traffic and public utility management etc. to address all impacts during Project pre-construction, construction and operation phases. The EMP is a part of the bidding document of the civil works contractors. In addition, stringent monitoring requirements and actions have been included in the Environmental Monitoring Plan (EMoP) on ambient impacts on air, water, and noise and vibration levels. Semi-annual Environmental Monitoring reports (EMR) will be prepared by GC and submitted to lenders through CMRL. A third-party monitoring agency also monitors the work independently and submits verification reports i.e. External Monitoring Report (EMR) to CMRL and lenders. The preliminary estimated cost of the EMP including implementation and monitoring is USD 3.78 million (INR 276 million). This cost estimate is exclusive of land acquisition and R&R cost.

20. Benefits far outweigh negative impacts. Overall, the major environmental impacts associated with Balance C5 are limited to the construction period and can be mitigated to an acceptable level by implementation of recommended measures and by best engineering and environmental practices. The EMP and EMoP have been updated considering the latest design and shall be further revised, if necessary, for any unanticipated impacts during project implementation or if there is any change in the project design and with approval of lenders.

1. INTRODUCTION

1.1 Background

1. The expanded Chennai Metropolitan Area (CMA) comprises the Greater Chennai Corporation, Avadi Corporation, Tambaram Corporation, Kancheepuram Corporation, 12 Municipalities, 13 Town Panchayats, 1 Special Grade Town Panchayat and 22 Panchayat Unions (Comprised of 1321 villages). The present extent of CMA is 5904 Sq.km. The expanded CMA falls in five Districts of the Tamil Nadu State viz. Chennai District, parts of Thiruvallur District, Kancheepuram District, Chengalpattu District, and part of Arakkonam Taluk of Ranipet District. In year 2011, the resident population of CMA was 8.65 million, while the population projection for year 2026 is 12.6 million.

2. Chennai, the capital city of the state of Tamil Nadu, is part of the Chennai Metropolitan Area (CMA) and plays a vital role in the economy of South India.[1] The Chennai Metropolitan Development Authority (CMDA) devised the Chennai Second Master Plan 2026 and estimated that the population would grow to 12.6 million people with an estimate of daily passenger traffic of 20.8 million in 2026.[2] CMA has emerged as a leading national automotive hub with major manufacturers operating their plants in the area. CMA also houses a growing number of software firms, financial services, and call centers. Like other metropolitan areas in the country, CMA is currently facing the challenges of accelerated urbanization growth that have considerably strained the area's transportation system. The increase in economic activities has boosted the regional economy and job creation, which in turn necessitates improvement in ease of travel and connectivity.

3. The existing transportation system in CMA is marked by high traffic density, carbon emissions, and frequent road incidents. In addition to the high volume of vehicles and already congested roads, inadequate parking space and the encroachment of street space by vendors on major roads have exacerbated the traffic congestion. Major roads along the proposed project alignments are forecast to function beyond respective design service volume in year 2035 in absence of the project lines. The accelerating use of private vehicles has put Chennai in the fifth rank in carbon emission from the transport sector among 54 South Asian cities.[3]

4. Inadequate transportation infrastructure and poor service have resulted in an unfavorable decrease in the share of public transport from 54 percent in 1970 to 28 percent in 2014.[4] The Chennai Second Master Plan 2026 proposes to increase the public and private mode split to 70:30. The mass transit transportation, especially an integrated metro system will be essential to achieve this intended split.

5. The city has two mainline railway terminals. Urban Mass Rapid Transit System (MRTS) of 19.35 km from Chennai Beach to Velachery is in operation, construction of balance MRTS section from Velachery to St Thomas Mount is in process. Chennai Metro Phase 1 of 54.05km is in operation. Chennai suburban railway network supplements MRTS. A Schematic diagram of urban mass rapid transit network is in Figure 1.1.

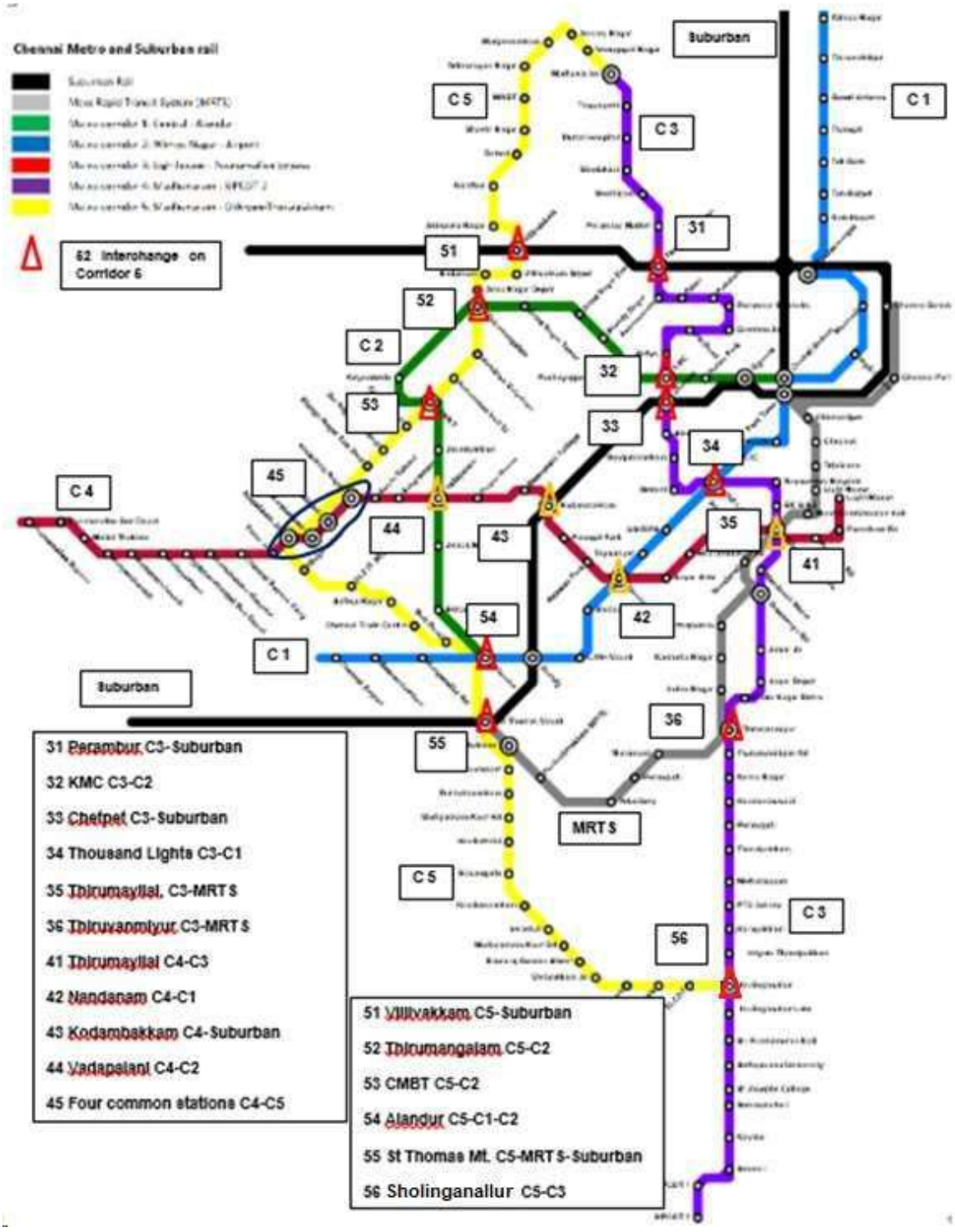
[1] Indian National Census, The Census Organization of India, 2011.

[2] Second Master Plan for Chennai Metropolitan Area 2026, Chennai Metropolitan Development Authority, 2008.

[3] International Council for Local Environmental Initiative Study, 2012.

[4] Comprehensive Detailed Project Report for Chennai Metro Phase-II, Chennai Metro Rail Limited, 2018.

Figure 1.1: Rail Transport Network in Chennai



Source: CMRL

1.1.1Chennai Metro Rail Network

6. Phase 1 of Chennai metro rail network covers 54.05 km in two corridors. Corridor 1 (Blue Line) starts from Washermanpet to Airport (23.09 Km), and extension from

Washermanpet to Wimco Nagar (9.00 km) in Thiruvottiyur. Corridor 2 (Green Line) starts from Chennai Central to St. Thomas Mount (21.96 Km) via Koyambedu.

7. The Government of Tamil Nadu (GoTN) has created a Special Purpose Vehicle (SPV) for implementing the Chennai Metro Rail Project. This SPV named as "Chennai Metro Rail Limited (CMRL)" was incorporated on 03.12.2007 under the Companies Act. It has now been converted into a Joint Venture of Government of India (GoI) and GoTN with equal equity holding. The CMRL, as the implementing agency, shall be responsible for implementing, operating, and maintaining the city's metro system. CMRL developed the Comprehensive Mobility Plan (CMP) for CMA in 2015 to identify the present and future mobility patterns of CMA. The detailed study identified three corridors (corridors 3, 4, and 5) for Phase 2 of the Chennai Metro Rail to alleviate CMA's transportation capacity constraints.

8. **Corridor 3.** Madhavaram to SIPCOT (Siruseri), length of the corridor is 44.622 km comprising 28 underground stations and 19 elevated stations. It provides interchange with Corridor 4 (at Thirumayilai) and Corridor 5 (at Sholinganallur). It offers interchange with Phase I Metro (at Thousand Lights and Kilpauk Metro) and MRTS (at Thiruvanmiyur and Thirumayilai) and connects with suburban railway system (at Peramabur and Chetpet).

9. The Corridor 3 (JICA Section) is 35.234 km long section from Madhavaram depot to Sholinganallur station via Adyar runs on the Eastern periphery of the city: it is being funded by JICA. This section comprises 28 underground stations and 10 elevated stations. Whereas, 9.388 km long section from Sholinganallur to Siruseri SIPCOT II is being financed by ADB; This section comprises 9 Elevated stations and viaduct.

10. **Corridor 4.** Lighthouse to Poonamallee bypass, length of the corridor is 25.8 km comprising underground length 10.314 km and 9 underground stations (Lighthouse to Kodambakkam Flyover) and elevated length 15.45 km and 18 elevated stations (Powerhouse to Poonamallee bypass). Corridor 4 has 4 stations in common with Corridor 5 (at Alwar Thirunagar, Valasaravakkam, Karambakkam and Alapakkam), offers interchange with Corridor 3 (at Thirumayilai), Phase I Metro (at Vadapalani and Nandanam) and MRTS (at Thirumayilai); it connects with suburban railway system (at Kodambakkam). Construction of the elevated section from Powerhouse to Poonamallee bypass commenced in March 2021 and scheduled to be completed by December 2024. Systems works are scheduled to be completed and the entire Corridor 4 is commissioned by December 2026.

11. **Corridor 5.** Madhavaram to CMBT (JICA Section) via Anna Nagar West, Revenue length of the corridor is 15.352 km comprising 11 elevated stations and 5 underground stations. It is integrated with Phase I Metro (at Koyembedu, Alandur, St Thomas Mount) and MRTS (at St Thomas Mount); connects with suburban railway system (at Villivakkam and St Thomas Mount).

12. **Balance Corridor 5** is the 30.002 km line connecting Chennai Mofussil Bus Terminal (CMBT) to Sholinganallur including 23 stations. CMBT forms part of Corridor 5 from Madhavaram to CMBT being financed by JICA and Sholinganallur forms part of Corridor 3. Balance C5 has 4 stations in common with Corridor 4 (at Alwar Thirunagar, Valasaravakkam, Karambakkam and Alapakkam). Construction of viaduct and stations of MDB Corridor 5 from CMBT to Sholinganallur commenced in November 2021 and scheduled to be completed by November 2024. Systems works are scheduled to be completed and metro commissioned by November 2025. It is financed by AIIB for civil works and ADB for system works.

1.2 Environmental Impact Assessment

1.2.1Categorization

13. As per ADB's Safeguard Policy Statement (SPS) 2009, Category A is defined as if it is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works. An environmental impact assessment is required.

14. As per AIIB's Environmental and Social Framework (ESF) 2022, Category A is defined as if it is likely to have significant adverse environmental and social impacts that are irreversible, cumulative, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works and may be temporary or permanent in nature. The Bank (AIIB) requires the Client to conduct an environmental and social impact assessment (ESIA) or equivalent environmental and social assessment, for each Category A Project, and to prepare an environmental and social management plan (ESMP) or environmental and social management planning framework (ESMPF) (or other similar Bank-approved documentation), which is included in the ESIA report for the Project.

15. Considering the above policies of ADB and AIIB, the project (Balance Corridor 5) has been categorized as Category A and the EIA report has been prepared and updated.

1.2.2 Purpose of the EIA Report

16. The main objective of this updated EIA report is to identify and assess the additional environmental impacts after incorporating the change in design (i.e inclusion of grade separator of length 3.14 km from Mugalivakkam to Manapakkam), change in project alignment from Okkiam Thoraipakkam to Sholinganallur, etc., and to propose additional mitigation measures for Balance C5 corridor.

17. This updated EIA report documents the environmental impact assessment of Balance C5 and identifies the environmental issues to be considered at pre-construction, construction, and operation phases of the project. In this report, the different activities that are likely to take place during construction and operation have been analyzed and the potential impacts that may accompany them have been discussed. The updated EIA addresses the national environmental management requirements of GoI and the MDB's environmental safeguard requirements. In general, the updated EIA Report is outlined as below to address various aspects:

- Provide background of the project in terms of land use, existing Metrorail network and the proposed Metrorail corridors, methodology of preparation of the report and its content.
- Analysis of policy and legal framework within which environmental safeguards for the project shall be recommended and implemented.
- Provide information about the baseline environmental settings.
- Provide information on potential environmental impacts of Balance C5 with its magnitude, distribution, and duration.
- Provide information on required mitigation measures with cost to minimize the impacts.
- Analysis of the alternatives considering alternative locations, designs, management approaches, for selection of most feasible and environmental acceptable options.
- Provide details of stakeholder consultations.
- Plans for stakeholders to communicate grievances and suggestions and for their Redressal.

- Formulate environmental management and monitoring plan with institutional measures for effective implementation of mitigation measures proposed.

18. Social Impact Assessment (SIA) with a Resettlement Action Plan (RAP) for implementation is presented as a separate Report.

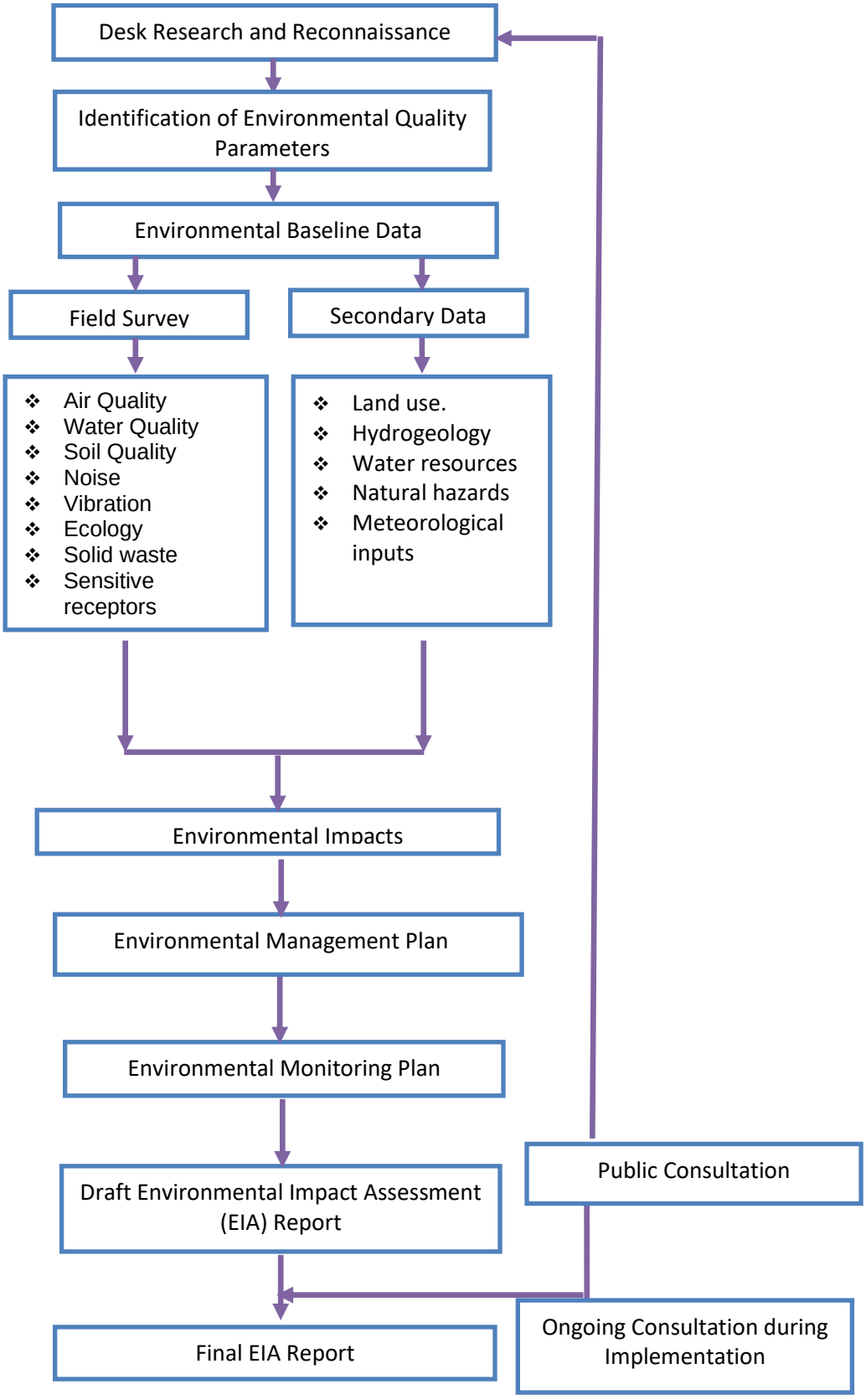
19. As shown in Figure 1.2, the updated EIA followed a number of steps:

- Review of available baseline reports, and technical reports/studies related to Balance C5.
- Conduct field visits to collect primary or secondary data relevant to Balance C5 areas to establish the baseline.
- Assess the potential impacts on environmental attributes due to the location, design, installation and operation of MDB Corridor 5 through field investigations and data analysis.
- Explore opportunities for environmental enhancement and identify measures.
- Update the Environment Management Plan (EMP) prepared earlier, covering the measures for mitigating the impacts identified.
- the implementation of Balance C5 and prepare an Environmental Monitoring Plan (EMoP).
- Propose the institutional arrangement to implement EMP and EMoP.
- Identify critical environmental parameters required to be monitored subsequent to
- Carry out consultation with key stakeholders and administrative authorities to identify their perception on Balance C5, introduce project components and anticipated impacts; and
- Disclosure of the updated EIA Report on CMRL and lenders' website along with the EIA Executive Summary in Tamil and English languages.

20. The baseline data for air, water and soil quality was collected in width 75m on either side of proposed center line of alignment, and data for noise and vibration in width 200m on either side of alignment. Sensitive receptors located in width 200m on either side of center line of alignment was identified (given in **Annexure 1**) according to the silence zone defined by the Central Pollution Control Board (CPCB).

1.2.3 Approach and Methodology

Figure 1.2: Methodology of Environmental Impact Assessment



2. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

21. India has well defined environment-related institutional and legislative framework. The legislation covers all components of the environment viz. air, noise, water, soil, terrestrial and aquatic flora and fauna, natural resources, and sensitive habitats. India is also signatory to various international conventions and protocols. The environmental legislations in India are framed to protect the valued environmental components and comply with its commitment to international community under above conventions and protocols. MDBs have also defined their Environmental and Social Policies. This chapter will describe the applicability of the above laws and regulations, conventions, protocols, and safeguards.

22. The laws, regulations, policies and guidelines applicable to this project based on the location, design, construction and operation are summarized in the subsequent sections in the following order.

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

2.1 The National (India) Environmental Laws, Policies and Regulations

23. GoI's environmental legal framework comprises a set of comprehensive acts and regulations aimed at conserving various components of the biological and physical environment including environmental assessment procedures and requirements for public consultation.

2.1.1 Forest Clearance applicable to the Project

22 1.569 Ha of land area between Vellakal station and Medavakkam Koot Road Bus Stop station is located in the Nanmangalam Reserve Forest area for which diversion of forest area for non-forest purpose under the Forest (Conservation) Act, 1980 is required and it mandates forest clearance from the Regional Office, Ministry of Environment, Forests, and Climate Change **(**MoEF&CC, for area less than 5ha). MoEF&CC has accorded Forest clearance (Stage II) to this project vide letter F.No.4-TNB080/2022-CHN/ 267 dated 2nd March,2023. The Forest clearance (Stage II) copy is attached as Annexure 13.

2.1.2 Metro Rail Policy 2017

23 GoI's Union Cabinet approved a new Metro Rail Policy in 2017 that aims to enable the development and implementation of metro projects in a comprehensive and sustainable manner from the social, economic, and environmental perspectives. The Policy improves the integrated management of Metro development in three main aspects, (i) The new policy proposes that an Unified Metropolitan Transport Authority shall be set up for planning and developing multimodal transportation, which enable the overall planning and development of all modes of transport under the strong lead institutions; (ii) The need to carry out an alternative analysis is a welcome addition in the policy to help in better system selection; and (iii) The requirement to look at the 5-km catchment area for providing feeder services through walking, cycling and para-transit modes (community transport system) is promising.

2.1.3 Legislations Relevant to the Project

24 The policies and requirements which are most relevant in the context of this Corridor are provided in Table 2.1 below.

Table 2.1: Summary of Environmental Legislation Relevant to Balance C5

Legislation	Objective	Responsible Institution
Environment (Protection) Act (1986) and Rules (1986); National Conservation Strategy and Policy Statement on Environment and Development of 1992; National Environment Policy of 2006	To protect and improve the overall environment	MoEF&CC
The Wildlife Protection Act (1972 and amended in 1993)	To protect wild animals and birds through the creation of National Parks and Sanctuaries	MoEF&CC
The Noise Pollution (Regulation and Control) Rules, 2000 (Amended 2002)	To provide for the prevention and control of noise pollution and for the establishment of Boards to carry out these purposes	Tamil Nadu Pollution Control Board (TNPCB)
Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015	Suggested mitigation measures for the prevention and control of noise and vibration during operation phase.	None notified
The Water (Prevention and Control of Pollution) Act 1972 (Amended 1988) and Rules 1974	To provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water.	TNPCB
The Tamil Nadu Water (Prevention and Control of Pollution) Rules, 1983 amended May 2009		
Model Groundwater (Control and Regulation) Bill 1970, amended in 1972, 1996 and 2005 The Tamil Nadu Groundwater (Development And Management) Act, 2003	To provide for the prevention, control and abatement of groundwater pollution	Central Ground Water Authority (CGWA) and Tamil Nadu Ground water Authority
The Air (Prevention and Control of Pollution) Act, 1981(Amended 1987) and Rules 1982	To provide for the prevention, control and abatement of air pollution, and for the establishment of Boards to carry out these purposes	TNPCB for construction activities; Road Transport Authority for construction vehicles
Solid Waste Management Rules, 2016	Provisions for collection, storage segregation, transportation,	TNPCB

Legislation	Objective	Responsible Institution
	processing and disposal of municipal solid wastes	
Hazardous and Other Wastes (Management and Transboundary Movement) Amendment Rules 2019	To protection the general public against improper handling, storage and disposal of hazardous wastes	TNPCB
The Forest (Conservation) Act 1980 (Amended 1988) and Rules 1981 (Amended 2003)	To protect and manage forests	MoEF&CC
Construction and Demolition Waste Management Rules, 2016	Large generators (who generate more than 20 tons or more in one day or 300 tons per project in a month) shall submit waste management plan and get appropriate approvals from the local authority before starting construction or demolition or remodeling work	TNPCB
The Mines and Minerals (Development and Regulation) Act, 1957	GoI Act: To regulate mining activities TN Rules: To regulate mining of minor minerals including building minerals To protect the environment from quarry operation	Department of Geology & Mining, GoTN
Central Motor Vehicle Act (1988)	To control vehicular air and noise pollution. To regulate development of the transport sector	Department of Transport and Road Safety, GoTN.
Indian Treasure Trove Act, 1878 (as modified up to September 1949); Ancient Monuments and Archaeological Sites and Remains Act (1958) updated as per Archaeological Sites and Remains (Amendment & Validation) Act 2010	Conservation of Cultural and historical remains found in India Chance finds during construction	Archaeological Survey of India
Annexure XXV, Special Rules for conservation of Heritage Buildings Vol II: Second Master Plan for Chennai Metropolitan Area 2026 amended May 2013	To protect heritage assets	CMDA
National Policy on HIV/AIDS and the World of Work National Policy on Safety, Health and Environment at Workplace	To regulate the safety, health and environment at workplace	Ministry of Labour and Employment, GoI

Legislation	Objective	Responsible Institution
Tamil Nadu Building and Construction Workers (Conditions of Employment and Miscellaneous Provisions) Act, 1984 Minimum Wages Act, 1948; Workmen's Compensation Act, 1923; The Contract Labour (Regulation & Abolition) Act, 1970 and Rules Employees State Insurance Act, 1948 (ESI); 8, The Payment of Wages Act, 1936, amended in 2005; The Tamil Nadu Labour Welfare Fund Act, 1972 The Equal Remuneration Act 1976; Workmen's Compensation Act, 1923	To regulate the employment and conditions of service of building and other construction workers and to provide for their safety, health and welfare measures	Department of Labour and Employment, GoTN
Interstate Migrant Workmen (Regulation of Employment and conditions of Service) Act 1979	In case workers and labourers working at the project sites are migrants from other states during construction	
Child Labour (Prohibition and Regulation) Act, 1986	To regulate the employment of children including age limits, type of employment, timing of work, information disclosure and health and safety	

2.1.4 Required Clearances/Permissions

25 As per GoI EIA Notification 2006, all railways and metro rail projects in India are exempted from obtaining Environmental Clearance (EC), therefore EC for Balance C5 is not required. However, part of the alignment passes through Nanmangalam reserve forest, and the requisite forest clearance for diversion of forest land (1.569 Ha) for non-forest purpose from the Forest Department is obtained (Annexure 13).

26 Before the start of civil works for any section of Balance C5, CMRL has already obtained necessary clearances/permissions from statutory authorities such as MOEF&CC, TNPCB, CMDA, DGC etc.. For implementation of Balance C5, required clearances/ permissions related to environment and labour safeguards have been summarized in Table 2.2.

Table 2.2: Applicable Permissions and Clearances Required for Balance C5

SN	Permissions/ Clearances	Acts/Rules/Notifications/ Guidelines	Concerned Agency	Responsibility
A. Pre-construction Stage				
1.	Forest Clearance to divert forest land to non-	Forest Conservation Act, 1980	Tamil Nadu Forest Department (TNFD)	CMRL (Obtained)

SN	Permissions/ Clearances	Acts/Rules/Notifications/ Guidelines	Concerned Agency	Responsibility
	forest purposes.		and Regional Office, MoEF&CC	
2.	Permission for felling of 259 trees and translocation of 145 trees in public areas	Tamil Nadu Government Order No 39 date 02.07.2021 and G.O No 66 dated 07.04.2022	District Green Committee (DGC)	CMRL (Obtained permission for tree felling and translocation)
3.	Building Permissions for stations and depots	Second Master Plan for Chennai Metropolitan Area 2026 amended May 2013	CMDA	Contractor and CMRL (Obtained)
B. Construction Stage				
4.	Consent to Establish & Operate for Ready Mix Concrete plant, STP and Diesel Generators.	Air (Prevention and Control of Pollution) Act 1981 Water (Prevention and Control of Pollution) Act 1974	TNPCB	Contractor engaged by CMRL (CTOs are obtained for construction plants, STPs and DG Sets being utilized under Balance corridor 5)
5.	Permission for withdrawal /dewatering of groundwater[1]	Chennai Metropolitan Area Groundwater (Regulation) Act, 1987 as amended till 2008 Guidelines/Criteria for evaluation of proposals/requests for ground water abstraction (With effect from 16.11.2015)	Head of Municipal Area (Greater Chennai Municipal Corporation) and CGWA	Contractor engaged by CMRL. (Not applicable as of now) – If required the contractor will obtain permission from the CGWA.
6.	Consent to recharge groundwater with dewatering water if any	Water (Prevention and Control of Pollution) Act 1974 amended 1988, Environment (Protection) Amendment Rules, 2017 (Discharge Standard for Sewage Treatment Plants (STPs)), Model Groundwater (Control and	Head of Municipal Area and CGWB/PWD	Contractor engaged by CMRL. (Not applicable as of now) – If required the contractor

[1] The Contractor will avoid extraction of groundwater as much as possible. If not avoidable, the permission will be obtained prior to the extraction.

SN	Permissions/ Clearances	Acts/Rules/Notifications/ Guidelines	Concerned Agency	Responsibility
		Regulation) Bill 1970, amended in 1972, 1996 and 2005		will obtain from the GW permission from the CGWA.
7.	Authorization for storage (diesel) and disposal of Hazardous Waste	Hazardous and Other Wastes (Management& Transboundary Movement) Amendment Rules, 2019	TNPCB	Contractor engaged by CMRL (Obtained from TNPCB)
8.	Consent for disposal of sewage from labour camps.	Water (Prevention and Control of Pollution) Act 1974 amended 1988, Environment (Protection) Amendment Rules, 2017 (Discharge Standard for Sewage Treatment Plants (STPs))	TNPCB	Contractor engaged by CMRL (Obtained from TNPCB)
9.	Pollution Under Control Certificate for various vehicles use for construction	Central Motor and Vehicle Act, 1988	Department of Transport & Road Safety, GoTN authorised testing centres	Contractor engaged by CMRL (Obtained)
10.	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Labour and Employment Department, GoTN	Contractor engaged by CMRL (Obtained)
11.	Roof Top Rainwater Harvesting (RWH)	Central Groundwater Authority (CGWA) Guidelines NBC – Rainwater harvesting guidelines	TNPCB / PWD, GoTN	Contractor engaged by CMRL (Implemented)
12.	Permission for use of fresh water for construction and drinking purpose.	Environment (Protection) Act, 1986	Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB)	Contractor engaged by CMRL (Agreement made between contractor and CMWSSB)
13.	Permission for Quarry Operation	The Mines and Minerals (Development and Regulation) Act, 1957	Department of Geology and Mining, GoTN	Contractor engaged by CMRL (Not applicable)
14.	Authorization for Disposal of Construction and	Construction and Demolition Waste	TNPCB, District Collector, Relevant	Contractor engaged by

SN	Permissions/ Clearances	Acts/Rules/Notifications/ Guidelines	Concerned Agency	Responsibility
	Demolition Waste	Management Rules, 2016	government authorities	CMRL (Obtained)
15.	Consent to Establish, pre-casting and material yards, , crushers, batching plant, stations	Air, Water and Noise Regulations	TNSPCB	Contractor engaged by CMRL (Obtained)
16.	Consent/Permission to muck/waste disposal	Construction and Demolition Waste Management Rules, 2016 Solid Waste Management Rules, 2016	TNPCB	Contractor engaged by CMRL. (Obtained from District Collector)
17.	Installation and operation of DG sets at stations	Air (Prevention and Control of Pollution) Act, 1981 amended 1987; CPCB Notification and DG Guidelines Environmental Protection (Amendment) Rules, Noise Pollution (Regulation and Control) Rules, 2000	TNPCB	CMRL (Obtained)
18.	Information to Government and compliance for labour engagement, welfare, safety and health	Tamil Nadu Building and Construction Workers (Conditions of Employment and Miscellaneous Provisions) Act, 1984 Minimum Wages Act, 1948; Workmen's Compensation Act, 1923; The Contract Labour (Regulation & Abolition) Act, 1970 and Rules Employees State Insurance Act, 1948 (ESI); The Payment of Wages Act, 1936, amended in 2005; The Tamil Nadu Labour Welfare Fund Act, 1972; The Equal Remuneration Act 1976; Workmen's Compensation Act, 1923; Interstate Migrant Workmen (Regulation of Employment and conditions of Service) Act 1979; Child Labour (Prohibition and Regulation) Act, 1986	Labour and Employment Department, GoTN	Contractor (Complied)

SN	Permissions/ Clearances	Acts/Rules/Notifications/ Guidelines	Concerned Agency	Responsibility
19.	Transportation and Storage of Diesel (HSD) – Class B (No need of license for transport or storage if total quantity in possession at any one place does not exceed 2500 liters and none of it is contained in a receptacle exceeding 1000 liters in capacity)	Petroleum Rules, 2002	Petroleum and Explosives Safety Organization (PESO)	Contractor engaged by CMRL. (Not applicable – Current storage is less than 2500 liters)

2.1.5 Institutional Administrative Framework

27 The administrative framework in India for implementation and monitoring of Metro Rail Projects involves following key agencies.

28 **Ministry of Environment, Forests and Climate Change (MoEF&CC):** The MoEF&CC is apex body in India responsible for protection and enforcement of laws and regulations. In view of the growing importance of environmental affairs, the Government of India set up a Department in November 1980 under the portfolio of the Prime Minister. The department, later renamed as the MoEF&CC plays a vital role in environmental management for sustained development and for all environmental matters in the country.

29 The major responsibilities of MoEF&CC includes, Environmental resource conservation and protection, Environmental Impact Assessment of developmental projects, Co-ordination with the other ministries and agencies, voluntary organizations and professional bodies on environmental action plans, Policy-planning, Promotion of research and development, manpower planning and training and creation of environmental awareness; Liaison and coordination with international agencies involved in environmental matters.

30 Developmental project proponents are also required to submit Environmental Impact Statements/Assessments to establish that preventive measures are planned by installing adequate pollution control and monitoring equipment, and that effluent discharged into the environment will not exceed permissible levels. The MoEF&CC appraises these statements/ assessments and approves the project from the environmental angle.

31 **Tamil Nadu Pollution Control Board (TNPCB):** The Tamil Nadu Pollution Control Board was formed under the provisions of section 4 of Water (Prevention & Control of Pollution) Act, 1974. The Board is also functioning as the State Board under section 5 of the Air (Prevention & Control of Pollution) Act, 1981. The prime objective of all these Acts is maintaining, restoring and preserving the wholesomeness of quality of environment and prevention of hazards to human beings and terrestrial flora and fauna.

32 **Central Ground Water Board (CGWB):** The CGWB is responsible for the development, dissemination of technologies, and monitoring of India's groundwater resources, including their exploration, assessment, conservation, augmentation, protection from pollution and distribution. The CGWB, under the Ministry of Water

Resources, was established in 1970. Various activities related to regulation and control of ground water development in the country is the responsibility of the Central Ground Water Authority (CGWA) specifically constituted under the Environmental (Protection) Act, 1986. The CGWA has identified over exploited areas across India where groundwater withdrawal is regulated. To date, 43 critical/ overexploited notified areas have been identified in 10 states. Construction of new ground water structures is prohibited in the notified areas while permission of drilling tube wells is being granted only to the government agencies responsible for drinking water supply.

33 **The National Green Tribunal (NGT):** The NGT was established on 18.10.2010 under the National Green Tribunal Act 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues. The Tribunal shall not be bound by the procedure laid down under the Code of Civil Procedure, 1908, but shall be guided by principles of natural justice.

34 The Tribunal's dedicated jurisdiction in environmental matters shall provide speedy environmental justice and help reduce the burden of litigation in the higher courts. The Tribunal is mandated to make and endeavor for disposal of applications or appeals finally within 6 months of filing of the same. Initially, the NGT is proposed to be set up at five places of sittings and will follow circuit procedure for making itself more accessible. New Delhi is the Principal Place of Sitting of the Tribunal and Bhopal, Pune, Kolkata and Chennai shall be the other four place of sitting of the Tribunal.

2.2 International and Regional Agreements and Conventions

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

A. Nature conservation;
B. Hazardous material;
C. Atmospheric emissions; and
D. Marine environment.

36 The Nature conservation and Climate change agreements will be applicable to this Corridor.

A. Nature conservation

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

B. Hazardous material

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

C. Atmospheric emissions

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

D. Marine environment

No.	Marine environment
1	IWC (International Whaling Commission)

2.3 MDBs' Requirements Applicable to the Project

37 MDBs' project planning activities related to environmental and social safeguards generally comprise, a) screening and categorization by Bank; b) due diligence of the project by Bank; c) environmental and social assessment by Borrower and its review by Bank; d) information disclosure by Borrower and Bank and consultation by Borrower; e) monitoring and reporting by Borrower and Bank; and f) grievances. As a borrower, CMRL is entitled to ensure the implementation of the Environmental and Social Framework of AIIB and Safeguard Policy Statement of ADB.

2.3.1 Safeguard Policy Statement (SPS) July 2009 of ADB

38 The SPS 2009 is the policy set out by the ADB to address emerging environmental and social challenges of development in its developing member countries. The objectives of ADB's safeguards are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; (ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible; and (iii) help borrowers/clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks.

39 ADB's SPS sets out the policy objectives, scope and triggers, and principles for four key safeguard areas:

i. Safeguard Requirement 1: Environmental
ii. Safeguard Requirement 2: Involuntary Resettlement
iii. Safeguard Requirement 3: Indigenous Peoples
iv. Safeguard Requirement 4: Special Requirements for Different Finance Modalities.

2.3.2 Environmental and Social Framework (ESF) 2019 of AIIB

40 The AIIB's Environmental and Social Framework (ESF) is a system that supports the Bank and its clients in achieving environmentally and socially sustainable development outcomes. The objectives of this ESF are to:

40.1 Reflect institutional aims to address environmental and social risks and impacts in Projects (defined below in Section II, Definitions, of the ESP).

40.2 Provide a robust structure for managing operational and reputational risks of the Bank and its shareholders in relation to Projects' environmental and social risks and impacts.

40.3 Support the environmental and social soundness and sustainability of Projects.

40.4 Facilitate the integration of environmental and social aspects of Projects into the decision-making process by all parties.

40.5 Provide a mechanism for addressing environmental and social risks and impacts in Project identification, preparation and implementation.

40.6 Enable Clients (defined below in Section II, Definitions, of the ESP) to identify and manage environmental and social risks and impacts of Projects, including those of climate change.

40.7 Provide a framework for public consultation and disclosure of environmental and social information in relation to Projects.

40.8 Provide a grievance redress mechanism designed to enable Project-affected people to voice their concerns and grievances in connection with the environmental and social aspects of Projects.

40.9 Improve development effectiveness and impact to increase results on the ground, in both the short and long term.

40.10 Support Clients, through Bank financing of Projects, to strengthen their environmental and social management systems.

40.11 Support Clients, through Bank financing of Projects, to implement their obligations under national environmental and social legislation (including under international agreements adopted by the Member) governing these Projects, including commitments relating to climate change.

40.12 Support Clients, where feasible and appropriate, to mobilize resources for technical assistance for the preparation of environmental and social documents and capacity enhancement.

40.13 Facilitate cooperation on environmental and social matters with development partners.

41 ESF of AIIB comprises the following:

i. **Environmental and Social Policy (ESP).** This comprises mandatory environmental and social requirements for all investments.

ii. **Environmental and Social Standards (ESS).** Three associated mandatory environmental and social standards (ESSs) set out more detailed environmental and social requirements relating to the following:

ESS 1: Environmental and Social Assessment and Management.

ESS 2: Land Acquisition and Involuntary Resettlement; and

ESS 3: Indigenous Peoples.

2.4 Applied Standards

42 The project will follow national as well as international best practices and standards related to the environment, health and safety, such as World Bank Group (WBG) Environmental, Health, and Safety (EHS) General Guidelines April 30, 2007. When host country regulations differ from the levels and measures presented in the international Guidelines, projects are expected to achieve whichever is more stringent. Appropriate and less stringent levels or measures than those provided in the international Guidelines can be adopted if they are protective of human health and the environment. Some international standards for environmental components are listed here:

✓ Air Quality
- WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide *Global Update, 2005. (EHS Guidelines WBG April 2007)*
- Environment (Protection) Amendment Rules 2022

Air quality guideline values in terms of PM10, PM2.5 and SO2 are more stringent in WBG guidelines than Indian national standards.

✓ Water quality
- Pollution Prevention and Abatement Handbook, WB 1998 / April 1999 for stormwater
- General Standards of discharge for environmental pollutants Part A- Effluents, Schedule VI, Environmental Protection Rules 1986, MoEFCC, Government of India
  In relation to Indian post-treatment inland surface water standards, WBG effluent discharge guideline values for toxic metals are more stringent; they prescribe coliform levels while Indian standards do not.
- Designated Best Use Classification of Surface water, CPCB 1978 for propagation of wildlife and fisheries.
- WHO Guidelines for Drinking Water Quality 2017
- Drinking Water Specification IS 10500-2012, Bureau of Indian Standards
  Drinking water standards as per WHO cover fewer substances than Indian standards.

✓ Soil (in terms of permissible content in foods)
- UK EA Soil Guideline Values cover hydrocarbons and toxic metals.
  EC Regulations 1881/2006, 629/2008 and 835/2011 cover toxic metals, nitrates, Persistent Organic Pollutants (POPs) and Polycyclic Aromatic Hydrocarbons (PAHs)
- In India, Prevention of Food Adulteration Rules 1955 prescribe permissible limits of lead, copper, arsenic, zinc, cadmium, mercury, chromium, nickel.

✓ Noise
- WHO Guidelines for Community Noise ca. 1999
- The Noise Pollution (Regulation and Control) Rules, 2000 (Amended 2002)

✓ Vibration
- Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, September 2018

- Transit Noise and Vibration Impact Assessment, US FTA, May 2006
- Metro Rail Transit System Guidelines for Noise and Vibrations, RDSO, Sept 2015

✓ Biodiversity **(**IUCN Red List and Guidance Note 6 of IFC)

- determine the biodiversity footprint of the project and whether there is no-go areas;
- avert loss of biodiversity and ecosystems, and at a minimum sustaining current biodiversity values through avoiding impact on biodiversity and ecosystems or minimised through mitigation.

✓ Climate Change (IFI's Framework of a harmonised approach of GHG accounting)

- Rational approach to resource use, including the most effective measures in the field of energy efficiency
- Estimation of GHG emissions
- Information on the climate change risks

✓ Occupational Health and Safety (World Bank Group)

✓ Community Health and Safety (World Bank Group)

3. DESCRIPTON OF THE PROJECT

3.1 Description of Balance C5

43 Balance Corridor 5 consists of 23 elevated metro stations and viaducts of approximately 30.002 km length, between CMBT Metro Station (excluded) to Sholinganallur Metro Station (excluded). This section Chennai Mofussil Bus Terminus (CMBT) to Sholinganallur hereafter referred as Balance Corridor 5 (BC5). This section forms part of Chennai Metro Rail Corridor 5 sharing 4 stations (namely Alwar Thirunagar, Valasaravakkam, Karambakkam and Alapakkam) in common with Corridor 4; allowing interchange with Corridor 3, Corridor 1 and Corridor 2 of Phase I Metro, MRTS and also connecting with suburban railway system. Remaining section of the Corridor 5 from Madhavaram to CMBT which is being financed by Japan International Cooperation Agency (JICA) constitutes one of the Associated Facilities to Balance Corridor 5. It is funded by AIIB (Civil Works) and ADB (System works). Stations of the Balance C5 (excluding the 4 common stations with Corridor 4) are depicted in in Table 3.1.

Table 3.1 List of Stations – Balance C5

No.	STATION NAME	CHAINAGE (M)	INTER-STATION DISTANCE (M)	ELEVATED/UG
1.	CMBT (Part of JICA C5)	15352	-	Elevated (140x21.95)
2.	Koyambedu market	16632	1280	Elevated (140x21.95)
3.	Natesan Nagar	17895	1263	Elevated (140x21.95)
4.	Virugambakkam	18737	842	Elevated (140x21.95)
5.	Mugalivakkam	23855	5118	Elevated (140x21.95)
6.	Ramapuram	25121	1266	Elevated (140x21.95)
7.	Manapakkam	26155	1034	Elevated (140x21.95)
8.	CTC	27367	1212	Elevated (140x21.95)
9.	Butt Road	28680	1313	Elevated (140x21.95)
10.	Alandur	29785	1105	Elevated (140x21.95)
11.	St. Thomas Mount	30936	1151	Elevated (140x21.95)
12.	Adambakkam	31788	852	Elevated (140x21.95)
13.	Vanuvampet	32744	956	Elevated (140x21.95)
14.	Ullagaram	33595	851	Elevated (140x21.95)
15.	Madipakkam	34536	941	Elevated (140x21.95)
16.	Kilkattalai	35605	1069	Elevated (140x21.95)
17.	Echangadu	36357	752	Elevated (140x32.35)
18.	Kovilambakkam	37371	1014	Elevated (140x21.95)
19.	Vellakkal	38443	1072	Elevated (140x21.95)
20.	Medavakkam I	40100	1657	Elevated (140x32.35)
21.	Medavakkam II	41167	1067	Elevated (140x32.35)
22.	Perumbakkam	42245	1078	Elevated (140x21.95)
23.	Classic Tamil Institute	43244	999	Elevated (140x21.95)
24.	Elcot Park	44424	1180	Elevated (140x21.95)
25.	Balance C5 End	45354	930	-

Source: Detailed Design Consultant, CMRL

Figure 3.0: Metro Network Phase 2

Source: *Chennai Metro Rail Limited*

Land use along the alignment is summarized in Table 3.2.

Table 3.2: Land use abutting the Alignment

Section / station	Land use
CMBT to Mugalivakkam	Residential + street front retail
Mugalivakkam to Manapakkam	Large employment, commercial
Manapakkam to CTC	Residential + large employment commercial
CTC to Velakallu	Residential + Madras War Cemetery + street front retail
Vellakkal to Medavakkam Koot Road	Forest scrub: Nanmangalam lake in the reserve forest is located 1km away from alignment
Medavakkam Koot Road to Global Hospital	Residential
Perumbakkam (formerly Global Hospital) to Sholinganallur	Aalignment passes through part of Pallikaranai wetland which is reserve forest; home and breeding ground to 350 species of flora and fauna. In principle silence zone. One large employment centre.

44 The topographical survey was carried out in detail using modern surveying instruments. The geotechnical investigations determined the required strength characteristics of the underlying soil/rock strata to design the foundation of the proposed structure. A total of 60 bore holes were drilled all along the Balance C5. Also, since the proposed site is located in Seismic Zone III (Moderate Risk Zone), suitable seismic measures will be adopted in the design of the structures.

45 The salient features of Corridor 5 Project are summarized in Table 3.3.

Table 3.3: Salient Features of Balance C5

Gauge (Nominal):	1435 MM
Route Length:	30.002 km fully elevated
Number of Stations:	23 all elevated (excluding 4 stations common with Corridor 4)
Speed:	
1. Design Speed	80 kmph
2. Scheduled Speed	32 kmph

Train Operation Plan * :

Particulars	2025	2035	2045	2055
Trains/hour (3 Car, 6 Car)	15 (11,4)	15 (5,10)	15 (0,15)	17 (0,17)
Head Way (Second)	240	240	240	212
Capacity (6p/m^2;8p/m^2)	14,730, 18,741	19,590 24,915	23,640 30,060	26,792 34,068
Max. PHPDT Demand	17,539	24,528	29,441	35714
Total Coach Requirement	90	126	156	192

* MMBT-CMBT-SLR

Traction Power Supply:

1. Traction System Voltage	25 kV AC
2. Current Collection	Overhead Electric Traction

3. Receiving Substations (RSSs) — 4 RSS at Mugalivakkam, St Thomas Mount, Medavakkam, Perumbakkam

Power Demand (MVA) *:

Load	2025		2035		2045		2055	
	Normal	Emergency	Normal	Emergency	Normal	Emergency	Normal	Emergency
Thiruverkadu GSS-Mugalivakkam RSS (Chainage 7186 to 13366) 6.180km								
Traction	2.46	6.34	3.24	8.36	3.90	10.05	4.42	11.39
Auxiliary	5.13	7.70	6.38	9.40	7.18	10.70	7.70	11.55
Total	7.59	14.04	9.62	17.76	11.08	20.75	12.12	22.94
Alandur GSS-St Thomas RSS (Chainage 13366 to 23109) 9.743km								
Traction	3.88	8.59	5.11	11.33	6.15	13.62	6.97	15.44
Auxiliary	2.57	5.13	3.02	6.03	3.53	7.06	3.85	7.70
Total	6.45	13.72	8.13	17.33	9.68	20.68	10.82	23.14
Kadaperi GSS to Medavakkam RSS (Chainage 23109 to 34947) 11.838km								
Traction	4.71	9.22	6.21	12.16	7.47	14.62	8.47	16.57
Auxiliary	2.57	5.13	3.02	6.03	3.53	7.06	3.85	7.70
Total	7.28	14.35	9.23	18.19	11.00	21.68	12.32	24.27
Mambakkam GSS to Perumbakkam RSS (Chainage 34947 to 46272) 11.325km								
Traction	4.51	9.22	5.94	12.16	7.15	14.62	8.10	16.57
Auxiliary	2.57	5.13	3.02	6.03	3.53	7.06	3.85	7.70
Total	7.28	14.35	9.23	18.19	11.00	21.68	12.32	24.27

*Composite ToP

Rolling Stock:

1. Rolling Stock with light weight Stainless Steel/Aluminum Body
2. Max. Axle Load — 16 T
3. Dimensions — L22.6 x W2.9m x H3.9m

Maintenance Facilities: No separate Depot

Signalling, Telecommunication and Train Control:

1. Type of signalling — Communication based Train Control System (CBTC) with unattended train operation permitting an operational headway of 90 seconds.
2. Telecommunication — Integrated System with Optic Fiber cable, Supervisory Control and Data Acquisition (SCADA), Close Circuit Television (CCTV), Central Voice Recording System (CVRS) etc.

Fare Collection:

Automatic Fare Collection (AFC) System with smart card/token etc.

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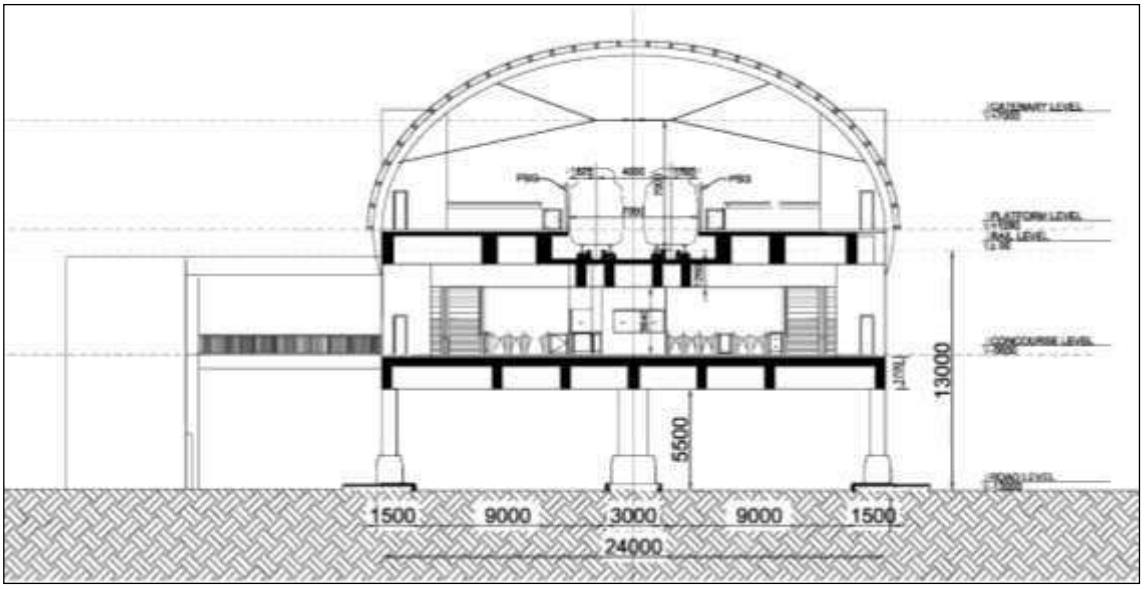
24. Elevated stations located at the center median of existing roads will be 140 m long and 24 m wide. These elevated stations will be constructed using the cantilever method. The typical elevated station consists of three levels: ground, concourse and platform. Passenger facilities, operational and commercial areas are provided at the concourse level. Platforms will be at a level of 13 m and concourse floor at about 7 m above the road, with a minimum of 5.5 m of vertical clearance under the concourse. To reduce physical and visual impact, stations will be transparent with minimum walls on the sides. Figure 3.1 shows the typical elevated station.

Figure 3.1: Typical Elevated Station



Labour Camp

46 The Contractor during the progress of work, will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour. Contractor has established labour colonies / camps as part of the project. Emphasis was given to use existing facilities (established under ongoing lines). However, locations of the camps was finalized in consultation with CMRL. The Contractor engaged by CMRL has coordinated with the CMDA for land use clearance, TNPCB and Greater Chennai Corporation to establish the labour camps for construction.

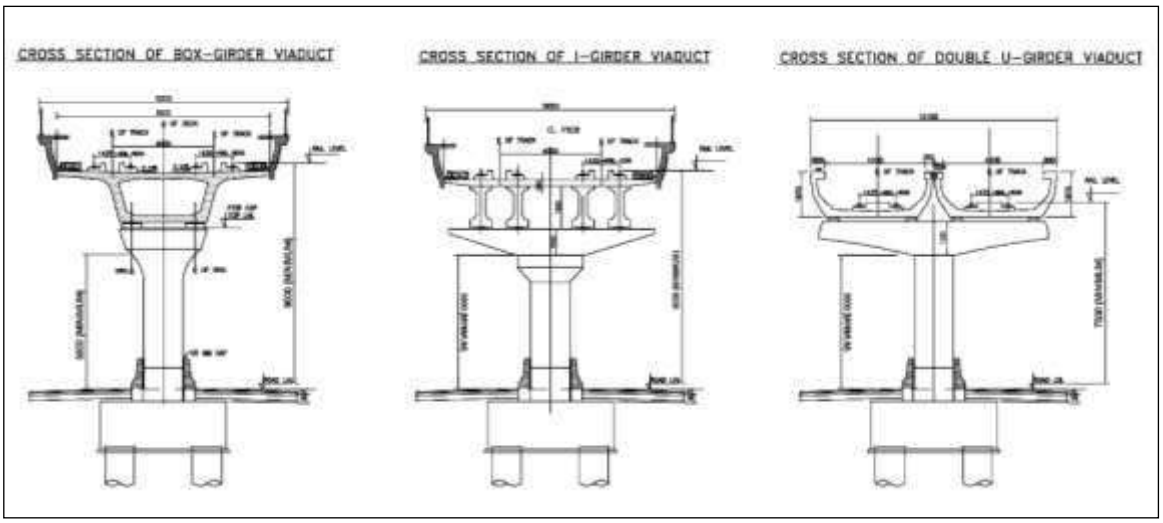
Construction Activities and Methodology

47 Main construction activities include demolition of structures and ground clearing; excavation/ cut and fill; Transport of construction materials, muck and waste; casting of concrete elements and preparation of concrete and their transportation; Pile driving where cast-in-situ is not feasible, blasting in rock etc.

48 Elevated Sections. Substructure – open foundation, pile, pile caps, columns; station structure; earth retaining structures are cast-in-situ. The structural elements for superstructure i.e. box segments, I-Girders, U-girders and sometimes pile caps are pre-casted. Pre-cast construction may be segmental or non-segmental type. In the case of segmental method, structural segments are pre-casted in casting yards, pre-stressed and then transported to the location of use and launched by means of suitable launching arrangement. The construction yard has arrangements for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 3 ha (minimum) is required for setting up construction yard.

49 The typical viaduct is shown in Figure 3.2.

Figure 3.2: Typical superstructure of viaduct



Grade Separator (MIOT Section)

50 Tamil Nadu Highways and Minor Ports Department proposed a Grade Separator from Mugalivakkam to Manapakkam section of total length 3.14 Km including approaches. It consists of Four lanes – dual 7.5m carriageway and 0.5m crash barrier on both sides on the first level, and Metro viaduct cum 3 Metro stations (Mugalivakkam, Ramapuram and Manapakkam) on the second level.

51 In addition to the provision of Metro transport system, the Grade separator was included in the scope of CMRL to further ease the traffic congestion in the section. A Design Development Consultant (DDC) was engaged to prepare the DPR and detailed designs of combined structures.

52 The inclusion of grade separator in this section doesn't have any additional adverse environmental impacts, it also facilitates the better flow of vehicular traffic during operation phase. The geographical representation and concept diagram of the grade separator and the three metro stations involved are shown in Fig. 3.3 , 3.4 and 3.5 below.

Fig. 3.3: Layout of MIOT Integrated Grade Separator

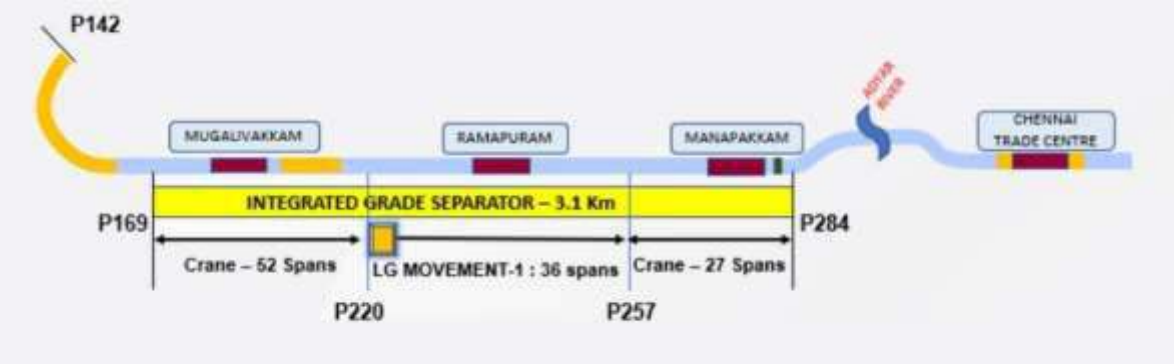
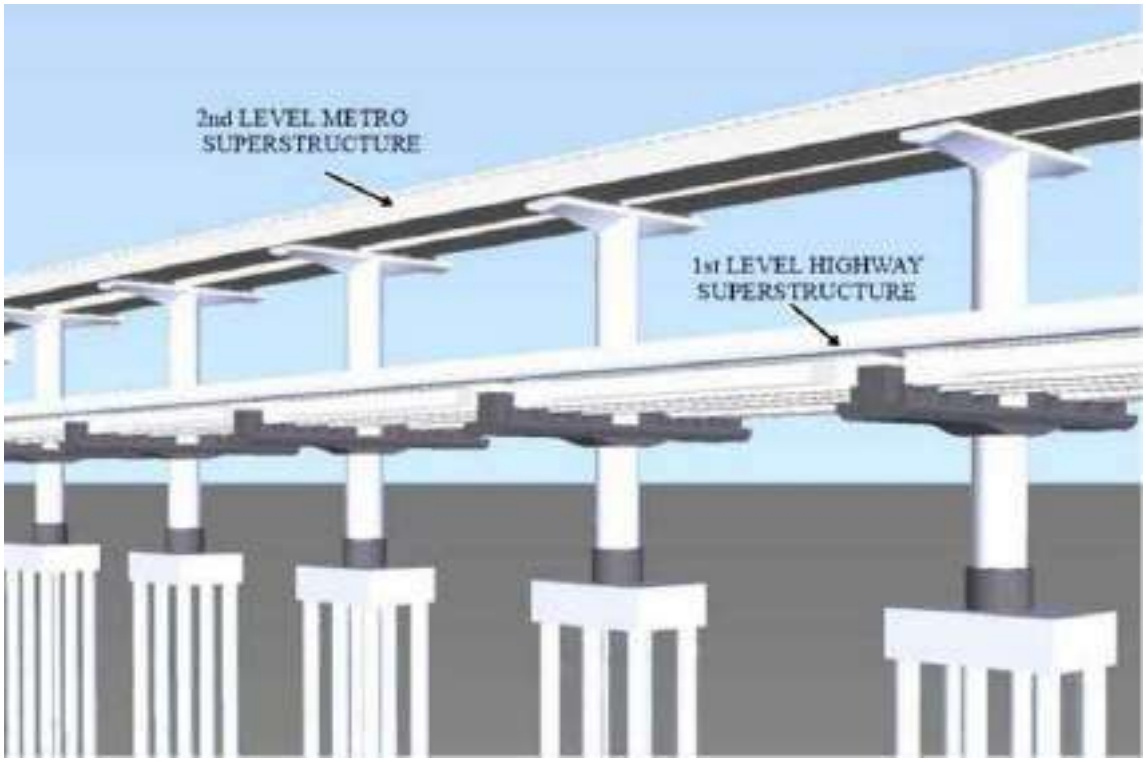


Fig. 3.4: location of the proposed Integrated Grade Separator cum Metro Viaduct/Stations

Fig. 3.5: Concept Diagram of the MIOT Grade separator



53 The typical cross section diagrams of grade separator are shown in Figure 3.6 & 3.7 below.

Fig. 3.6: Typical Cross-section of Integrated Grade Separator cum Metro Station

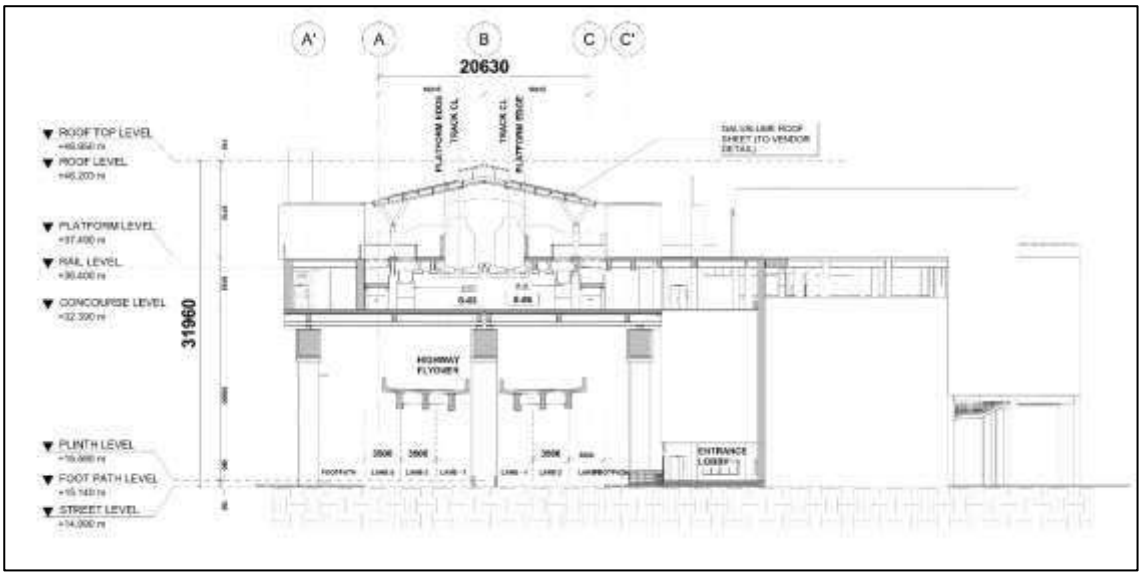
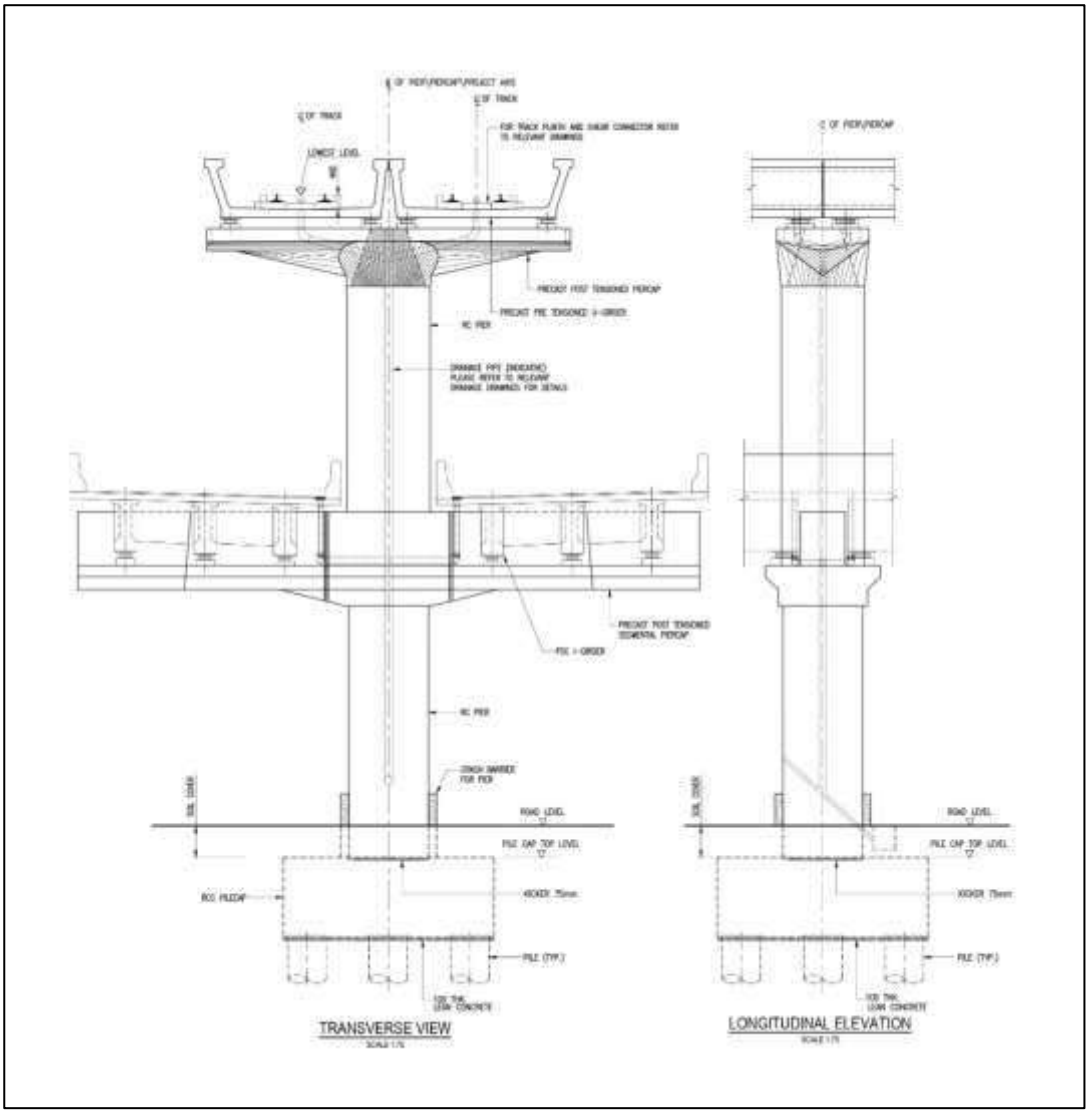


Fig. 3.7: Typical Cross-section of Grade Separator and Metro Viaduct at a Pier



Kathipara Balance Cantilever Bridge:

54 The Kathipara balance cantilever bridge of length 413m, connects the butt road viaduct to the Alandur metro station with a sharp curvature section of radius 120m. This 5-span continuous bridge comprises of a Rail level of 45.5m, crossing 3 levels of existing interchanges. Primarily, there is a peripheral road at ground road, cloverleaf flyover at second level and at third level, there is CMRL Phase 1 metro viaduct including balance cantilever span. After completion of the proposed grade separator, it will be India's longest & tallest continuous metro viaduct with such a sharp curvature as shown in Figures 3.8 & 3.9 below.

Fig. 3.8: Location of proposed Kathipara Balance Cantelever Bridge

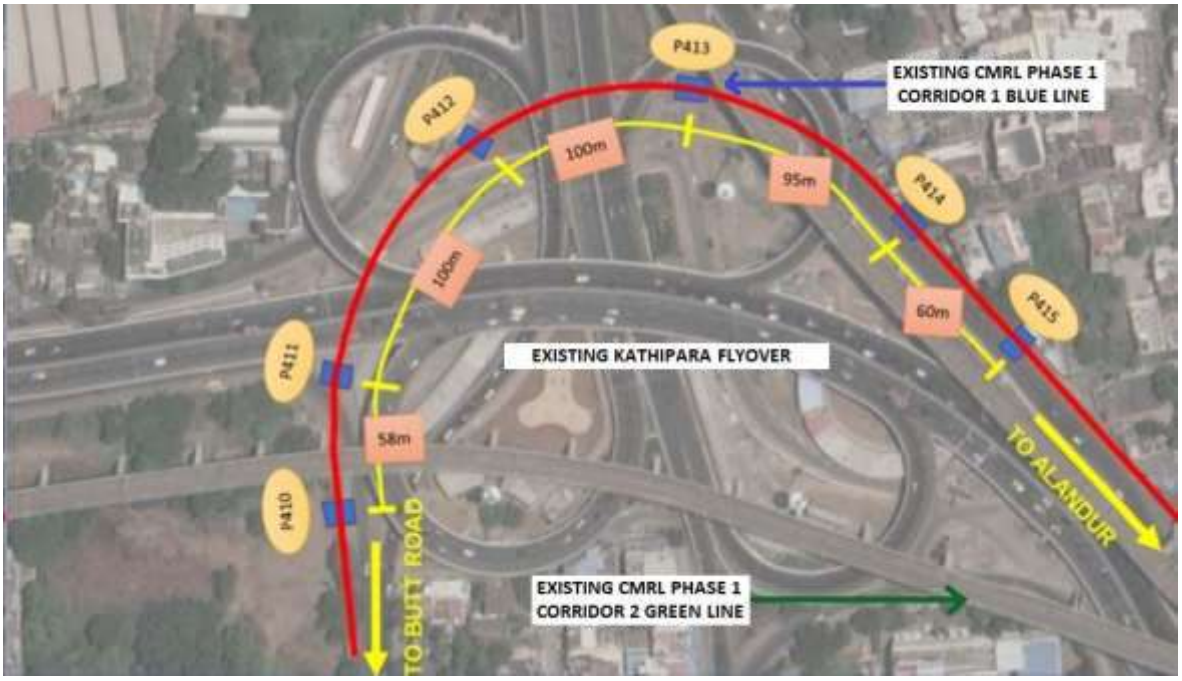
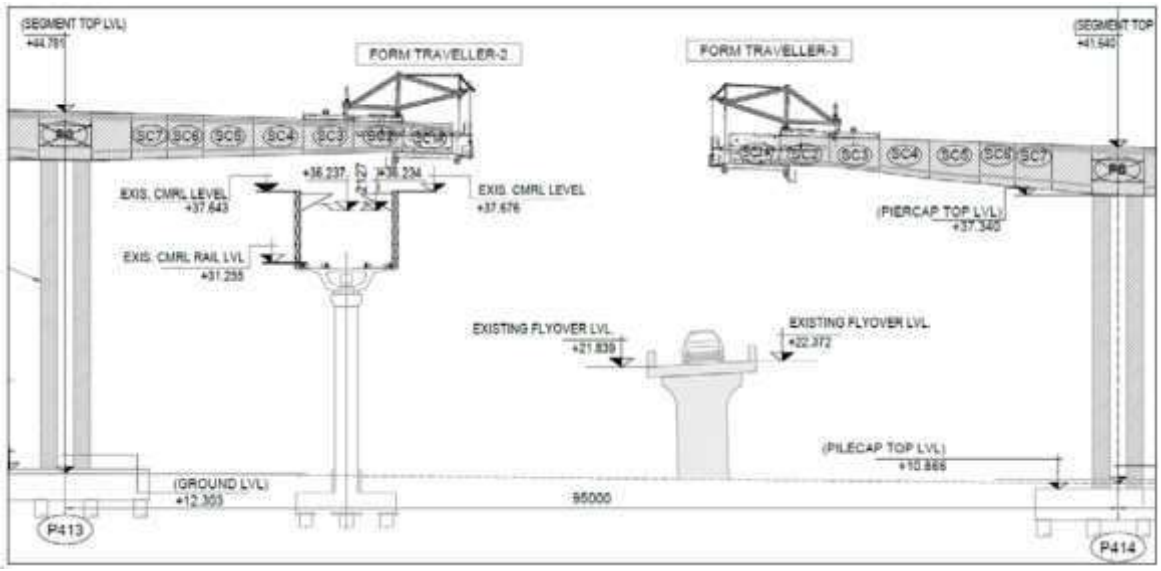


Fig. 3.9: Concept diagram of intersections between Proposed Kathipara GS and existing infrastructures

55 The erection of the piers and decks is executed by using methods such as Slipform and Form traveler respectively. The top level of the structure after the installation of the systems will be 53.5m.

Fig. 3.10: Design drawing of GS with existing Phase 1 Rail line and flyover.



3.2 Associated Facilities

56 As per ADB's SPS 2009, the associated facilities are those that are not included or funded by the Project but are: (i) directly and materially related to the Project; (ii) carried out or planned to be carried out, contemporaneously with the Project; and (iii) necessary for the Project to be viable and would not be constructed or expanded if the Project did not exist.

57 The remaining section of Corridor 5, which starts from Madhavaram to CMBT financed by JICA constitutes one of the Associated Facilities to Balance C5. A due diligence survey of sensitive locations was conducted. The avoidance and mitigation measures have been incorporated in the EMP.

58 From chainage 31300 to chainage 31700 after St. Thomas Mount Station, Southern Railways and CMRL agreed to take up their structures constructed within the same right of way available with MRTS. This stretch has been assessed as part of this EIA. Though not fully constitute the associated facility, to have a closer association and review the works as per the specifications, it is agreed to have joint meetings on quarterly basis to review the safeguard performance and documentations (Annexure 2).

59 The construction and operation of Balance C5 will require power and water from the existing electricity grid and water supply system. Electricity is required for the operation of the Metro system for running trains, station services (e.g. lighting, lifts, escalators, signaling & telecom, firefighting etc. within premises of the metro system). The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. These existing grid substations and water supply network are being operated and managed by respective agencies in full compliance with state and local policies and regulatory frameworks.

60 Chennai City has 230kV, 110kV, 33kV power transmission and distribution network to cater to various types of demand in the vicinity of proposed corridor. Keeping in view

of reliability requirements of the corridor, four RSSs are proposed to avail power supply for traction as well as auxiliary services from Tamil Nadu Transmission Corporation Limited grid sub-stations at 110kV voltage through transmission lines or cable feeders for Corridor 5. M/s Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) has confirmed the availability of supply.

61 Gas Insulated Substation (GIS), which offer the advantage of considerable saving in space requirement as well as reduced maintenance, are proposed for each Receiving cum Traction Substation and Auxiliary Substations of Balance C5. Each elevated station shall be provided with an Auxiliary Substation with two 33kV/415V, 3-phase, 500 kVA dry type cast resin transformers and the associated HT & LT switchgear. In addition, provision shall be made for one DG set at each station for emergency loads. In addition, it is proposed to provide standby DG set of 250 kVA at all elevated stations to cater to all emergency loads. Power Demand is estimated in Table 3.3.

62 During construction, water consumption will be of the order of 448 KLD for construction and 270 KLD for labour camps. During operation, the water demand at stations for cleaning, drinking, toilet, and air conditioning will be of the order of 381 KLD (16.6KLD for each station) Source : CMRL Phase II DPR.

63 Water for dust suppression (sprinkling) and wheel / vehicle body washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater. Used water from wheel / vehicle body washing are treated and re-used. Water for curing of concrete will be sourced from municipal supply, surface runoff or water from dewatering. Water for concrete batching plants and labour camps were sourced through CMWSSB.

64 Rain water from construction yards, work areas and Labour camps will be discharged into public storm water drains; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. In view of the distributed nature of the linear construction and quantities of wastewater, it is not proposed install sewage and effluent treatment plants by CMRL. If feasible ETP/STP may be proposed to install at work areas.

65 The water requirement for the stations will be met through the public water supply system i.e. through CMWSSB. CMWSSB water supply will be supplemented by rainwater harvesting at elevated stations.

3.3 Implementation Plan, Schedule and Cost

66 Balance C5 will be implemented under design consultant and civil work contracts. There will be several packages for different components such as civil works contracts, detailed design, system contracts, supply and installations, rolling stocks etc. It is estimated that the project will be commissioned 53 months from award of civil works. Table 3.11 shows the detailed schedules of the two civil work packages. The capital cost of Balance C5 including taxes and duties for December 2018 is estimated at USD 1,037 million.

67 The project progress status shall be presented in the monthly progress report (MPR), and quarterly progress report (QPR) under the Project.

Table 3.11: Implementation Schedule

CMRL - PHASE II - Implementation Schedule (CS-ECV02)

Date : 23-Feb-21

S.No	Activity	Start	Finish	Remarks
	CS-ECV02 - CMBT to Puzhuthivakkam			
	Pre Construction			
1	Notice For invitation		22-Jan-21	Completed
2	Pre Bid Meeting, Queries , Addendum and Bid Submission	23-Jan-21	27-May-21	
3	Bid Opening		28-May-21	
4	Technical , Financial Evaluation & issue of LOA	29-May-21	25-Aug-21	
5	Contract Commencement		22-Sep-21	
	Construction - Civil Works			
	Viaduct			
6	Submission of Initial works programme Establishment of site office.	23-Sep-21	20-Oct-21	
7	Establishment and Commissioning of Batching Plant and submission of Detail works programme.	21-Oct-21	01-Dec-21	
8	Commencement of Barricading and obtaining approvals for Traffic diversion.	23-Sep-21	01-Dec-21	
9	Completion of the initial pile load tests	01-Dec-21	05-Jan-22	
10	Completion of first working pile	05-Jan-22	12-Jan-22	
11	Completion of 50% working piles	12-Jan-22	18-May-22	
12	Completion of 100% working piles	18-May-22	24-Aug-22	
13	Completion of first Pile Cap	29-Dec-21	09-Feb-22	
14	Completion of 50% pile caps	09-Feb-22	15-Jun-22	
15	Completion of 100% pile caps	15-Jun-22	21-Sep-22	
16	Casting of first Pier	23-Feb-22	09-Mar-22	
17	Completion of 50 % Piers	09-Mar-22	13-Jul-22	
18	Completion of 100 % Piers	13-Jul-22	19-Oct-22	
19	Establishing Casting Yard with prestressing arrangements, handling equipment and formwork/moulds ready for production of precast elements.	01-Dec-21	09-Mar-22	
20	Casting of first pre-cast pier-cap at casting yard for approval of formwork and casting beds by Engineer.	10-Mar-22	06-Apr-22	
21	Casting of 50% pre-cast pier-cap at casting yard	07-Apr-22	10-Aug-22	
22	Casting of 100% pre-cast pier-cap & cast insitu pier caps	11-Aug-22	14-Dec-22	
23	Completion of Casting of 100% I-Girders	06-Apr-22	24-Aug-22	
24	Casting of first U-girder at casting yard for approval of formwork and casting beds by Engineer.	06-Apr-22	04-May-22	
25	Casting of 50% U girder at casting yard	05-May-22	01-Mar-23	
26	Casting of 100% U girder at casting yard	02-Mar-23	23-Aug-23	
27	Erection of first Pier Cap	04-May-22	18-May-22	
28	Erection of 50% Pier Cap	19-May-22	05-Oct-22	
29	Erection of 100% Pier cap	06-Oct-22	08-Feb-23	
30	Completion of Precast & Cast in-situ Portal frames	06-Apr-22	19-Oct-22	
31	Commencement of Fabrication of Launching Girders	19-Feb-22	20-Apr-22	
32	Erection of Launching Girders	21-Apr-22	15-Jun-22	
33	Erection of first U-girder using Launching Girder	28-Apr-22	29-Jun-22	
34	Erection of 50% U girder	30-Jun-22	05-Apr-23	
35	Erection of 100% I-girder	18-Aug-22	16-Nov-22	
36	Erection of 100% U girder	06-Apr-23	01-Nov-23	
37	Partial access of Viaduct for track (Approx. 4 km with Continuous stretch)		14-Jun-23	
38	Partial access of Viaduct for track (Approx. 4 km Continuous stretch & cumulatively 8 km stretch)		27-Sep-23	
39	Partial access of Viaduct for track (Balance stretch)		10-Jan-24	
40	Partial access of Viaduct to E&M contractor along with cable tray supports and all associated works (Approx. 4 Km stretch)		19-Jul-23	
41	Partial access of Viaduct to E&M contractor along with cable tray supports and all associated works (Approx. 4 Km stretch)		01-Nov-23	
42	Partial access of Viaduct to OHE and E&M contractor along with cable tray supports and all associated works (Balance 4 Km stretch).		14-Feb-24	
43	Completion of all works of Viaduct including all ancillary works		20-Mar-24	
	STATION			
44	Piling & Pile Cap Works	06-Jan-22	24-Aug-22	
45	Construction of Pier upto Concourse Lvl	25-Jun-22	21-Sep-22	
46	Construction of Pier upto Pier Cap Lvl	25-Jul-22	19-Oct-22	
47	Structural works upto Concourse Lvl	23-Sep-22	08-Feb-23	
48	Structural works upto Platform Lvl	22-Dec-22	28-Jun-23	
49	Station Roof Structure	28-Jun-23	29-Nov-23	
50	Entry/ Exit Structure - Foundation	18-Aug-22	16-Nov-22	
51	Entry/ Exit Structure - Structural Works	17-Nov-22	14-Jun-23	
52	Entry/ Exit Structure - Sump & Pump Room	18-Aug-22	05-Apr-23	
53	Architectural Finishing works - Concourse Lvl	01-Mar-23	20-Mar-24	
54	Architectural Finishing works - Platform Lvl	19-Jul-23	29-May-24	
55	Architectural Finishing works - Entry/Exit	15-Jun-23	20-Mar-24	
56	Access to Track Contractor		14-Jun-23	
57	Access to M&E Contractor		14-Jun-23	
58	Access to S&T Contractor		19-Jul-23	
59	Access to Traction [PS&OHE] Contractor		20-Sep-23	
60	Access to Lift, Escalator , AFC Contractor		20-Mar-24	
61	Track Installation	14-Jun-23	09-May-24	

S.No	Activity	Start	Finish	Remarks
62	System Installation	14-Jul-23	06-Sep-24	
63	Integrated Testing and Commissioning	07-Sep-24	07-Feb-25	
64	CMRS	07-Feb-25	07-Apr-25	
65	ROD		08-Apr-25	

CMRL - PHASE II - Implementation Schedule (CS-ECV03)

Date : 23-Feb-21

S.No	Activity	Start	Finish	Remarks
	CS-ECV03 - Puzhuthivakkam (Excluding Station) to Elcot			
	Pre Construction			
1	Notice For Invitation		12-Nov-20	Completed
2	Pre Bid Meeting, Queries , Addendum and Bid Submission	13-Nov-20	16-Mar-21	
3	Bid Opening		17-Mar-21	
4	Technical , Financial Evoluation & issue of LOA	18-Mar-21	14-Jun-21	
5	Contract Commencement		12-Jul-21	
	Construction - Civil Works			
	Viaduct			
6	Submission of Initial works programme Establishment of site office.	13-Jul-21	09-Aug-21	
7	Establishment and Commissioning of Batching Plant and submission of Detail works programme.	10-Aug-21	20-Sep-21	
8	Commencement of Barricading and obtaining approvals for Traffic diversion.	13-Jul-21	20-Sep-21	
9	Completion of the initial pile load tests	20-Sep-21	25-Oct-21	
10	Completion of first working pile	25-Oct-21	01-Nov-21	
11	Completion of 50% working piles	01-Nov-21	07-Mar-22	
12	Completion of 100% working piles	07-Mar-22	13-Jun-22	
13	Completion of first Pile Cap	18-Oct-21	29-Nov-21	
14	Completion of 50% pile caps	29-Nov-21	04-Apr-22	
15	Completion of 100% pile caps	04-Apr-22	11-Jul-22	
16	Casting of first Pier	13-Dec-21	27-Dec-21	
17	Completion of 50 % Piers	27-Dec-21	02-May-22	
18	Completion of 100 % Piers	02-May-22	08-Aug-22	
19	Establishing Casting Yard with prestressing arrangements, handling equipment and formwork/moulds ready for production of precast elements.	20-Sep-21	27-Dec-21	
20	Casting of first pre-cast pier-cap at casting yard for approval of formwork and casting beds by Engineer.	28-Dec-21	24-Jan-22	
21	Casting of 50% pre-cast pier-cap at casting yard	25-Jan-22	30-May-22	
22	Casting of 100% pre-cast pier-cap & cast insitu pier caps	31-May-22	03-Oct-22	
23	Completion of Casting of 100% I-Girders	24-Jan-22	13-Jun-22	
24	Casting of first U-girder at casting yard for approval of formwork and casting beds by Engineer.	24-Jan-22	21-Feb-22	
25	Casting of 50% U girder at casting yard	22-Feb-22	19-Dec-22	
26	Casting of 100% U girder at casting yard	20-Dec-22	12-Jun-23	
27	Erection of first Pier Cap	21-Feb-22	07-Mar-22	
28	Erection of 50% Pier Cap	08-Mar-22	25-Jul-22	
29	Erection of 100% Pier cap	26-Jul-22	28-Nov-22	
30	Completion of Precast & Cast in-situ Portal frames	24-Jan-22	08-Aug-22	
31	Commencement of Fabrication of Launching Girders	09-Dec-21	07-Feb-22	
32	Erection of Launching Girders	08-Feb-22	04-Apr-22	
33	Erection of first U-girder using Launching Girder	15-Feb-22	18-Apr-22	
34	Erection of 50% U girder	19-Apr-22	23-Jan-23	
35	Erection of 100% I-girder	07-Jun-22	05-Sep-22	
36	Erection of 100% U girder	24-Jan-23	21-Aug-23	
37	Partial access of Viaduct for track (Approx. 4 km with Continuous stretch)		03-Apr-23	
38	Partial access of Viaduct for track (Approx. 4 km Continuous stretch & cumulatively 8 km stretch)		17-Jul-23	
39	Partial access of Viaduct for track (Balance stretch)		30-Oct-23	
40	Partial access of Viaduct to E&M contractor along with cable tray supports and all associated works (Approx. 4 Km stretch)		08-May-23	
41	Partial access of Viaduct to E&M contractor along with cable tray supports and all associated works (Approx. 4 Km stretch)		21-Aug-23	
42	Partial access of Viaduct to OHE and E&M contractor along with cable tray supports and all associated works (Balance 4 Km stretch).		04-Dec-23	
43	Completion of all works of Viaduct including all ancillary works		08-Jan-24	
	STATION			
44	Piling & Pile Cap Works	26-Oct-21	13-Jun-22	
45	Construction of Pier upto Concourse Lvl	14-Apr-22	11-Jul-22	
46	Construction of Pier upto Pier Cap Lvl	14-May-22	08-Aug-22	
47	Structural works upto Concourse Lvl	13-Jul-22	28-Nov-22	
48	Structural works upto Platform Lvl	11-Oct-22	17-Apr-23	
49	Station Roof Structure	17-Apr-23	18-Sep-23	
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58	Access to S&T Contractor		08-May-23	
59	Access to Traction (PS&OHE) Contractor		10-Jul-23	
60	Access to Lift, Escalator , AFC Contractor		08-Jan-24	
61	Track Installation	03-Apr-23	27-Feb-24	

S.No	Activity	Start	Finish	Remarks
62	System Installation	03-May-23	26-Jun-24	
63	Integrated Testing and Commissioning	27-Jun-24	27-Nov-24	
64	CMRS	27-Nov-24	25-Jan-25	
65	ROD		26-Jan-25	

4. DESCRIPTION OF THE ENVIRONMENT (BASELINE DATA)

68 The collection of current baseline information on physical, ambient, ecological, and socioeconomic environment of the project area of influence provides an important reference for conducting an EIA. The description of environmental settings includes the characteristics of the area in which the project activities would occur and likely to be affected by project related impacts. Compiled existing baseline conditions include primary data on air quality, water quality, noise, soil, ecology and biodiversity, and socioeconomic aspects. Secondary data were also collected from published sources such as Indian Meteorological Department (IMD), NGO reports on ecology, press reports on water availability, water quality, water table etc.

4.1 Data Collection Methodology

69 The data on water, air, and soil were collected through field monitoring conducted in 2016, 2019 and 2022. Initially for the preparation of CMRL Phase II Detailed Project Report the base line data was collected during the year 2016. In 2019, the EIA report was prepared so another set of baseline data along the alignment was collected to add the baseline data of missing locations in the project environment. The noise and vibration data were further elaborated in 2019 and the modeling study was conducted in 2022 including the sensitive receptors along the Balance C5. Data on biodiversity was collected through field studies in May 2018. Meteorological data was collected from IMD. Efforts have been made to compile the available data from literature, books, maps and reports. The methodology adopted for data collection is highlighted wherever necessary. Environmental attributes and samplings of baseline surveys are presented in Table 4.1 and monitoring locations are presented in Table 4.2 and Figure 4.2. The detailed analysis reports received from the monitoring laboratory are provided in Annexure 7, whereas summary from the reports is discussed in respective sections. In 2022, Prior construction the contractor has carried the baseline study at their respective project locations.

70 MoEF&CC OM No. J-11013/41/2006-1A-11 (I) (Part) dated 29th August, 2017 pertains to projects/activities requiring EC under EIA Notification, 2006. This project is not listed among activities/projects requiring EC. Moreover, treatment of water, wastewater is not among the project activities – it will be done by municipal authorities. Treatment and safe disposal of surplus soil if any will be done by the Contractor as provided for in EMP. Contractor has collected baseline soil and groundwater quality data once prior to operation of the plants and quarterly during construction. After Construction, Contractor will conduct soil and groundwater analysis and be obliged to reinstate the used sites no worse than the conditions of pre-construction. In addition to monitoring of air quality pre-construction and during construction, measures to mitigate air pollution which have been specified in the EMP and approved by CMRL will be implemented during construction. Thus, adequate provision has been made in the EMP and EmoP to address pollution due to all constituents of air, water and soil notwithstanding values measured for this report.

Table 4.1 Environmental Attributes and Data Source

Sl. No	Attribute	Parameter	No. of Samples	Source
Physical Environment				
1.	Geology	Geological Status	---	Literature review
2.	Seismology	Seismic Hazard	---	Literature review
3.	Climate	Climate Parameters	---	IMD
4.	Soil Quality	Physico-chemical parameters	18	Sampling/ Monitoring locations

Sl. No	Attribute	Parameter	No. of Samples	Source
Ambient Environment				
5.	Water Quality	Physical, Chemical and Biological parameters	17 (Groundwater) Global Hospital (Surface)	Sampling/ Monitoring locations
6.	Ambient Air Quality	PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO	23	Sampling/ Monitoring locations
7.	Noise	Noise levels in dB (A) Lmax, Lmin, Leq, L_{10}, L_{50}, L_{90}	20 by land use + 10 (Sample Sensitive Receptors)	Sampling/ Monitoring locations
8.	Vibration	Peak Particle Velocity in mm/s	2 by land use + 6 (Sample Sensitive Receptors)	Sampling/ Monitoring locations
Ecological Environment				
9.	Trees	Number	Once	Field Studies
10.	Flora and Fauna	Sightings	Once	Literature review
Socio-Economic Environment				
11.	Socio-economic aspects	Socio-economic profile	Once	Field Studies by Social Team, Literature review.

Table 4.2: Details of Sampling / Monitoring Locations*

Location Code	Distance from Sampling Location to Alignment	Tests conducted	Land Use**
Baseline Study 2016 and 2019			
5C	Alwar Thiru Nagar junction, 7m	A,W,S,N	Residential+ commercial
5D	MIOT Hospital, 18m	A,W,S,N	Industrial
5E	Medavakkam Junction, 30m	A,W,S,N	Residential
5F	Global Hospital, 38m (700m from hospital)	A,W,S,N	Residential
5G	Kalpana Hospital, Adambakkam MRTS, 1m	A,W,S	Residential
5H	Madipakkam Koot Road, 10m	A,W,S	Residential+ Commercial
5I	Velakallu Bus Stop, 7m	A,W,S	Residential+ Commercial
Baseline study at Project alignment and Facilities 2022			
Location Code	**Location**	**Tests conducted**	**Land Use****
PC1	Manapakkam	A,W,S,N	Commercial
PC2	Ramapuram	A,W,S,N	Commercial
PC3	CTC	A,W,S,N	Commercial
PC4	Vayalanallur Casting Yard	A,W,S,N	Commercial
PC5	Adyar River	A,W,S,N	Commercial
PC6	Mugalivakkam	A,W,S,N	Commercial

PC7	Nandampakkam Steel Yard	A,W,S,N	Commercial
PC8	Nandampakkam Batching Plant	A,W,S,N	Commercial
PC9	Vanuvampet	A,W,S,N	Commercial
PC10	Koyambedu	A,W,S,N	Commercial
PC11	Alandur	A,W,S,N	Commercial
PC12	TP3 Kovilambakkam	A,N	Commercial
PC13	Kovilambakkam Batching Plant	A,N	Commercial
PC14	Perumbakkam Office	A,N	Commercial
PC15	Elcot	A,N	Commercial
PC16	Kolapakkam Casting Yard	A,N	Commercial

A: Air, W: Water; S: Soil, N: Noise
**Locations for noise and vibration at sensitive receptors are listed under Table 4.17 and Table 4.19 respectively.*
***As per CPCB guideline which is presented under Noise Section.*

71 A further 213 environmentally sensitive receptors located within 200m on either side of alignment (from center line) as listed in Annexure 1 have been identified from site reconnaissance, comprising educational institutions, religious places, hospitals and courts of law. To elaborate the baseline, a full set of data on air, water (surface and ground), soil, noise and vibration were collected prior to the construction commencement.

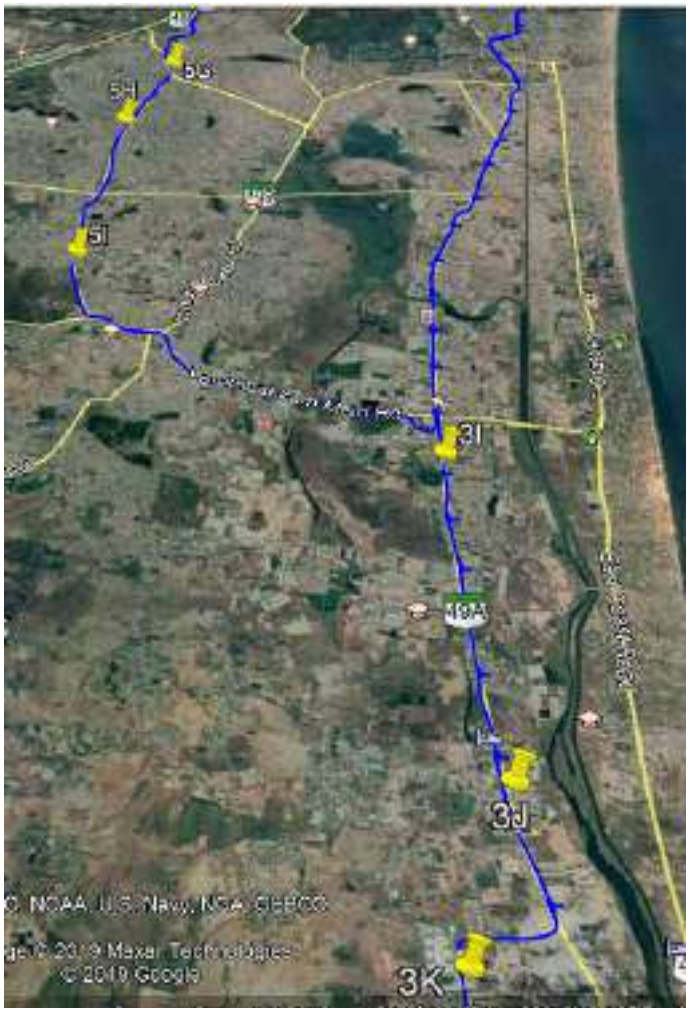
72 Locations of sampling for air, water and soil quality during the year 2016, 2019 and 2022, are depicted in Figure 4.1.

73 Sampling locations were selected to represent land use along the alignment namely commercial, residential and silence zone (health centers, religious and educational uses). The baseline information is categorized as physical, ambient, ecological and socioeconomic environment with depiction in following sections.

Figure 4.1 Monitoring Locations –Soil, Air, Water and Noise Part 1 by land use

locations 5C to 5F; Field Survey: July 2016

Monitoring Locations – Soil, Air, Water Part 2 by Land use



locations 5G to 5I; Field Survey: Nov/Dec 2019

Monitoring Locations – Soil, Air, Water & Noise Part 3 by Land use

locations PC1 to PC16; Field Survey: 2022

Monitoring Locations – Soil, Air, Water & Noise Part 3 by Land use

Locations PC1 to PC16; Field Survey: 2022

4.2 Physical Environment

4.2.1 Physiography

74 Chennai is located on the South–Eastern coast of India in the North–Eastern part of Tamil Nadu. It is situated on a flat coastal plain that's why it is also known as the Eastern Coastal Plains. The study area is lies between Latitude of 13° 10' N to 12° 49' N and Longitude of 80° 10' E to 80° 14' E. Chennai is a low-lying area and the land surface is almost flat. It rises slightly as the distance from the sea-shore increases but the average elevation of the city is not more than 3 m above mean sea-level, while most of the localities are just at sea-level and drainage in such areas remains a serious problem. The topographical setting of project area is shown in Figure 4.2.

Figure 4.2 Topographical setting of Project Area

Source: https://en-gb.topographic-map.com/map-qjlf3/Chennai/?center=13.13766%2C79.9367&zoom=13

4.2.2 Soil

75 The recent sandy soil (Entisols) is immature soils and is predominant in the city and it occurs in small patches. The major soil in this region belongs to Alfisols and Entisols. Inceptisols and Vertisols are found in a very limited area only. These soils are generally poor in soil nutrients. They have medium to high permeability. They have low water holding capacity except in patches of clayey soils.

76 As per the predominant pattern shown up during the geotechnical investigation done in year 2016, hard rock is found at depth varying from 15 m to 20 m; sandy silty clayey soil upto depth 10.5 and weathered rock in the intervening range of depth. Ground water is found at depth upto 3 m.

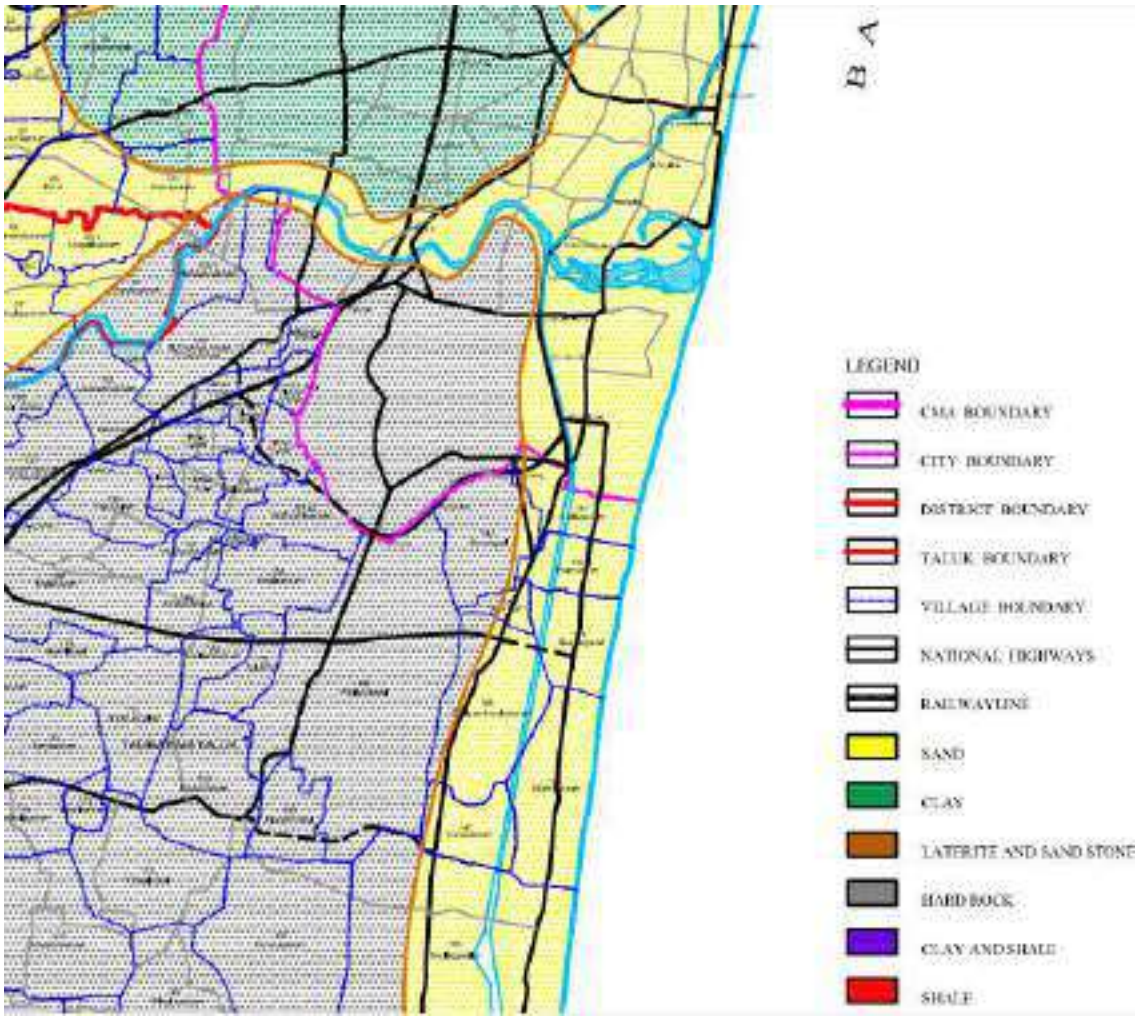
77 The laboratory analysis results for soil are reported in Table 4.3. The soils are slightly alkaline in nature. Organic matter content in soils varies from 0.57% to 1.26%. The soil types found along the alignments, as recorded in the Master Plan 2026 for

CMA are presented in Table 4.3 and Figure 4.3, subject to more specific findings from geotechnical investigations.

Table 4.3: Soil Types along alignment

Section	Type of soil
CMBT to Alapakkam	Clayey
Alapakkam to Porur to Ramapuram (Formerly DLF IT SEZ)	Sandy
Ramapuram (Formerly DLF IT SEZ) to Sholinganallur	Hard Rock

Figure 4.3: Soil Types in CMA



Second Master Plan for Chennai Metropolitan Area 2026, CMDA

78 In 2016 and 2019, As part of the baseline studies, Soil samples were collected in 11 locations and tested for 16 parameters, and the results are recorded as shown in **Table. 4.4**.

Table 4.4 Results of Laboratory Analysis of Soil Sample (2016 and 2019)

S. No.	Parameter	Unit	5C	5D	5E	5F	5G	5H	5I
1	pH (at 25^{0}C)		7.11	7.75	7.86	7.28	6.15	5.34	5.94
2	Conductivity (1:2 soil water sus.)		0.19	0.22	0.25	0.17	102	35	61
3	Chloride	mg/kg	24.79	33.37	19.11	47.67	42.6	18.3	68.3
4	Available Phosphorous	Kg/hec	28.24	25.83	23.97	22.16	0.28	0.31	0.51
5	Total Zinc as Zn	mg/kg	12.35	12.37	13.20	14.36	14.2	32.2	16.2
6	Manganese as Mn	mg/kg	166.32	190.32	118.37	197.08	15	16.2	14.3
7	Total Lead as Pb @	mg/kg	9.65	10.77	11.40	8.78	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)
8	Total Copper as Cu	mg/kg	14.82	19.45	16.23	16.88	22.3	24.3	14.3
9	Organic Carbon	%	0.73	0.63	0.59	0.66	0.92	0.84	0.86
10	Water Soluble Sulphate	mg/kg	20.12	18.99	22.53	27.64	145	82	16.3
11	Boron	mg/kg	1.86	2.27	1.76	1.33	0.039	5813	9563
12	Iron	mg/kg	420.37	448.5	428.23	455.64	245	318	184
13	Nickel	mg/kg	18.27	20.18	18.21	20.02	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)
14	Bicarbonate	mg/kg	125.69	138.62	126.35	126.36	24.3	16	32
15	Calcium	mg/kg	140.09	160.24	86.82	76.28	17.1	7.39	27.4
16	Magnesium	mg/kg	27.28	27.98	22.36	20.36	24.6	38.6	44.3
17	Sand	%	34.93	31.97	35.17	35.78	53.5	51.7	44.4
18	Silt	%	38.88	39.05	39.06	37.66	28.5	26.3	32.6
19	Clay	%	28.19	28.98	26.77	28.56	18	22	23
20	Sodium	mg/kg	56.45	45.55	47.45	42.32	1458	2154	1436
21	Potassium	kg/hec	70.18	78.03	98.53	92.76	45.6	98	148
22	Sulphur	mg/kg	29.18	26.78	26.27	19.27	48.4	27.4	5.46
23	Organic Matter	%	1.26	1.08	1.03	1.05	1.6	1.45	1.84
24	Orthophosphate	mg/kg	70.65	67.08	73.91	76.20	794	214	12.3
25	Carbonate	mg/kg	2.99	5.01	5.03	3.88	18.6	12.6	14
26	Arsenic	mg/kg	BDL	BDL	BDL	BDL	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)
27	Mercury	mg/kg	BDL	BDL	BDL	BDL	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)
28	Cadmium as Cd	mg/kg	1.24	1.66	1.31	1.36	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)
29	Molybdenum	mg/kg	0.60	0.82	0.69	0.63	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)
30	Available Nitrogen	Kg/hec	199.97	305.36	268.66	264.53	5250	14	24

** As per Bureau of Indian Standards. The rest are as per ISO Soil Standards.*
4 locations 5C to 5F July 2016, 3 locations 5G to 5I Nov/Dec 2019, @ EPA screening limit soil residential 1200ppm eq to 1200mg/kg Source: https://www.atsdr.cdc.gov
5C Alwarthiru nagar, 5D MIOT Hospital, 5E Medavakkam junction, 5F Global Hospital, 5G Kalpana Hospital Adambakkam, 5H Madipakkam Koot Road, 5I Velakallu Bus Stop

79 In 2022, before the initiation of the construction activity, Soil samples were collected in 11 locations and tested for 16 parameters, and the results are recorded as shown in **Table. 4.4A**.

Table 4.4A Results of Laboratory Analysis of Soil Sample (2022)

S.No	Parameters	Units	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
1	pH value @ 25ºC	-	6.08	6.53	6.10	6.82	6.88	6.91	7.01	7.12	7.22	6.78	7.15
2	Electrical Conductivity @ 25°C	µS/cm	396	427	325	473	489	501	524	511	489	488	509
3	Organic Matter	%	0.48	0.55	0.42	0.61	0.58	0.7	0.71	0.73	0.54	0.57	0.71
4	Moisture Content @105º C	%	4.54	5.21	3.98	5.79	5.83	6.15	6.13	5.54	5.64	5.28	5.88
5	Chloride (as Cl-)	meq/L	0.96	1.11	0.85	1.24	1.25	1.34	1.39	1.19	1.19	1.34	1.31
6	Sulphates	mg/kg	0.10	0.12	0.09	0.13	0.14	0.18	0.15	0.16	0.16	0.14	0.17
7	Manganese (as Mn)*	mg/kg	3.24	3.89	2.92	4.22	4.26	4.16	4.12	4.29	4.13	4.16	4.19
8	Copper (as Cu)*	mg/kg	0.11	0.14	0.11	0.16	0.14	0.14	0.13	0.17	0.18	0.17	0.18
9	Cadmium (as Cd)*	mg/kg	0.07	0.10	0.08	0.13	0.15	0.16	0.15	0.15	0.15	0.15	0.15
10	Lead (as Pb)*	mg/kg	0.12	0.16	0.13	0.19	0.18	0.17	0.16	0.21	0.21	0.22	0.2
11	Chromium (as Cr)*	mg/kg	1.03	1.37	1.12	1.64	1.59	1.54	1.59	1.49	1.54	1.54	1.54
12	Selenium (as Se)*	mg/kg	1.46	1.94	1.58	2.32	2.3	2.19	2.19	2.28	2.05	2.19	2.19
13	Arsenic (as As)*	mg/kg	0.57	0.75	0.61	0.90	0.82	0.57	0.79	0.76	0.72	0.84	0.82
14	Nickel (as Ni)*	mg/kg	0.33	0.43	0.36	0.54	0.51	0.46	0.51	0.43	0.46	0.56	0.51
15	Boron (as B)*	mg/kg	0.65	0.86	0.72	1.08	1.02	1.11	1.05	1.15	1.16	1.09	1.12
16	Zinc (as Zn)*	mg/kg	0.97	1.29	1.08	1.62	1.54	1.68	1.58	1.46	1.54	1.52	1.54

4.2.3 Geology and Minerals

80 The geological formations in the region are from the Archaeans to the recent Alluvium (Table 4.5). The geological formations can be grouped into three units, namely (i) the Archaean crystalline rocks, (ii) consolidated Gondwana with Tertiary sediments and (iii) the recent Alluvium. Most of the geological formations are concealed by the alluvial materials, except for a few exposures of crystalline rocks like charnockites along the railway track in Guindy area. The thickness of Gondwana shales is highly variable in the city.

Table 4.5 Geological Formation in the Project Area

Geological succession in Chennai district Group	System	Age	Lithology	Aquifer Characteristics
Quarternary	Recent	Sub-Recent	Soils, Alluvium (sand & silt)	Moderate to good porous aquifer system
Tertiary	(Cuddalore Sandstone equivalents)	Eocene to Piliocene	Sandstone & and shale (fossiliferous)	Moderately Porous Aquifer
---UNCONFIRMITY---				
Mesozic	Upper Gondwana (Sri Perumbudur Beds)	Lower Cretaceous to Lower Jurassic	Brown Sandstone and siltstone; Grey shale; Black shale	Less Porous aquifer with minor fractures
---UNCONFIRMITY---				
Azoic	Archaean	--	Charnockites, Granites, Gneisses	Fractured Aquifer

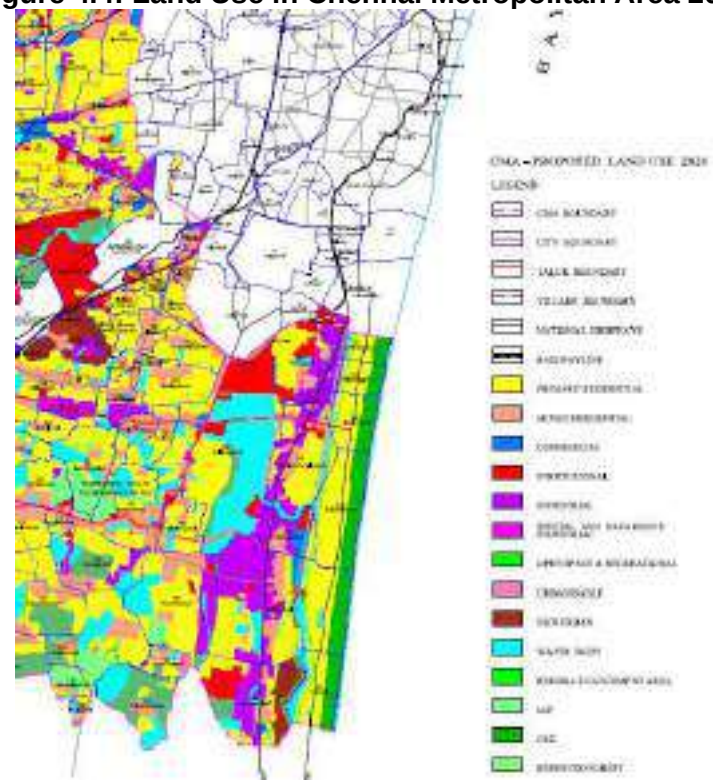
Source: cpheeo.nic.in

4.2.4 Land Use

81 Landuse along the alignment of Balance C5 is predominantly mixed residential except industrial at Alapakkam, and commercial at CMBT, from Mugalivakkam to

Manapakkam (2km) and from Perumbakkam to Sholinganallur (Approx 3km). Land use in year 2006 is depicted in Figure 4.4 and classified in Table 4.6.

Figure 4.4: Land Use in Chennai Metropolitan Area 2006



Source: Second Master Plan for Chennai Metropolitan Area, 2026

Table 4.6: Land use in CMA

	Land use 2006		Land use 2026	
	Area (ha)*			
Land use	**Chennai City**	**Rest of CMA**	**Chennai City**	**Rest of CMA**
Residential	9523	22877	8342	45593
Commercial	1245	390	714	880
Industrial	908	6563	822	10690
Institutional	3243	3144	2868	3888
Open Space and Recreational	366	200	1000	392
Agricultural	99	12470	Nil	7295
Non-urban	82	2433	113	2333
Others	2087	56507	3754	28147
Urbanisable	Nil	Nil	Nil	2075
Total	17553	104584	17613	101293

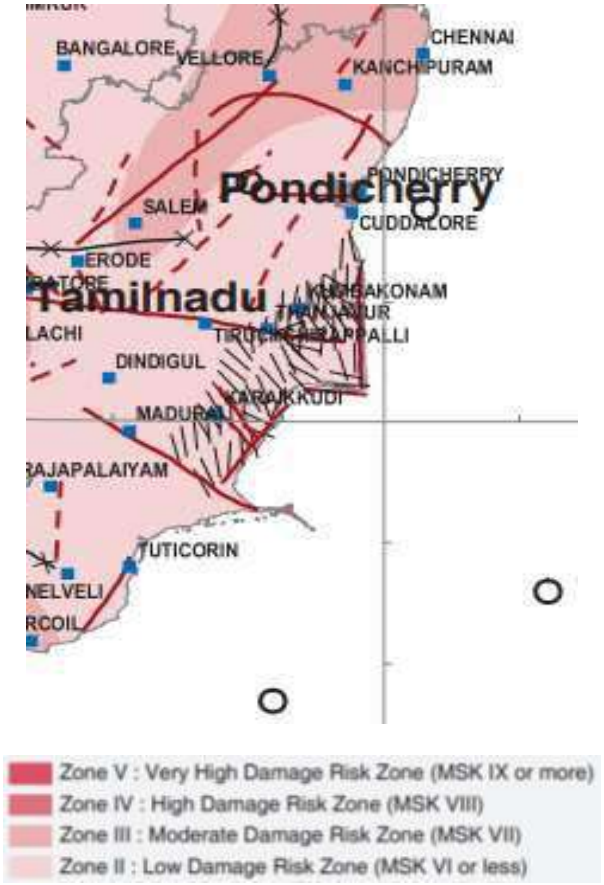
** Rounded off*

Source: Second Master Plan for Chennai Metropolitan Area, 2026

4.2.5 Seismicity

82 As per seismic zoning map of India shown at Figure 4.5, Tamil Nadu and Chennai are located in Moderate Seismic Zone (Zone III–BIS: 1893 (2001)).

Figure 4.5 Earthquake Hazard Map



Source: Vulnerability Atlas, 2nd edition, BMTPC

83 The last reported tremor in Chennai was on 12 February 2019 due to earthquake measuring 5.1 Richter (Source: IMD) with epicenter 10 km deep in Bay of Bengal.

4.2.6 Meteorology

4.2.6.1 Temperature

84 Chennai has a tropical wet and dry climate. The city lies on the thermal equator and is also on the coast, which prevents extreme variation in seasonal temperature. Meteorological data like monthly total rainfall, maximum & minimum temperature, wind rose and relative humidity of the Chennai for a period of Jan 2011 to Dec 2023 collected from IMD. Table 4.7 and Table 4.8 depict that the hottest part of the year is in the month of May with maximum temperature varies 41.0°C to 43.0°C. The coolest part of the year is January, with minimum temperature varies 18.7°C to 20.6°C.

Table 4.7 Monthly Highest Maximum Temperature (Deg C)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	30.6	32.3	36.6	38.6	42.8	41.8	39.2	38.5	36.7	36.2	32.5	31.8
2015	31.3	33.1	35.1	36.8	42.2	39.6	41.0	37.6	36.9	35.7	32.6	32.4
2016	33.0	34.0	39.0	41.0	41.0	39.0	37.0	38.0	37.0	37.0	34.0	31.0
2017	31.0	36.0	36.0	41.0	43.0	41.0	39.0	37.0	36.0	36.0	34.0	33
2018	31.1	32.8	35.6	36.6	39.1	39.8	38.1	37.8	37.3	36.4	32.7	31.3
2019	30.8	34	35.6	36.8	41.5	41.5	40.4	38.3	36.8	34.4	35.1	31
2020	32.2	33	34.4	36.2	41.8	40.6	38.3	36.5	36.6	37.1	33.3	31.2
2021	32	33.5	38.3	41.2	40.3	39.9	37.2	36.8	36.6	35.9	32.2	32.4
2022	32.2	33.5	37.6	36	39.8	40.1	36.6	37.2	37.5	35.1	31.8	31.9
2023	31.1	34.1	34	38.1	41.8	42.3	37.6	38.2	36.4	36.5	32.6	32.2

Source: Regional Meteorological Centre, Chennai

Table 4.8 Monthly Lowest Minimum Temperature (Deg C)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	20.3	19.0	22.1	25.6	24.3	23.0	23.6	22.9	23.7	23.4	21.3	21.0
2015	19.0	20.8	23.2	23.5	25.6	24.6	23.9	23.1	23.5	24.3	22.4	21.5
2016	19.0	20.0	23.0	25.0	25.0	24.0	24.0	24.0	23.0	22.0	19.0	19.0
2017	19.0	19.0	22.0	26.0	27.0	25.0	24.0	24.0	24.0	23.0	23.0	21
2018	19	19	21	25.4	26.6	25.2	22.4	23.2	22.4	23.8	22.6	20
2019	19.7	21	23.6	26.4	28.4	23.4	23.8	23.2	22.9	23.9	22.8	22
2020	18.7	20.3	23.7	23.1	27.9	25.4	24.2	24.6	24	23.6	20.8	20.7
2021	20.6	20.4	22.6	23.1	24.6	24.4	23.8	23.6	24	24.2	20.8	19.2
2022	20.6	20.4	22.2	26.4	24.7	22.8	24.7	23.9	25	22.2	21.3	19.8
2023	19.5	20	22	24.7	25	24.5	24.6	22.8	23.8	23.3	23.3	20.6

Source: Regional Meteorological Centre, Chennai

4.2.6.2 Rainfall

85 The city gets most of its seasonal rainfall from the North–East monsoon, from October to December. South-West monsoon prevails from June to September. Cyclones in the Bay of Bengal sometimes traverse through the city. The highest annual rainfall recorded is 1,049.3mm in November 2015 during an extreme weather event, the highest since November 1918 when 1,088 mm of rainfall was recorded. The monthly rainfall is given in Table 4.9.

Table 4.9: Monthly Rainfall (mm)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	0.1	9.9	0.0	0.0	13.5	96.2	69.7	222.6	130.8	405.5	196.9	149.9
2015	2.8	0.0	0.0	12.3	7.9	20.3	205.9	106.5	75.0	159.9	1,049.3	454.7
2016*	0.4	0.0	0.0	0.0	216.8	133.1	41.3	24.5	264.7	16.4	73.8	219.9
2017*	0.0	5.0	2.5	0.0	0.5	60.0	55.0	90.0	65.0	160.0	155.0	9.0
2018	1.9	1	2.9	0.0	0.0	63.1	117	191.5	60.7	162.2	190.7	35.8
2019	0.2	4	0.0	0.0	0.0	44.7	142.9	120.9	184.1	318.2	108.2	178.8
2020	67.8	0.8	0.0	25.6	0.0	41.8	69.2	69.4	113	318.5	525.9	189.1
2021	166.2	8.5	0.0	24.4	16.8	54.7	242.8	168.2	92.1	216.4	1044.3	224.1
2022	90.3	0.0	0.0	0.0	39.5	167.1	107.2	102.2	121.21	171.0	526.2	263.1
2023	4.1	0.8	52.7	1.5	44.9	210.8	56.3	56.3	200.6	109.5	564.7	594.6

*Source: Regional Meteorological Centre, Chennai, * www.meteoblue.com*

4.2.6.3 Humidity

86 Mean Relative Humidity is presented in Table 4.10 and Table 4.11. It varies 62% to 90% at 08:30 hrs. and 56% to 88% at 17:30 hrs. 2016 and 2017 data were collected at different time slots.

Table 4.10: Monthly Mean Relative Humidity at 08:30 hrs (%)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	78	79	72	72	67	64	70	78	77	82	82	83
2015	83	81	74	72	69	66	70	77	77	83	91	86
2016*	94	100	94	94	100	100	100	100	100	94	100	100
2017*	100	94	94	94	89	100	100	100	100	100	100	100
2018	78	79	81	74	68	62	64	71	78	81	82	83
2019	82	79	77	78	75	66	74	72	83	86	87	86
2020	86	83	85	84	76	63	82	81	81	79	85	83
2021	85	76	77	74	66	67	76	79	82	85	94	84
2022	87	72	84	83	78	72	75	73	73	81	87	87
2023	82	82	79	73	72	66	69	76	75	80	90	86

*Source: Regional Meteorological Centre, Chennai, * (www.timeanddate.com)*

Table 4.11: Monthly Mean Relative Humidity at 17:30 hrs (%)

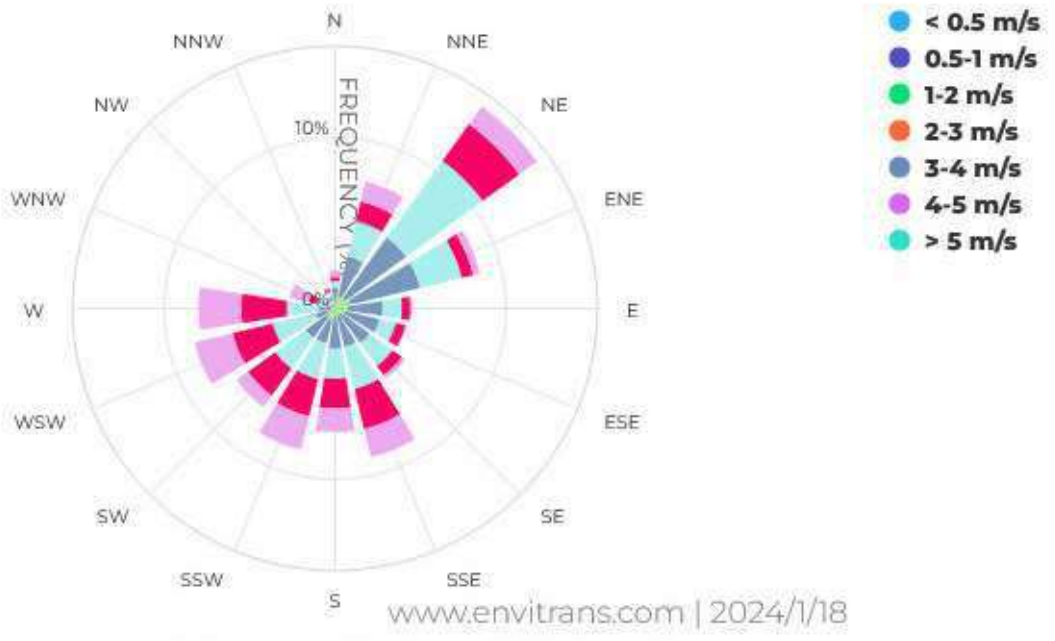
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	69	67	64	68	68	66	65	74	75	80	77	76
2015	73	71	67	69	69	65	70	71	75	78	87	78
2016*	38	30	29	30	30	37	37	33	37	30	27	27
2017*	35	24	38	23	25	16	33	42	47	36	43	40
2018	68	67	68	70	69	60	56	67	73	76	74	73
2019	66	68	67	74	80	70	70	65	78	78	79	80
2020	74	75	76	80	75	64	75	77	77	76	80	73
2021	74	63	65	69	68	65	65	72	76	80	88	73
2022	74	60	71	77	77	69	68	65	71	71	80	77
2023	65	62	67	66	67	67	51	70	73	73	84	77

*Source: Regional Meteorological Centre, Chennai, * (www.timeanddate.com)*

4.2.6.4 Wind

87 The wind rose diagram has been prepared based on the annual data for the year 2023. The prominent direction in Chennai city is NE. Wind rose diagram for the Chennai is shown in Figure 4.6.

Figure 4.6: Wind Rose for Chennai



Source: www.envitrans.com

4.3 Ambient Environment

88 To assess the impact on existing ambient environment due to Balance C5 implementation, it is necessary to have baseline status of ambient environmental parameters.

4.3.1 Water Resources

89 As the city lacks a perennial water source, catering to the water requirements of the population has remained an arduous task. Ground water levels from Jan 2022 to Jan 2023 were up to 10m below ground in pre-monsoon as well as post-monsoon seasons and rise in water level of up to 2m to 4m in all observation wells in Chennai district between pre-monsoon and post-monsoon months. From May 2016 and May 2022, the ground water levels were up to 4m in 77% of observation wells (Groundwater Yearbook of Tamil Nadu and UT Puducherry, 2022 – 23, Central Groundwater Board).

90 As per data provided by CMWSSB, in Jan 2024, the combined water level in the five reservoirs namely Red Hills, Cholavaram, Chembarambakkam, Kandigai and Poondi lakes was 11757 mcft. In May 2019 the combined storage level of these reservoirs was about 160 mcft or 8 MLD. On 19 June 2019, Chennai city officials declared that “Day Zero”, or the day when almost no water is left, had been reached, as all the four main reservoirs supplying water to the city had run dry. Two years of deficient monsoon rainfall, particularly in late 2017 and throughout much of 2018 had led to this crisis (India Today 20 June 2019). Chembarambakkam lake is the nearest to the corridor at distance of 12 km to 15 km.

91 Chennai receives about 985 MLD from various sources against the required amount of 1,200 MLD. As of year 2018, 300 million litres of water was estimated to have been be sourced from the four reservoirs in Chennai with their storage standing at 40% of their capacity; 180 MLD from the desalination plants in Minjur and Nemmeli and 70 MLD (against the usual 180 MLD) from Veeranam tank. Krishna water of

about 400 MLD supplements these sources; and other water sources, including abandoned stone quarries, agriculture wells and Neyveli Corporation mines. (Down to Earth 22 May 2019).

4.3.2 Drainage

92 Adyar River originates at the confluence (Thiruneermalai) of two streams that drains the upstream area of Chembarambakkam tank. It is a small river of 42 km length and a catchment of 800 Sq. km. The river carries flow all through 365 days of a year with an average discharge of 89.43 MCM/Year at Kathipara cause way. It drains the southern part of the district and remains flooded during monsoon. During the high tides, the backwater from the Bay of Bengal enters inland up to 3 to 4 km.

93 Cooum or Koovum (sometimes called Triplicane River) is the other main river flowing through the central part of the district and carries only drainage water, which is highly polluted. It originates from the surplus waters from the Cooum tank in Tiruvallore taluk and the tanks, which are in enroute, discharge their surplus water into the river during flood season. The flow of Cooum River at Korattur is 40.2 MCM/year for an average duration of 31 days in a year.

94 Otteri nala is another small stream flowing in the northern part of the city. Buckingham canal is the man made one for navigation purposes earlier, but now it act as sewerage carrier in the city.

4.3.3 Water Quality

95 In 2016, Water samples have been tested at seven locations namely (i) Alwar Thiru Nagar junction (ii) MIOT Hospital (iii) Medavakkam Junction (iv) Global Hospital (v) Kalpana Hospital, Adambakkam MRTS (vi) Madipakkam Koot Road and (vii) Velakallu Bus Stop. Later in 2022, before the commencement of construction activities, Water samples were collected from 12 locations. The results of the tests conducted in 2016, 2019 and 2022 are recorded in tables 4.12 and 4.12A below.

96 Considering the construction of piers in Adyar River and Adambakkam Lake, the water samples in the two waterbodies were collected and analyzed in October 2020 (Annexure 7-1). The level of COD showed a high level of industrial contamination in Adambakkam Lake.

97 Laboratory analysis depicts that the parameters in groundwater samples are well within the prescribed permissible limits for drinking water as per IS 10500:2012 except turbidity, manganese and mercury at Alwar Thiru Nagar, chloride, nitrogen and coliforms at Porur junction, hardness at MIOT Hospital, Medavakkam and Kalpana Hospital Adambakkam, calcium at MIOT Hospital and Medavakkam, aluminum at Kalpana Hospital Adambakkam, Madipakkam Koot Road, Velakallu bus stop, mercury at MIOT Hospital, chloride at Alwar Thiru Nagar, MIOT hospital and Medavakkam junction, total nitrogen and coliforms at all locations. The results of the water samples (borewell) tested at 11 locations in 2022 are found well within the permissible limits for drinking water except Barium and Lead at all 11 locations and Arsenic at PC3(Chenni trade centre).

98 The measured values of TDS, TSS and BOD at Global Hospital (surface water) were found to violate General Quality Standards of Schedule VI Environment Protection Rules (EPR) 1986 for discharge of pollutant effluents in surface water: these standards are applicable for industries, operations or processes other than those industries, operations or process for which standards have been specified (104 industries) in Schedule I of EPR.

Table 4.12 Results of Laboratory Analysis of Water Sample (2016 & 2019)

SN	Parameter	Unit	5C	5D	5E	5F *	5G	5H	5I	Acceptable/Permissible Limit for drinking water IS 10500 mg/L	Effluent standards – inland surface water EPR 1986 max. mg/L	Wildlife & fisheries - surface water CPCB 1978 Primary criteria mg/L	Drinking water – CPCB 1978 Primary criteria mg/L
1	pH at 25^0C	-	7.13	7.82	7.99	8.15	6.97	7.21	7.61	6.5-8.5/ no relaxation	5.5 to 9.0	6.5 to 8.5	6.5 to 8.5
2	Turbidity	NTU	67.3	<0.1	<0.1	76.5	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	1/5 max	-	-	-
3	Total Dissolved Solids	mg/L	*1826*	*1528*	*1256*	*4386*	921	225	179	500/2000 max	-	-	-
4	Aluminium as Al	mg/L	BDL	BDL	BDL	0.054	**7.1**	**7.1**	**7.6**	0.03/0.2 max	-	-	-
5	Free Ammonia (as NH_3)	mg/L	<1	<1	<1	>0.5	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	-	Total ammonia 0.5 / no relaxation	5.0	1.2 or less
6	Barium (as Ba)	mg/L	0.13	0.146	0.046	0.23	BDL(DL:1.0)	BDL(DL:1.0)	BDL(DL:1.0)	0.7 max/ no relaxation	-	-	-
7	Boron (as B)	mg/L	0.004	BDL	0.04	BDL	4.6	BDL(DL:2.0)	BDL(DL:2.0)	0.5/1	-	-	-
8	Calcium as Ca	mg/L	82.6	210.5	206.4	123.8	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	75/200	-	-	-
9	*Chloride as Cl*	mg/L	*670.1*	*310.4*	*280.9*	*1995.7*	0.08	BDL(DL:0.01)	BDL(DL:0.01)	4.0/no relaxation	-	-	-
10	Copper as Cu	mg/L	BDL	BDL	BDL	BDL	109	24.2	44.4	0.3/no relaxation	3	-	-
11	Fluoride as F	mg/L	>1	>1	>1	>1	147	43.5	14.5	1.0/1,5	2	-	-
12	Iron as Fe	mg/L	0.15	BDL	BDL	0.14	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.3/ 1.0	3	-	-
13	Magnesium (as Mg)	mg/L	52.7	32.6	27.6	188.1	0.46	0.68	0.72	30/100	-	-	-

14	Manganese as Mn	mg/L	0.54	0.02	BDL	0.21	0.38	0.11	0.13	0.1/0.3	2	-	-
15	Nitrate as NO_3	mg/L	BDL	9.5	17.2	1.1	32	10.3	11.3	45/ no relaxation	-	-	-
16	Phenolic Compounds	mg/L	BDL	BDL	BDL	BDL	BDL(DL:0.01)	0.03	BDL(DL:0.01)	0.001/0.002			
17	Selenium (as Se)	mg/L	BDL	BDL	BDL	BDL	32	BDL(DL:1.0)	BDL(DL:1.0)	0.1/ no relaxation	0.05	-	-
18	Silver (as Ag)	mg/L	BDL	BDL	BDL	BDL	47	BDL(DL:1.0)	BDL(DL:1.0)	0.1/ no relaxation	-	-	-
19	Sulphate as SO_4	mg/L	46.1	158.2	11.7	155.6	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)	200/400	-	-	-
20	Sulphide (as S)	mg/L	BDL	BDL	BDL	BDL	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.05/ no relaxation	2.0	-	-
21	Total Alkalinity as $CaCO_3$	mg/L	*460.6*	*411.6*	*382.2*	*225.4*	BDL(DL:2.0)	BDL(DL:2.0)	BDL(DL:2.0)	200/600	-	-	-
22	Total Hardness as $CaCO_3$	mg/L	*422.3*	*659.2*	*628.3*	*1081.5*	BDL(DL:4.0)	BDL(DL:4.0)	BDL(DL:4.0)	200/600	-	-	-
23	Zinc as Zn	mg/L	BDL	0.032	BDL	BDL	0.21	0.05	0.06	5/15	5	-	-
24	Cadmium (as Cd)	mg/L	BDL	BDL	BDL	BDL	0.21	BDL(DL:0.01)	BDL(DL:0.01)	0.003/ no relaxation	2.0	-	-
25	Cyanide (as CN-)	mg/L	BDL	BDL	BDL	BDL	0.14	18	19	0.05/ no relaxation	0.2	-	-
26	Lead as Pb	mg/L	BDL	BDL	BDL	0.009	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	0.01/ no relaxation	0.1	-	-
27	Mercury (as Hg)	mg/L	**0.006**	**0.006**	0.0008	BDL	BDL(DL:0.002)	BDL(DL:0.002)	BDL(DL:0.002)	0.001/ no relaxation	0.1	-	-
28	Nickel	mg/L	BDL	BDL	0.002	0.004	BDL(DL:0.001)	BDL(DL:0.001)	BDL(DL:0.001)	0.02/ no relaxation	3.0	-	-
29	Total Arsenic as As	mg/L	BDL	BDL	BDL	0.003	2.7	42.3	10.1	0.01/0.05	0.2	-	-
30	Total Chromium (as Cr)	mg/L	BDL	BDL	BDL	BDL	BDL(DL:1.0)	BDL(DL:1.0)	BDL(DL:1.0)	0.05 max/no relaxation			
31	Total Suspended	mg/L	21	5	3	184	BDL(DL:1.0)	BDL(DL:1.0)	BDL(DL:1.0)	-	100	-	-

	Solids												
32	Vanadium (as V)	mg/L	BDL	BDL	BDL	BDL	BDL(DL:1.0)	BDL(DL:1.0)	BDL(DL:1.0)	-	0.2	-	-
33	Ammonical Nitrogen (as N)	mg/L	<1	<0.1	<1	>0.5	3.9	2.1	1.9	-	-	-	-
34	Total Kjeldahl Nitrogen (as N)	mg/L	0.2	11.8	21.5	3.2	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	-	100	-	-
35	Chromium (as Hexavalent Chromium)	mg/L	BDL	BDL	BDL	BDL	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	0.05/no relaxation	-	-	-
36	Oil and Grease	mg/L	<1	<1	<1	1	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	-	10.0	-	-
37	Dissolved Oxygen		4.6	5.1	4.5	3.7	BDL(DL:0.0001)	BDL(DL:0.0001)	BDL(DL:0.0001)	-	-	4 or more	6 or more
38	Chemical Oxygen Demand	mg/L	64	36	60	220	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	-	250	-	-
39	Biochemical Oxygen Demand (3 day 27 deg C)	mg/L	23	11	23	75	0.62	0.42	0.36	200/600	30	-	2 or less
40	Total Phosphate as P	mg/L	0.9	0.3	1.1	0.27	0.38	0.11	0.14	-	-	-	-
41	Dissolved Phosphate (as P)	mg/L	0.9	0.3	1.1	0.27	BDL (DL:0.5)	BDL (DL:0.5)	BDL (DL:0.5)	-	5.0	-	-
42	Sodium as Na	mg/L	575	352.5	150	1010	BDL (DL:0.5)	BDL (DL:0.5)	BDL (DL:0.5)	-	-	-	-
43	Potassium as K	mg/L	15	3.4	6	30	402	103	157	-	-	-	-

44	Nitrate Nitrogen	mg/L	BDL	2.1	3.9	0.25	86	46	38	0.01/no relaxation	10.0	-	-
45	Total Nitrogen	mg/L	0.2	11.8	21.5	3.2	11.6	13.2	8.6	0.01/no relaxation	-	-	-
46	Organic Phosphorus	mg/L	BDL	BDL	BDL	BDL	268	92	72	5/15	5.0	-	-
47	Coliform Count	MPN/100 ml	<1	35	<1	54	8	2	2	Absent	-	-	-
48	Faecal Coliform	MPN/100 ml	<1	<1	<1	<1	23	17	22	Absent	-	-	-
49	Total Coliform Organism	MPN/100 ml	<1	12	<1	14	11	4	8	Absent	-		50 or les

locations 5C to 5F July 2016, 3 locations 5G to 5I Nov/Dec 2019 5F surface water sample; 5C Alwar Thiru Nagar, 5D MIOT Hospital, 5E Medavakkam junction, 5F Global Hospital, 5G Kalpana Hospital Adambakkam, 5H Madipakkam Koot Road, 5I Velakallu Bus Stop

Table 4.12A Results of Laboratory Analysis of Water Samples – Bore wells (2022)

S.No	Parameters	Units	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
1	Turbidity	NTU	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
2	pH Value @ 25 ^{o}C	-	6.78	7.22	7.82	7.34	7.15	7.19	7.49	7.51	7.46	7.40	7.51
3	Electrical Conductivity @ 25^{o}C	µS/cm	495	643	1466	1062	1125	1342	1125	1254	1215	1346	1461
4	Total Dissolved Solids @ 180ºC	mg/l	316	414	950	685	731	872	731	815	790	875	950
5	Total Suspended Solids @ 105^{o}C	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
6	Oil & Grease	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
7	Total Phosphorous (as P)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
8	Total Nitrogen (as N)	mg/l	4.77	6.33	15.8	11.4	15.6	20.5	29.2	31.6	46.0	32.5	54.6
9	Volatile Organic Compound	ng/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10	Dissolved Oxygen (as DO)	mg/l	6.3	7.20	6.9	6.6	6.2	6.5	6.6	6.4	6.3	6.4	6.6
11	Manganese (as Mn)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
12	Selenium (as Se)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
13	Barium (as Ba)	mg/l	2.11	2.54	1.76	4.21	3.64	4.29	4.12	4.09	4.16	3.85	4.16
14	Silver (as Ag)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	Aluminium (as Al)	mg/l	0.09	BDL	0.15	0.15	0.12	0.17	0.17	0.17	0.14	0.16	0.16
16	Boron (as B)	mg/l	0.18	0.28	0.28	0.48	0.39	0.45	0.41	0.42	0.43	0.41	0.51
17	Copper (as Cu)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	Zinc (as Zn)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Cadmium (as Cd)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20	Cyanide (as CN)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
21	Lead (as Pb)	mg/l	0.23	0.31	0.46	0.53	0.43	0.46	0.46	0.49	0.49	0.51	0.51
22	Mercury (as Hg)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
23	Nickel (as Ni)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
24	Arsenic (as As)	mg/l	BDL	BDL	0.36	0.02	0.03	0.029	0.031	0.022	0.024	0.023	0.024
25	Total Chromium (as Cr)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	Escherichia coli (MPN)	Present/ Absent	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present

4.3.4 Air Quality

99 The air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological and topographical conditions. The monitoring results for ambient air quality tests conducted in 2019 and 2022 are presented in Table 4.13. 24-hour air quality monitoring results indicates that Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) were within the permissible level of National Ambient Air Quality Standards (NAAQS), SO_2 was within World Health Organization (WHO) guidelines. Particulate Matter was within NAAQS but exceeded WHO guideline at all locations. Concentration of Carbon Monoxide (CO) exceeded the permissible level of NAAQS but was within WHO guideline except at MIOT Hospital. The NAAQS laid down by CPCB and WHO guideline are given in Table 4.14.

Table 4.13 Ambient Air Quality

Parameters	Sulphur dioxide (as SO2)	Oxides of Nitrogen (as NO2)	Respirable Particulate Matter (PM10)	Respirable Particulate Matter (PM2.5)	Carbon Monoxide (as CO)
Units	µg/m3	µg/m3	µg/m3	µg/m3	mg/m3
5C	9.58	13.6	84.12	41.67	6
5D	10.8	15.38	73.34	33.96	9
5E	8.82	9.35	69.97	25.14	6
5F	6.23	9.48	62.37	29.16	4
5G	16.4	27.9	69.5	31.8	BDL
5H	11.6	23.8	60.7	33.4	BDL
5I	14.3	26.1	59.5	29.8	BDL
PC1	14.1	21.9	61.6	30.1	BDL
PC2	12.6	19.4	60.8	28.5	BDL
PC3	14.6	24.0	62.8	33.1	BDL
PC4	13.8	22.3	60.5	29.4	BDL
PC5	12.3	24.6	59.8	30.4	BDL
PC6	13.8	22.6	60.5	31.2	BDL
PC7	12.3	29.5	61.2	30.5	BDL
PC8	12.6	25.1	62.2	31.2	BDL
PC9	11.2	24.8	61.8	31.5	BDL
PC10	12.0	25.1	64.5	31.2	BDL
PC11	13.1	24.9	64.8	32.4	BDL
PC12	22	34.2	73.8	30.4	BDL
PC13	16.5	27.8	69.2	26.7	BDL
PC14	19.3	32.8	70.5	28.3	BDL
PC15	13.8	30	81.6	34.1	BDL
PC16	21.1	32.1	74.7	32.5	BDL

Table 4.14 National Ambient Air Quality Standards

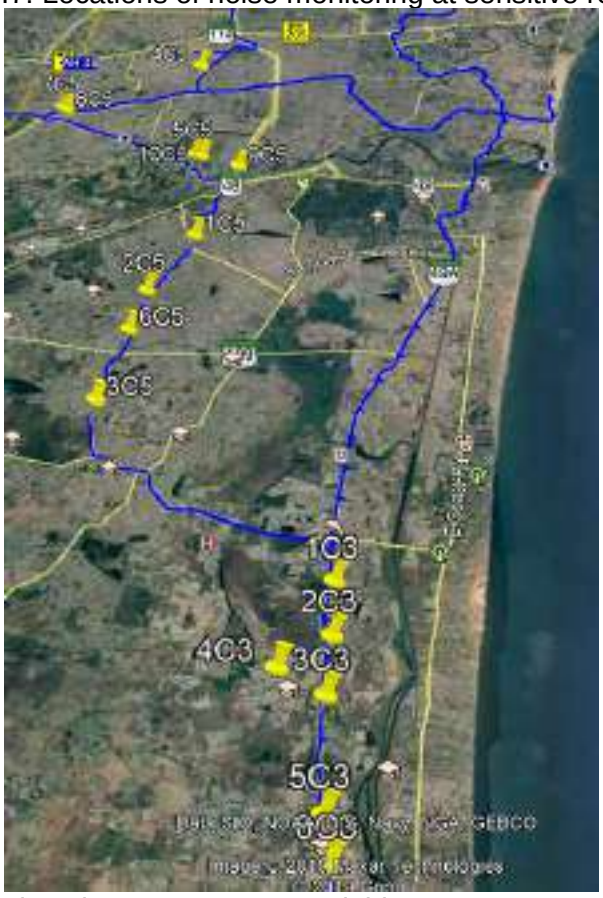
Pollutant	Time weighted Average	Concentration in Ambient Air*		WHO Guideline
		Industrial, Residential, Rural &Other Area	Ecological Sensitive Area	
Sulphur Dioxide (SO_2) µg/m^3	Annual	50	20	-
	24 Hours	80	80	-
Oxides of Nitrogen (NO_2) µg/m^3	Annual	40	30	40
	24 Hours	80	80	-
Particulate Matter PM_{10} µg/m^3	Annual	60	60	20
	24 Hours	100	100	50
Particular Matter $PM_{2.5}$ µg/m^3	Annual	40	40	10
	24 Hours	60	60	25
Carbon Monoxide (CO) mg/ m^3	24 Hours	-	-	7
	8 Hours	02	02	10
	1 Hour	04	04	30

**Source: CPCB guidelines for AAQM*

4.3.5 Noise

100 The noise data was collected at 4 noise monitoring stations in year 2016. Later in 2019, monitoring of noise was conducted at 10 selected sensitive receptors which are located within 200 m on either side of the alignment from center line (Annexure 1). The noise levels observed are listed in Table 4.15 and Table 4.16, locations are depicted in Figure 4.2 and Figure 4.7. Later in 2022, Baseline Noise levels are recorded in 16 locations along the project alignment before the commencement of construction activities and the noise levels observed are listed in 4.15A.

Figure 4.7: Locations of noise monitoring at sensitive receptors



10 locations 1C5 to 10C5; Field Survey: Dec 2019

Table 4.15 Ambient Noise Level dBA (by land use) – 2016

Location	Landuse	L_{10}	L_{50}	L_{90}	L_{max}	L_{min}	Leq_{day}	Leq_{night}
5C	Residential + Commercial	80.55	76.27	63.35	81.60	61.26	77.66	66.61
5D	Industrial	79.04	75.47	70.16	79.91	70.00	76.39	73.22
5E	Residential	72.59	67.78	58.70	73.79	56.49	69.37	60.91
5F	Residential	72.68	63.59	59.35	80.68	57.25	66.13	63.14

Field Survey: 5C to 5F July 2016

Table 4.15A Ambient Noise Level dBA (by land use) – 2022

Location	Landuse	Leq_{day}	Leq_{night}
PC1	Commercial	60.6	48.9
PC2	Commercial	59.0	48.2
PC3	Commercial	60.6	49.2
PC4	Commercial	53.0	48.0
PC5	Commercial	61.7	50.6
PC6	Commercial	60.8	51.8
PC7	Commercial	61.6	50.9
PC8	Commercial	61.2	52.9
PC9	Commercial	61.0	51.1
PC10	Commercial	59.8	51.4
PC11	Commercial	62.0	50.7
PC12	Commercial	72.3	67.9
PC13	Commercial	67.6	64.7
PC14	Commercial	73.8	64.3
PC15	Commercial	72.6	63.4
PC16	Commercial	68.2	65.0

Field Survey: PC1 to PC16 Pre-construction Baseline study 2022

Table 4.16 Ambient Noise Level dBA (at sample sensitive receptors)

S.No	Name of the Sensitive Receptor	Locations on MDB Corridor 5	Type of Sensitive Receptor	Distance from the outer most proposed tracks (m)	Leq (Day) 50 dB(A)	Leq (Night) 40 dB(A)
1C5	Kalpana Hospital	Adambakkam MRTS – Medavakkam Main Road	Hospital	1.0	54.8	32.1
2C5	Anjanka Hospital	Madipakkam Koot road bus stop– Venkateshwara Nagar	Hospital	11.0	42.8	35.3
3C5	Sri Varasidhi Vinayakar Temple	Vellakallu Bus stop – Medavakkam Koot Road Bus stop	Temple	23.05	47.4	35.0
4C5	MM Hospital	Sai Nagar Bus stop – Elango Nagar Bus Stop	Hospital	29.76	49.7	37.3
5C5	St.Joseph College	CTC – St. Wesley Church	College	39.00	54.8	36.2
6C5	Ravindrabharathi Global School	Venkateshwara nagar – Echankadu Bus Stop	School	42.64	54.3	34.6
7C5	Govt. Boys School	Porur – Mugalivakkam	School	46.03	54.9	36.4
8C5	DMI St. Joseph Hospital	Porur – Mugalivakkam	Hospital	52.5	48.7	38.2
9C5	National Matriculation Hr.	St. Wesley Church – Alandur	School	56.0	51.4	38.7

	Sec School					
10C5	Cantonment Board High School	CTC – St. Wesley Church	School	77.93	45.2	34.8

Field survey: Dec 2019

101 The Ambient Noise limits laid down by CPCB and WHO have been given in Table 4.17. The noise levels monitored at 4 locations in 2016 along the alignment were above the national and international permissible limits. Noise data was also monitored at 10 sensitive locations belonging to the silence zone, with 50% slightly exceeding GoI standards of 50dB the daytime limit (none per WHO guideline of 55dB), and none out of 10 exceeding 40 dB the night-time limit. The predominant source of ambient noise at monitored locations on is road traffic: all are located on urban arterials and regional highways.

Table 4.17 Ambient Noise Limits

Area Code	Category of Area	CPCB Limits dB (A) Leq		WHO Guideline **(LA eq dB)**	
		Day time*	Night time	Day time	Night time
A	Industrial area	75	70	70	
B	Commercial area	65	55	70	
C	Residential area	55	45	55	45
D	Silence Zone**	50	40		

*Source: CPCB guideline (as per The Noise Pollution (Regulation and Control) Rules, 2000) * CPCB day time is from 6.00 AM to 9.00 PM, WHO defines day time as 7.00 AM to 10 PM.; **Silence Zone is defined as an area up to 100m around premises of Hospitals, Educational Institutions, Courts of law and religious places or any others declared as such. Guidelines for Community Noise – WHO*

4.3.6 Vibration

102 Vibration consists of rapidly fluctuating motions of the particles without any net movement. Objects can vibrate differently in three mutually independent directions which are vertical, horizontal and lateral. It is common to describe vibration levels in terms of velocity, which represents the instantaneous speed at a point on the object that is displaced. Vibrations are transmitted from the source to the ground and propagate through the ground to the receiver.

103 The triaxial transducers are placed at proposed survey location. The signals obtained from all three axes are in horizontal, transverse and vertical directions viz. X- Easting, Y-Northing and Z-Vertical direction. The standard measurable units for velocity are in mm/s. Measuring the peak particle velocity (PPV) is mostly used for representation of vibrating situation when the pressure wave passes through the particles. Soil conditions have a strong influence on the level of ground-borne vibration. The PPVs are usually expressed in terms of m/s or mm/s.

104 The dynamic analysis and seismic response have been studied for 8 locations including 6 identified sensitive receptors on Balance C5 comprising educational institutions and hospitals which are located near by the project as shown in Figure 4.8 and Figure 4.9.

Figure 4.8: Locations of vibration measurement by land use

2 locations C5-B and C5-3; Field Survey: July 2019

Figure 4.9: Locations of vibration measurement at sample sensitive receptors

6 locations C5D to C5I ; Field Survey: Feb 2020

105 The induced ground vibration level is summarized in Table 4.20 and monitoring schedule is shown in Table 4.18. All the measurements are characterized on ground

level i.e., pickup point is on ground level. Peak VdB vibration level at 6 out of 8 monitored locations is found to exceed acceptable criteria for ground borne vibration prescribed by the Federal Transit Administration (FTA) USA and Railway Design and Standards Organisation (RDSO) India which are more valid for operation of this project (Annexure 3). However the observed levels at all 8 locations are well below the construction vibration damage criteria for blasting as per Indian authorities Directorate General of Mines Safety (DGMS) and Central Institute of Mining and Fuel Research (CMFRI or CMRI) which are relevant only if blasting is undertaken during construction (Table 4.19).

Table 4.18: Vibration Monitoring Schedule

No	Location	Monitoring schedule	Duration (hrs)	Dates
Part 1				
C5-B	Valasaravakkam	12:26 PM – 12:42 PM	24	17/07/2019 to 18/07/2019
C5-3	Sholinganallur	11:46 AM – 11:55 AM	24	13/07/2019 to 14/07/2019
Part 2				
C5-D	Kalpana Hospital	10:16 AM -6:24 PM	08	21/02/2020
C5-E	MM Hospital	10:28 AM – 6:33 PM	08	20/02/2020
C5-F	St Joseph School	10:32 AM – 6:32 PM	08	17/02/2020
C5-G	Ravindra Bharathi Global School	10:24 AM – 6:34 PM	08	18/02/2020
C5-H	DMI St Joseph Hospital	10:33 AM – 6:39 PM	08	19/02/2020
C5-I	Cantonment Board High School	08:25 AM – 4:29 PM	08	22/02/2020

Table 4.19: Standards for Vibration

Type of structure	Vibration (mm/s) for dominant excitation frequency, Hz		
	< 8Hz	8-25Hz	>25Hz
DGMS			
(A) Buildings/structures not belonging to the owner			
Domestic houses/structures (kuccha, bricks & cement)	5	10	15
Industrial building	10	20	25
Objects of historical importance & sensitive Structures	2	5	10
(B) Buildings belonging to the owner with limited span of life			
Domestic houses/structures	10	15	20
Industrial buildings	15	25	50

After CMRI Standard (Dhar et al, 1993)

Type of structures	PPV (mm/s)	
	<24 Hz	**>24 Hz**
Domestic houses, dry well interior, construction Structures with Cemented, bridge	5.0	10.0
Industrial buildings, steel or reinforced concrete	12.5	25.5

structures		
Object of historical importance, very sensitive Structures, more than 50 years old construction and Structures in poor state condition	2.0	5.0
IS 14881:2001		
Soil, weathered or soft conditions		70 mm/s
Hard rock conditions		100 mm/s

Source: DGMS (Tech) (S&T) Circular No. 7 of 1997

Table 4.20: Baseline Vibration

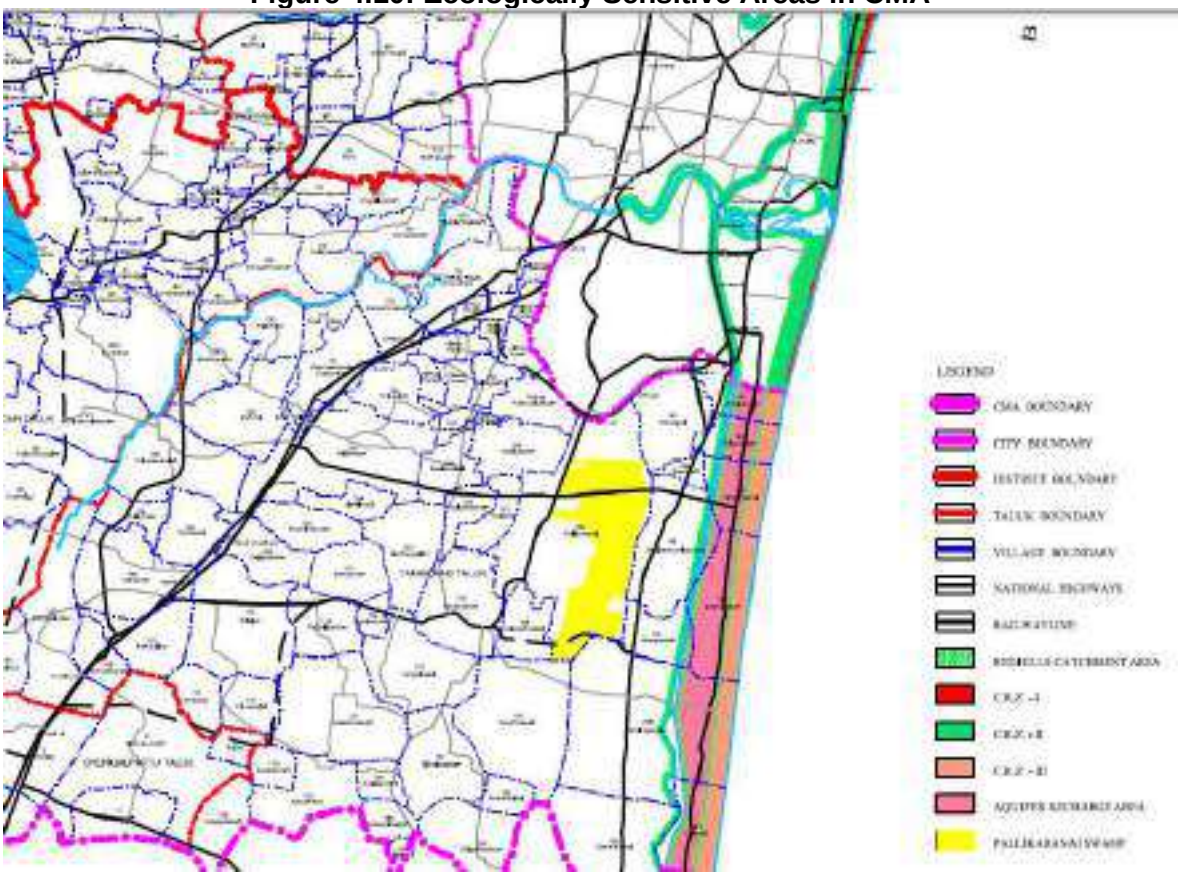
SN	Name of location	Surface Type	PPV (Maximum) mm/sec			VdB (Maximum)			VdB (Average)			VdB RMS		VdB acceptable
			East	North	Up	East	North	Up	East	North	Up	Max.	Time	
Part 1														
C5-B	Valasaravakkam	Soil	0.469	0.450	0.360	85.32	84.96	**83.02**	64.37	64.42	66.47	82.31 (East)	05.11 PM	72
C5-3	Sholinganallur		1.610	2.090	0.746	96.04	98.30	**89.35**	57.14	56.22	55.44	96.295 (North)	02.39 PM	75
Part 2														
C5-D	Kalpana Hospital	Tiles	0.117	0.101	0.136	73.27	71.99	74.57	67.47	68.27	69.08	71.56 (UP)	02:25 PM	65
C5-E	MM Hospital		0.145	0.114	0.239	75.13	73.04	79.47	67.07	67.94	72.03	76.46 (UP)	05:59 PM	65
C5-F	St Joseph School		0.063	0.108	0.240	67.86	72.57	79.51	62.00	65.79	70.35	76.50 (UP)	12:43 PM	75
C5-G	Ravindra Bharathi Global School		0.093	0.221	0.233	71.24	78.81	79.25	60.65	69.05	67.77	76.24 (UP)	12:08 PM	75
C5-H	DMI St Joseph Hospital		0.117	0.169	0.147	73.27	76.46	75.25	66.63	69.17	69.75	73.45 (North)	06:39 PM	65
C5-I	Cantonment Board High School		0.049	0.091	0.110	65.67	71.09	72.73	61.06	66.96	68.08	69.72 (UP)	03:18 PM	75

4.4 Ecological Environment

4.4.1 Ecologically Sensitive Areas in CMA

106 The ecologically sensitive areas in CMA are depicted in Figure 4.10. The following Table 4.21 lists the bird-watching areas in Chennai.

Figure 4.10: Ecologically Sensitive Areas in CMA



Source: Second Master Plan for Chennai Metropolitan Area, 2026

Table 4.21: Bird Watching Areas in Chennai

SN	Location
1	*Indian Institute of Technology, Adyar – tropical dry evergreen forest with exotic plantation
2	Pallikaranai Marsh – Open water interspersed with reeds and bulrushes
3	Adyar Estuary/creek/Adyar Poonga – Estuary with Mudflats
4	*Nanmangalam Forest Reserve – Scrub covered slopes and water covered pools
5	*Guindy National Park – Tropical Dry Evergreen Forest
6	*Vandalur Hills and Zoo – Undulating terrain with original scrub and planted trees
7	*Crocodile Bank – Coastal setting with artificial ponds and tall planted trees being used as a heronry
8	Pallavaram Hills – Original scrub and some trees
9	Manali and Madhavaram Jheel – Lakes
10	Edayanchatram – Open scrub
11	Thiruneermalai, Pammal – Hillock with some scrub
12	Red Hills and Cholavaram – Lakes
13	Ennore Creek – Coastal vegetation

14	Chemmencheri tank – Waterbody
15	Chembarampakkam lake
16	Nayapakkam – Wetland
17	Madras Christian College – Protected campus with planted tall trees
18	Muttukadu – Shallow backwaters connected to the Buckingham canal
19	Sriperambudur Lake
20	Chengalpet Lake and adjoining areas
21	*Vedanthangal Bird Sanctuary
22	Madhuranthakam Lake
23	Pazhaverkadu (Pulicat) lake area and SHAR Rd
24	Poondi reservoir
25	Thenneri Lake
26	Paranur (on GST Rd)
27	Mudaliar Kuppam
28	Kelambakkam Kovalam Road
29	Siruthavur RF
30	Perumal Eri (Mahabalipuram)
31	Perumbakkam Tank – Wetland

Source: Madras Naturalists' Society

107 Balance C5 alignment is located about 2km from the Guindy National Park, however, the wildlife clearance is not required but project activities will strictly follow the guidelines issued by MoEF&CC regarding the prohibited, regulated and permitted activities (Table 4.22) and consultations with the TNFD. The alignment is approximately 1 km away from Nanmangalam lake which is home to a number of bird species; it also runs along existing road passing through Pallikaranai marshland which is also home to a wide variety of birds and other fauna. Diversion of 1.569 Ha scrub forest land was diverted for the stretch traversing the Nanmangalam Reserve Forest. The alignment passing along Medavakkam main Road adjacent to Nanmangalam forest and along Perumbakkam main road through Pallikaranai marshland is depicted in Figure 4.11.

Figure 4.11 Balance C5 and Ecologically Sensitive Areas

RF Reserve Forest; BS Bird Sanctuary

108 Guindy National Park with an area of 2.70 sq km, which is under Reserve Forest category is classified as a Protected Area (ENVIS Centre of Wildlife and Protected Areas) and is located at distance of 2.6 km from the project alignment. In terms of density of vegetation cover, the area falls under sparse category.

109 The Guindy National Park is classified under tropical dry evergreen forests of the Coromandal coast and is being used for recreational purposes. The vegetation is mainly of the tropical dry evergreen type, and over 30 species of plants have been found including trees, shrubs, climbers, herbs and grasses. Chital and Blackbuck graze are found in the open grassland on the northern end of the park. Nocturnal animals include the toddy cat, civets, jungle cat, pangolin, and hedgehog. The dense forest, grasslands and water-bodies provide an ideal habitat for a large species of birds. Apart from snakes, certain species of tortoise and turtles, lizards, geckos, chameleons and the common Indian monitor lizard are also found here.

Table 4.22: Guidelines for Activities

Activity	Prohibited	Regulated	To be promoted
Discharge of effluents and solid waste in natural water bodies or terrestrial area	Yes	--	--
Felling of trees	---	Yes	---
Commercial use of natural water resources including ground water harvesting	---	Yes	---
Erection of electrical cables	---	Yes	---
Widening of roads	---	Yes	---
Movement of vehicular traffic at night	---	Yes	---
Air and vehicular pollution	---	Yes	---
Sign boards and hoardings	---	Yes	---
Underground cabling	---	---	Yes
Rain water harvesting	---	---	Yes
Renewable energy	---	---	Yes
Green technology for all activities	---	---	Yes

110 The Nanmangalam Reserve Forest is home to 70 species of birds in addition to 37 different species of butterflies and close to 14 species of damselflies and dragonflies. 449 different species of flowering plants are found inside the forest alone. The Reserve Forest's most famous inhabitant and star attraction is the great horned owl.

111 Pallikaranai Marsh is a freshwater swamp of 80 sq km, though the groundwater surrounding it with a high concentration of TDS indicates the sea water intrusion. It is one of the three wetlands in the state of Tamil Nadu which are included in wetlands identified under National Wetland Conservation and Management Programme. (MoEF&CC Annual report 2006-2007). Pallikaranai is reported with 212 species of birds, 10 mammals, 31 reptiles and amphibians, 50 fishes, 9 molluscs and 15 butterflies and 141 plant species. It is home to some of the birds such as the Black-bellied Tern[1] (EN) and Great Knot [2](EN). Pallikaranai known for diverse variety of

[1] This species is a long-distance migrant that largely travels along the coast making few stopovers (del Hoyo et al. 1996) but utilising different routes in the autumn and the spring (del Hoyo et al. 1996, Higgins and Davies 1996). It breeds from late-May to late-June, departing the breeding grounds in July and arriving on the wintering grounds between August and October (del Hoyo et al. 1996). The return migration to the breeding grounds takes place from March to April (del Hoyo et al.1996) although juvenile non-breeders often remain in the tropical parts of the wintering range for the breeding season (Hayman et al. 1986). The species forages in large flocks of one hundred to several thousand (del Hoyo et al.1996) at favoured sites on passage (Hayman et al. 1986), but during the winter it typically forages in small groups (Johnsgard 1981). A new global population was estimated at 292,000-295,000 individuals in 2007.

visitors and resident bird species. It is also home to some of the reptiles such as the fan throated lizard (LC), Eastern Russell's Viper (LC) and King Cobra (VU). Other estuarine fauna present at the marsh includes the windowpane oyster (NA), mud crab (NA), mullet (DD), halfbeak (NA) and Green Chromide (LC). Plankton study shows that the water body is Eutrophic in nature. (Source: https://tnswa.org/pallikaranai)

112 The focused biodiversity study is ongoing and upon finalization of the standalone Biodiversity Study Report with primary baseline information will be disclosed. As part of this Biodiversity Report, the Biodiversity Management Plan (BMP) was prepared based on the approved Working Plan of TNFD – Annexure 10.

4.4.2 Flora and Fauna

113 145 number of trees on project area Are transplanted and 259 trees are felled (as of December 2023) along the corridor up to Sholinganallur. No rare or endangered species of trees were noticed during field studies**.** The number of tree felling will be updated during the site clearance. The predominant tree species along the project corridors are listed below in Table 4.23.

Table 4.23: Predominant Tree Species along the Corridor

Species (Local name- Botanical name)	IUCN status
1. Vembu- *Azadirachta indica*	*LC*
2. Badam- *Terminalia catappa*	*LC*
3. Nirkadambai - *Neonauclea purpurea*	*NE*
4. Thoongu moonji – *Samanea saman*	LC
5. Panei - *Borassus flabellifer*	*NE*
6. Pungam – *Millettia pinnata*	*LC*
7. Gulmohar – *Delonix regia*	*LC*
8. Nettilingam- *Polyalthia longifolia*	*NE*
9.Vagai – *Albizia lebbeck*	*NE*
10.Thennai – *Cocos nucifera*	*NE*
11. Nuna – *Morinda tinctoria*	DD
12. Malabar Silk Cotton - *Bombax malabarica*	*NE*
13. Arasu – *Ficus religiosa*	*NE*
14.Al – *Ficus benghalensis*	*NE*
15. Ma – *Mangifera indica*	*DD*
16. Manjal Kondrai – *Peltophorum pterocarpum*	*LC*
17. Murungai – *Moringa oleifera*	*LC*
18. Poovarasu – *Thespesia populnea*	*LC*
19. Then Pazham (Singapore cherry) – *Muntingia calabura*	*DD*
20. Nochi (Shrub) – Vitex negundo	*LC*
21. Udhayan – Lannea coramandelica	*LC*
22. Foxtail Palm – Wodyetia bifurcata	*LC*

[2] This species is almost extinct in a large part of its range and is thought to be in very rapid decline overall, owing to a multitude of threatening processes that affect riverine species in southern Asia. It is therefore listed as Endangered. The population estimate is currently placed at 10,000-25,000 individuals, roughly equating to 6,700-17,000 mature individuals, until more data are available. It is found on large rivers (usually breeding on sandspits and islands) and marshes, occasionally on smaller pools and ditches, in lowlands (but not on the coast), up to 730 m.

23. Athi – Ficus carica	*LC*
24. Vilvam – Aegle marmelos	*NT*
25. Rain Tree – Samanea saman	*LC*
26. Gauva – Psidium gaujava	*DD*
27. Cheetha – Annona reticulata	*LC*
28. Areca Palm – Dypsis lutescens	*NT*

LC Least Concern; NE Not evaluated; DD Data Deficient; NT – Near Threatened

114 To minimize tree cutting it is proposed to transplant young trees to the extent possible. Local forestry officials will be consulted to transplant the trees at suitable locations.

115 Other than the species found in Nanmangalam and Pallikaranai, common birds observed in the project area are pigeons, parrot, crows, and doves; predominant mammals are mongoose, bat, Squirrel, monkey and mice etc.

116 Necessary mitigation measure will be implemented to reduce the indirect impacts of Balance C5 on avifauna in Nanmangalam reserved forest and Pallikaranai marsh and overall ecology.

4.5 Socioeconomic Environment

4.5.1 Utilities

117 The entire length of Balance C5 is planned to be run through the urban area elevated. The alignment will cross drains, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, traffic signals and street lights. The utility information is attached in Annexure 4.

4.5.2 Physical Cultural Resources

118 No protected archaeological monuments/sites nor heritage assets are located on or along the proposed alignment, except the Madras War Cemetery near Guindy have to be included, which is maintained by Commonwealth War Graves Commission (CWGC).

119 Of 213 sensitive receptors which are located within 200m on either side of the alignment, 158 are of having religious and cultural values. The religious structure identified are listed in the Annexure 1.

4.5.3 Demographic Features

120 The Project will improve passenger transportation in Chennai Metropolitan Area which is projected to support resident population of 125.82 lakh in year 2026. As in year 2014, almost all households in the urban parts of the 4 districts contributing to CMA are supported by at least one employed person. In the project affected households, about 50% of are working on salary or daily wages or contract or job works, 40% are business owners; 17% of households are in vulnerable category comprising those below income poverty line (about 4%), socially weak communities and women headed households.

121 The other socioeconomic baseline is described in the standalone Social Impact Assessment.

5. ANTICIPATED IMPACTS AND MITIGATION MEASURES

122 The potential impacts and risks were analyzed in the confines of Balance C5 alignment's direct impact area, which is defined in this study as a strip of 15m, however, sensitive receptors located within 200m on either side of the alignment were identified. Influence area where most of the socio-economic and cumulative impacts will occur is defined as the entire confine of the area in Chennai city.

123 Alignment of Balance C5 passes contiguous to Nanmangalam reserve forest and along and near existing road passing through Pallikaranai marshland: both these areas are home to a large number of native and migratory birds and other fauna. 1.569 Ha forest land was diverted to metro project near proposed metro station Medavakkam Koot Road Bus Stop vide MoEF&CC Forest Clearance approval letter F.No.4-TNB080/2022-CHN/ 267 dated 2nd March,2023 (Annexure 13). This will be permanent land use change from forest land to non-forest use.

124 The negative environmental impacts are:

- Impacts on the Nanmangalam reserve forest and Pallikaranai marsh land.
- Loss of about 259 trees for construction of Balance C5.
- Noise and vibration due to piling, excavation machines, and materials hauling.
- Safety risks, inconvenience of traffic nuisance and poor accessibility due to road closures and diversions, noisy conditions etc. will also be created due to plying of large number of heavy trucks transporting construction material, equipment and machinery in and around the project area.
- Increased noise and air pollution resulting from traffic volume due to construction.
- Increased local air pollution due to rock crushing, cutting and filling works
- Risks for damage to structures from vibration due to construction and operation.
- Risks and vulnerabilities related to occupational health and safety due to physical, chemical, biological hazards due to project construction and operation.
- Dislocation or involuntary resettlement of people as there will be a need for land acquisition for the viaduct and stations.

5.1 Impacts Screening

125 Adverse and positive impacts that are likely to result from Corridor development have been listed in Table 5.1 under the following headings:

- Impacts and Mitigation Measures due to Project Location and Design;
- Impacts and Mitigation Measures due to Construction;
- Impacts and Mitigation Measures due to Project Operation

Table 5.1: Impacts Assessment Matrix

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

Table 5.1: Impacts Assessment Matrix

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

Table 5.1: Impacts Assessment Matrix

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
2. Biological environment							
2.1 Trees, terrestrial and aquatic vegetation (Medium sensitivity)	Removal of trees	D	Permanent	Local	High	Moderate	Minimal -ve
	Damage to maintained trees and bushes Siltation of water bodies	C	Temporary	Limited	Low	Minor	Minimal -ve
	Damage to aquatic ecosystem due to accidental release of wastes	C	Temporary	Local	Medium	Moderate	Moderate -ve
	Growth of compensating trees	O	Permanent	Local	Low	Major +ve	Minimal -ve
2.2 Terrestrial fauna (mammals, birds, insects) (Low sensitivity)	Impact of height of viaduct and lighting on birds	D	Permanent	Local	Low	Moderate	Moderate –ve
	Impact of height of viaduct, noise and vibration, lighting on birds	C	Temporary	Local	Low	Moderate	None
		O	Permanent	Limited	Low	Moderate	Moderate –ve
2.3 Ecologically important areas (Medium sensitivity)	None	D				Neutral	None
	Extraction of sand from riverbeds. Banned.	C	Permanent	Local	Low	Neutral	None
	None	O				Neutral	None
3. Social environment (including those through environmental media)							
3.1 Private land and buildings (Medium sensitivity)	Transfer of private land	D	Permanent	Local	Medium	Major	High -ve
	Aesthetic impact. Limited reduction with proposed sleek structures	D	Permanent	Local	Medium	Major	High –ve
	Temporary use of land for construction, labor camps and traffic detours	C	Temporary	Limited	Medium	Moderate	None
	Aesthetic impact.	O	Permanent	Local	High	Major	High –ve
	Better Transport connectivity and increase in land value	O	Permanent	Local	High	Major	High +ve

Table 5.1: Impacts Assessment Matrix

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
3.2 Public property/infrastructure/ utility structures (High sensitivity)	Diversions of utility services including water pipelines and high-tension lines	D	Permanent	Local	Medium	Major	None
	Traffic diversions	C	Temporary	Local	High	Major	None
	None	O				Neutral	None
3.3 Noise (High sensitivity)	Metro noise adds to baseline noise which is already high. However, significant reduction with proposed design features.	D	Permanent	Limited	High	Major	Moderate -ve
	Noise due to operation of construction equipment and vehicular movement	C	Temporary	Local	Medium	Major	None
	Noise due to metro operations	O	Permanent	Local	Medium	Major	Moderate -ve
3.4 Vibration (High sensitivity)	Metro vibration adds to baseline level which is already high. Limited reduction with proposed design features.	D	Permanent	Limited	Medium	Major	High –ve
	Vibration due to operation of construction equipment	C	Temporary	Local	Medium	Major	None except in cases of building damage
	Vibration due to metro operations	O	Permanent	Local	Medium	Major	High –ve
3.5 Occupational health and safety (Medium sensitivity)	Design of Health and Safety features in stations and trains for construction workers and operating staff	D	Permanent	Limited	Medium	Moderate	Construction, operation accidents, EMR: minimal –ve COVID-19 Moderate –ve
	Impacts due to labour camp, working on heights and with heavy machinery; Transmission risk of COVID-19	C	Temporary	Limited	Medium	Moderate	Works: None except in case of disabling injuries.

Table 5.1: Impacts Assessment Matrix

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
							COVID-19: Moderate –ve
	Electromagnetic interference (EMI) Exposure to electromagnetic radiation Accidents COVID-19 Musculo-skeletal disorders and stress	O	Permanent	Limited	Medium	Moderate	Minimal -ve Minimal –ve Minimal -ve Moderate -ve Moderate -ve
3.6 Public health and safety (Medium sensitivity)	Safety risks due to flooding and earthquakes Transmission risk of COVID-19	D	Permanent	Limited	High	Major	Flooding High -ve Earthquake moderate -ve COVID-19 Moderate -ve
	Exposure to traffic, noise, dust and vibrations; Transmission risk of COVID-19	C	Temporary	Limited	Medium	Moderate	None Moderate -ve
	Electromagnetic interference (EMI) Exposure to electromagnetic radiation Incidents which disrupt services Transmission risk of COVID-19	O	Permanent	Local	Medium	Moderate	Minimal -ve Moderate -ve Minimal -ve Moderate -ve
3.7 Physical cultural resources (PCR) (Medium sensitivity)	Possible impact on religious or cultural buildings / structures within 200 meter of the alignment	D	Permanent	Limited	Medium	Minor	Minimal
	Chance finds	C	Short-lived	Limited	Low	Minor	Minimal
	None	O				Neutral	None
3.8 Energy (Medium	Energy Demand for lighting and equipment	D	Permanent	Limited	Medium	Moderate	Minimal –ve

Table 5.1: Impacts Assessment Matrix

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
Sensitivity)		C	Short-lived	Limited	Medium	Moderate	None
		O	Permanent	Limited	Medium	Moderate	Minimal -ve
3.8 Utilisation of metro (Medium Sensitivity)	The well designed alignment offers riding comfort, average speed and system capacity and thus the economical operation of the metro. The rational space planning of stations offers safety of passengers, optimises time spent in ingress & egress from station and energy consumption. Modal integration will improve ridership.	D	Permanent	Limited	High	Major +ve	High +ve
3.9 Utilisation of MIOT Grade Separator (Medium Sensitivity)	The Grade separator is designed as an integrated structure with the proposed elevated metro lines thereby reducing the additional land acquisition, felling of trees, etc.	D	Permanent	Limited	High	Major +ve	High +ve
	Better flow of vehicular movement through Grade separator, reduces traffic stagnation.	O	Permanent	Limited	High	Major +ve	High +ve

126 For each of these headings, potential impacts are evaluated, and mitigating measures have been proposed.

5.2 Impacts and Mitigation Measures due to Project Location and Design

127 These impacts are:

- Change of Land use and Socio-economic impacts
- Loss of trees
- Impact on avifauna
- Impacts on Utilities
- Impact on physical cultural resources (PCRs)
- Climate Vulnerability
- Operational Noise and Vibration

5.2.1 Land Use and Socio-economic Impacts

128 Balance C5 project will require transfer of 3.564 ha government land and acquisition of 6.052 ha private land. 811 families will be affected 59 families will be displaced from residential structures and 116 from commercial structures; 162 and 474 families respectively will be partially affected. These figures will be revised upon completion of field socio-economic survey of affected families, revision of detailed drawings, preparation of land plan and micro plan of impacts. The land acquisition, resettlement and socio-economic impacts are assessed in the SIA report.

5.2.2 Tree cutting

129 The construction of Balance C5 requires felling of about 259 trees and translocation of 145 trees in total. None of trees to be cut are rare or endangered species. Amount of oxygen produced per tree per year for urban forests was adopted as 11 kg (Oxygen Production by Urban Trees in the United States, David J. Nowak, Robert Hoehn, and Daniel E. Crane, Arboriculture & Urban Forestry 2007). Per US Department of Agriculture and Maharashtr SPCB data, one mature tree can absorb approximately 22 kg (or 48 pounds) of CO_2 each year. With removal of these trees, the process for CO_2 conversion will get affected and the losses are reported below:

i. Total number of Trees : 259
ii. Decrease in CO_2 absorption due to loss of trees: 5,698 kg/year
iii. Decrease in Oxygen production due to tree loss: 2,849 kg/year

130 Location for compensatory plantation will be decided by CMRL in consultation with owner of the land as well District Green Committee (DGC) such that displacement does not become necessary. The DGC/TNFD is responsible for the conservation and management of the trees. It is proposed to plant twelve saplings for each tree to be cut. Hence 3,108 trees shall be planted. The replantation plan including sites and species for compensatory plantation, and identification of trees to be transplanted will be prepared by CMRL in consultation with DGC, TNFD, CMDA and Municipal Corporation. The native plant species and miscellaneous indigenous tree species are recommended for plantation. Transplantation will be done in coordination with DGC/TNFD.

5.2.3 Impact on avifauna

131 Alignment of Balance C5 passes contiguous to Nanmangalam reserve forest and along and near existing road passing through Pallikaranai marshland: both areas are home to a large number of native and migratory birds and other fauna. The forest land to be diverted to the project is devoid of tree felling, hence no destruction to avifauna habitats due to tree felling will be expected. As mentioned in Table 3.2, the alignment is located 1 km away from Nanmangalam lake located in Nanmangalam forest.

132 Construction and operation of the metro viaduct on these sections could disturb nesting and breeding due to noise and vibration. Independently the elevated structure could impede flight of birds.

133 Effects of Artificial Light at Night on wildlife have been recorded: influences on nest site selection by sea turtles, changes in the diversity and behavior of nocturnal moths, and alterations to ecological interactions of insects. Trees in close proximity to sources of artificial lights budburst earlier than trees away from lights. More subtle effects of light pollution on birds are also known, such as disorientation, alterations in reproductive physiology, disruption of circadian rhythms, and changes of flight behavior (Light pollution is greatest within migration passage areas for nocturnally-migrating birds around the world, Sergio A. Cabrera-Cruz et al, Scientific Reports volume 8, Nature).

5.2.4 Impacts on Utilities

134 Balance C5 is planned to run through the urban area elevated. The alignment will cross drains, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, traffic signals, roadside lights etc. The Organizations /Departments responsible for concerned utility services are reported in Table 5.2.

Table 5.2: Organizations Responsible for Utilities

SN	Organization/ Department	Utility/Services
1.	Tamil Nadu Public Works Department	Roads and bridges other than National Highways
2.	Chennai Municipal Corporation	City roads and bridges, including hydrants and fountains etc., Roads, surface water drains, nallahs, sewer lines, streetlights
3.	Chennai Metropolitan Water Supply & Sewerage Board	Water and sewage treatment plants, pumping stations sewerage and drainage lines; water mains and their service lines
4.	National Highway Authority of India	Roads and bridges on National Highways
5.	Indian Railways	Railway crossings, subways, signals, bridges, stations etc.
6.	BSNL (OFC and Telephone Cables)	Tele cables, junction boxes, telephone posts, O.H lines
7.	Airtel, Vodafone, Idea, Jio, RailTel	Telecommunications cables, junction boxes, telephone posts, etc.
8.	Power Grid Corporation of India Ltd.	HT towers, cables
9.	Irrigation Dept.	Canal
10.	IOCL, BPCL	Petroleum pipelines
11.	Gas Authority of India (GAIL)	Gas pipelines
12.	Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO)	HT/other overhead Power lines

135 These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions and relocation or by supporting in position. Any interruption to these will have serious repercussions on the most sensitive suburban services and direct impact on the public besides set back in construction and project implementation schedule & costs. They may require temporary or permanent diversion subject to their depth, details such as piling configuration or span of viaduct, utility protection measures, etc.

136 During construction the most important and hazardous aspect will be pipelines network running along the alignment. A decision has to be taken regarding encasing these pipelines as shifting/relocating will be of great inconvenience to the residential areas. In case detailed pre-construction utility survey by Contractor identifies gas pipelines, HAZOP study (& risk analysis) will be conducted by contractor and CMRL during pre-construction period for any kind of handling of this issue in concurrence with gas supply agency. The similar study has to be conducted for water supply and high tension lines with the concurrence with concerned agencies.

137 In case public utilities are required to be shifted to private land in exceptional circumstances, then adequate compensation shall be made by CMRL to the property owner on the same principles as temporary land acquisition. Following completion of construction of metro, such utilities shall be rehabilitated on public land.

138 Ground survey to confirm location of pipelines and other utilities will be done by Contractor after which detailed design consultant will revise, where feasible, spans and pile arrangement. Where the alignment cannot be fine-tuned to avoid conflict with utilities, permanent diversions will be done section wise before commencement of construction of viaduct work on the pertinent section; temporary diversions can be done before or during construction. Plans for diversion or relocation of any utilities along with hazard studies if required will be prepared by the Contractor in consultation with and approval of respective utility agencies before finalisation of time schedule of metro construction works. Preferably they will have to be diverted by the agencies themselves. Any HAZOP investigation and utility diversion will be done 3 months before start of construction of viaduct (scheduled start of viaduct works is July 2021).

5.2.5 Impacts on Physical Cultural Resources

139 No protected archaeological monuments / sites or heritage assets are located on the project corridor, except the Madras War Cemetery near Guindy have to be included, which is maintained by Commonwealth War Graves Commission (CWGC). Of 213 sensitive receptors which are located within 200m on either side of the alignment, 158 are of having religious and cultural values.

140 Since the project involves piling for piers there are possibilities that contractor may encounter artefacts during piling operation. Chance find measures are included in the EMP to minimize the impacts on historical / archeological artifacts, in case found during excavation work. CMRL will inform and coordinate with Archaeological Survey of India if any ancient remains are encountered during construction work.

141 At pre-identified culturally valuable sites if any near the alignment, or finds in the project's direct area of impact the contractor shall prepare a monitoring scheme prior to construction at such locations. This scheme for monitoring vibration level shall be submitted to CMRL for approval. The scheme shall include:

- Monitoring requirements for vibrations at regular intervals throughout the construction period.

- Pre-construction structural integrity inspections of pre-identified culturally valuable structures
- Information dissemination about the construction method, probable effects, quality control measures, and precautions to be used.

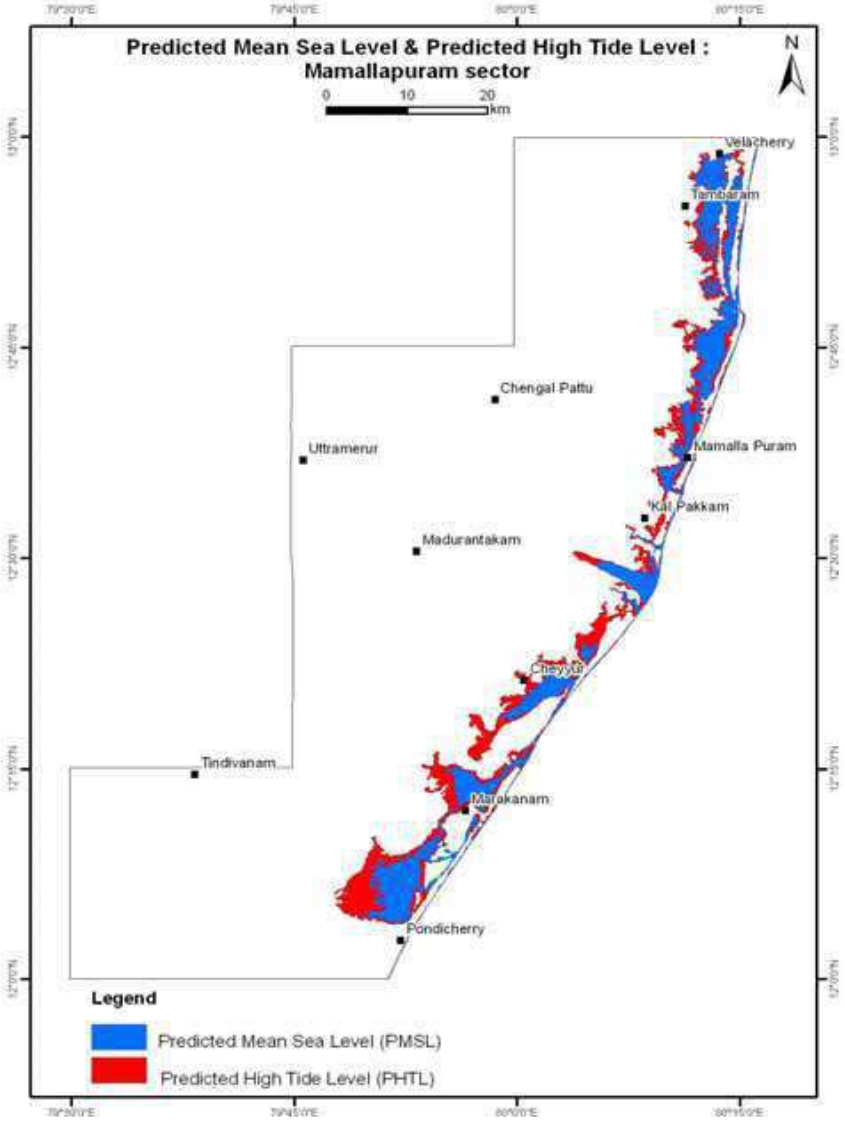
142 The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of PPV.

5.2.6 Climate Vulnerability

5.2.6.1 Sea level rise due to climate change

143 Vulnerability of project to rise in mean sea level (submergence) and high tide level (degradation) on the project is indicated in Figure 5.1. Length of elevated corridor 5 from Medavakkam to Sholinganallur may be submerged/degraded: passenger access can be cut off rendering the line unusable, rising tide level could also degrade Metro structures by way of increased corrosion.

Figure 5.1 Predicted MSL and HTL
(alignment indicated in black in inset)

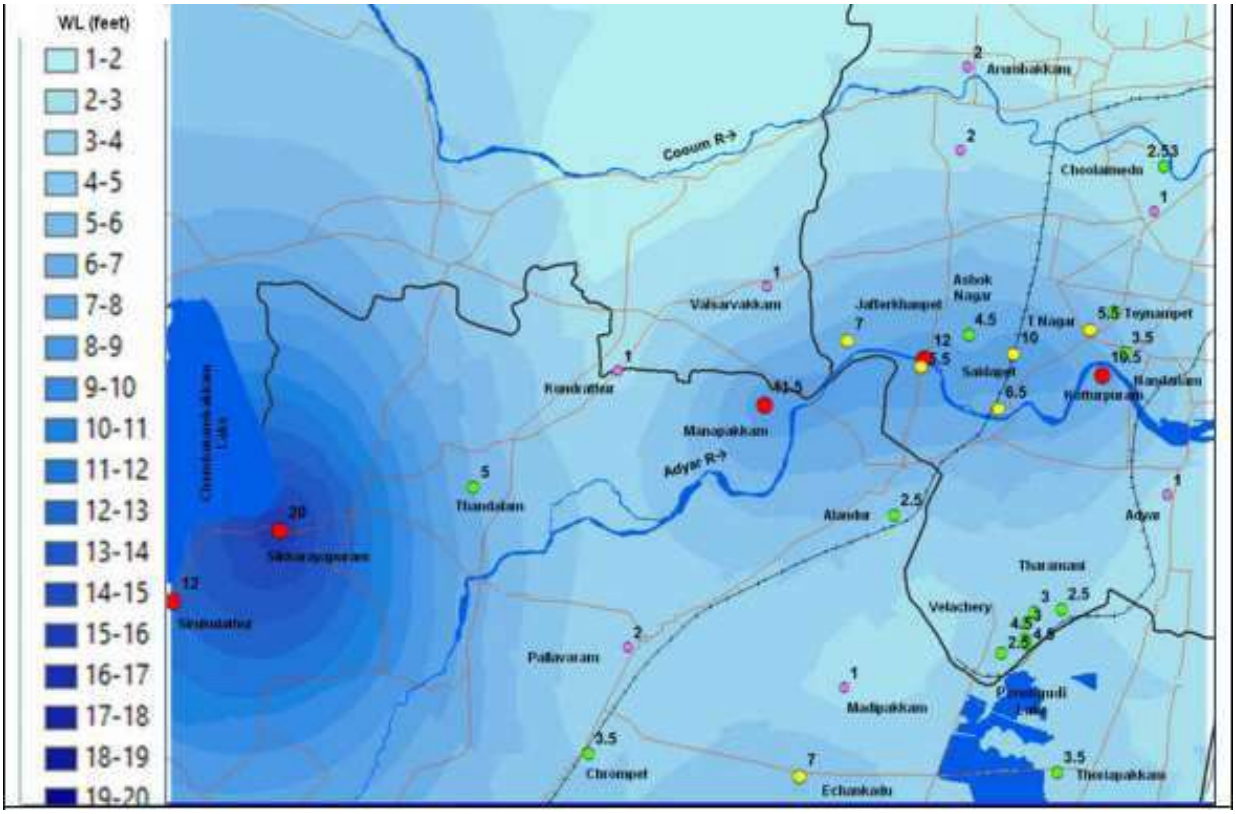


Source: Coastal Zones of India, SAC ISRO- MoEF&CC, 2012

5.2.6.2 Flooding resulting from Anomalous Heavy Rainfall

144 In year 2015 Chennai was flooded due to exceptionally heavy rainfall. Flooding was observed in areas adjoining Adyar river though lesser along Cooum river. The alignment of Corridor 5 is not located near these rivers[1] and therefore flooding is not a likely impact. Moreover Pallikaranai marsh could store excess water thus reducing flooding. Figure 5.2 depicts the inundated areas.

Figure 5.2: Chennai Flood map 2015



Source: Chennai Floods, 2015 A Satellite and Field Based Assessment Study, Disaster Management Support (DMS) Division National Remote Sensing Centre (NRSC / ISRO) Hyderabad, India

5.2.6.3 Risk Due to Earthquake

145 Chennai is located in Moderate Seismic Zone. Design of viaduct and elevated stations shall be done to facilitate robust safety and quicker evacuation.

5.2.7 Operational Noise and Vibration

146 As part of the detailed design a noise and vibration modeling and assessment along the alignment should be conducted prior to start of construction by CMRL and contractor at identified sensitive receptor locations within 50 m along the alignment (where operational stage noise level is expected to be higher than permissible limits). Appropriate mitigation measures including possibilities of installing noise barriers at sensitive receptor locations shall be determined by CMRL and contractor and agreed by MDBs.

[1] Proposed Alandur station which had up to 2.5 feet of water during the 2015 floods according to figure 5.2 is about 2500 meters away from NH45 bridge on Adyar River which saw water level of 12 feet; proposed Echangadu station which had 7 feet of water is located at 2600 meters from Pallikaranai marsh.

5.3 Impacts and Mitigation Measures Due to Construction

147 Although environmental hazards related to construction works are mostly of temporary nature. Appropriate measures should be included in the work plan and budgeted for. The most likely negative impacts related to the construction works are:

- Stormwater drainage and topsoil erosion
- Traffic diversion and risk to existing building
- Air pollution due to dust generation
- Noise and vibrations
- Increased energy demand and impacts on Water
- Impact due to supply of construction material
- Disposal of construction and demolition waste
- Disposal of Hazardous Waste
- Dewatering of Excavations
- Impacts due to batching plant and casting yard
- Impacts of labour camps
- Health and Safety

5.3.1 Soil Erosion Impact

148 Certain viaduct sections and station accesses require land outside the road right of way resulting in change of landuse characteristics**.** Change in land use and excavation of soil will lead to soil erosion. Every care has to be taken to avoid damage to the topsoil (more specific) from construction sites and yards. It has to be preserved and utilized. Problems could arise from dumping of construction spoils (concrete, bricks) waste materials (from contractor camps) etc. causing surface and ground water pollution.

149 Balance C5 will have elevated track and there are 23 elevated stations. Soil excavation will be required for piling activities for metro piers. Muck from piling and excavation activity containing Bentonite would also be generated in the project.

150 Mitigation measures: The excavated soil would be used for refilling at station site but muck from piling work will be disposed at locations/sites approved by pollution control board and Tamil Nadu Congress Committee. Responsibility of disposal of this soil will lies with contractor and will be regulated by standard norms. Disposal of Bentonite would be at designated landfill site approved by Government authorities.

151 Soil can be washed away from the temporary stacking of excavated soil on site before it is utilised for refill or disposed in environmentally friendly manner. Soil erosion by runoff will be controlled by installing proper drainage system.

152 Excavated top fertile soil can be preserved and used later for green belt development/ landscaping. Part of the excavated soil from piling would be re-used for refilling and balance will be disposed. Estimated quantity of disposable soil is 0.12 million cum, whereas 0.087 million cum of soil has been disposed as of December 2023.

153 If this muck is not contaminated by hazardous substances such as heavy metals or POPs[2], the contractor will be permitted to sell it as fill for activities outside the project;

[2] Methods Manual of Soil Testing in India from Ministry of Agriculture or any other internationally recommended guideline/standards will be used for the soil investigation.

in case of hazardous contamination it will be disposed at permitted sites by licensed vendors.

154 Sites for muck disposal will be decided by CMRL before start of construction in consultation with TNPCB, Municipal Corporation/Municipalities and CMDA. The sites will be located away from residential areas, water bodies and ecologically sensitive locations as to avoid disrupting natural drainage.

155 Material will be stabilised by watering or other accepted dust suppression techniques. The muck shall be filled in the dumping site in layers and compacted mechanically. Suitable slopes will be maintained on the stockpile. Once the filling is complete, it will be protected by low walls, provided with a layer of good earth on the top and covered with vegetation. A muck disposal plan will be prepared by Contractor, which will be approved by CMRL.

5.3.2 Traffic Diversion and Risk to Existing Buildings

156 During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are along the road. In order to retain satisfactory levels of traffic flow during the construction period, traffic management and engineering measures need to be taken. They can be road widening, traffic segregation, one-way movements, traffic diversions, acquisition of service lanes, etc.

157 Maintenance of diverted roads in good working condition to avoid slow down and congestion shall be a prerequisite during construction period.

158 Various construction technologies are in place to ensure that traffic impedance is done at the minimum. They are:

- The requirement would be mainly along the central verge/ side of the road
- To minimise traffic delays, segmental construction will be employed. .

159 **Traffic Management Guidelines:** The basic objective of the following guidelines is to lay down procedures to be adopted by contractor to ensure the safe and efficient movement of traffic and also to ensure the safety of workmen at construction sites. The Contractor shall develop detailed and robust traffic management plans consistent with the Indian Guidelines on Traffic Management in work zones (IRC:SP:55-2014), prior to mobilization for respective sections with site- or station-specific plans and measures to minimize the overall impact on traffic throughout the construction and operation periods.

- All construction workers should be provided with high visibility jackets with reflective tapes as most of viaduct and station works are on the right-of-way. The conspicuity of workmen at all times shall be increased so as to protect from speeding vehicular traffic.
- Warn the road user clearly and sufficiently in advance.
- Provide safe and clearly marked lanes for guiding road users.
- Provide safe and clearly marked buffer and work zones
- Provide adequate measures that control driver behaviour through construction zones.
- The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.
- Advance traffic updates/ information on communication systems for users of affected roads.

- Efforts will be given to divert traffic to roads wide enough to accommodate extra traffic.
- Incorporation of community safety considerations into plan design, especially at locations such as CMBT to Porur, St Thomas Mount to Velakallu, Medavakkam Koot road to Perumbakkam where buildings are close to the construction site.

In order to avoid risk to life and damage during construction near and above properties which are not proposed for permanent acquisition, such properties and premises shall be vacated and residents/users temporarily shifted for duration of construction.

5.3.3 Air Pollution

160 The major sources of ambient air pollution are demolition of structures to be removed; operation of construction equipment; installation of earth retaining structures, pile driving where cast-in-situ is not feasible, blasting operations; movement of vehicles transporting construction materials, muck and waste. The pollution is in terms of fugitive dust and emissions from trucks.

161 Trucks are required to transport raw material to casting yards and Ready Mix Concrete (RMC) plants; from pre-cast yards and batching plants to construction site and between construction site and muck/waste disposal site. Vehicular emission is estimated as in Table 5.3.

Table 5.3: Emissions due to truck movement during demolition and construction

Pollutant	Emission (ton)
Carbon Monoxide (CO)	115.0
$PM_{2.5}$	3.6
Hydro-Carbons (HC)	3.6
Nitrogen Oxide (NO_x)	240.0
VOC	37.0
Carbon dioxide (CO_2)	14868.0

162 Emissions from DG sets, pollution at sites of waste disposal and muck disposal during unloading and stacking, emissions from fuel and other hazardous chemicals are among other sources of air pollution.

163 Mitigation measures which will be adopted to reduce the air pollution are listed below:

- Contractor's transport vehicles and other equipment shall conform to emission standards. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.
- Procedure for truck maintenance, including selection of service providers considering environmental aspects, application of low-Sulphur fuel, no idling of trucks, routine maintenance (including assurance of proper engine operations related to emissions and noise), and disposal of used oil and other fluids, batteries, and tires etc.
- DG sets compliant with emission standards will be used
- The following dust protection methods will be used:
    - Dust screens during excavation and demolition near sensitive receptors
    - Dust filters atop cement silos
    - Wet suppression for aggregate crushing and screening

  - Good quality project roads with added petroleum emulsions and adhesives, speed control, traffic control.
  - Material of specifications as per contract will be procured by Contractor from Government-approved quarries
- The Contractor will ensure that trucks carrying loads of sand and aggregate required in construction being transported to construction yards are covered and loaded with sufficient free - board to avoid spills--within the largest compartment of tanker truck. Transportation will be scheduled by time and route to minimize air pollution in habitat areas.
- The Contractor will ensure that the authorized vendor covers loads of C&D waste and hazardous waste being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards. Containers carrying hazardous waste are loaded onto trucks with due care to avoid escape of fumes or spillage enroute. Transportation of muck and waste will be scheduled by time and route to minimize air pollution in habitat areas. The contractor will implement similar safeguards while transporting muck.
- The temporary muck storage areas will be maintained by the Contractor at all times until the excavate is re-utilized for backfilling or as directed by Employer. Dust control activities will continue even during any work stoppage. Soil erosion by runoff will be controlled by installing proper drainage systems using contour information It is suggested to avoid bringing soil from outside the project boundary and to use the excavated mounds for filling low lying area where it is necessary.
- The Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.
- Construction yards with aggregate crushing and screening, pre-casting, material and fuel storage and GC plants will be located away from habituated or ecologically sensitive areas.
- Labour residing in camps will be provided with LPG fuel for cooking.

5.3.4 Noise and Vibrations

164 Noise is a contributing factor to degradation of human health. The noise pollution will be generated by construction activities, mainly due to demolition of structures to be removed; installation of earth retaining structures; pile driving where cast-in-situ is not feasible; blasting in rock etc., and also due to the construction equipment if they are not in maintained condition. Also during such activities if existing vehicular traffic is not properly diverted then congestion and then continuous honking habits will also lead to incremental noise levels which are of indirect nature. This will also pave way for vehicular air pollution which is also to be minimized effectively. Corridor 5 construction is equipment intensive.

5.3.4.1 Noise Due to Operation of Construction Equipment

165 The major sources of noise during construction phase are due to operation of various construction equipment. Permitted number of impacts (example piling) at various noise levels is prescribed under Model Rules of the Factories Act, 1948. Actual noise from construction equipment (Lmax) measured at 50 feet distance (Construction Noise Handbook August 2006, FHWA, USA) ranged from 76 dB(A) to 84 dB(A); vibratory pile driver at 101 dB(A). The noise levels generated by various construction equipment are given in Table 5.4.

Table 5.4: Average Noise Levels Generated by Construction Equipment

Equipment	Typical Noise Level (dBA) at 50 ft from source
Air Compressor	81
Backhoe	80
Ballast Equalizer	82
Ballast Tamper	83
Compactor	82
Concrete Mixer	85
Concrete Pump	82
Concrete Vibrator	76
Crane Derrick	88
Crane Mobile	83
Dozer	85
Generator	81
Grader	85
Impact Wrench	85
Jack Hammer	88
Loader	85
Paver	89
Pile Driver (Sonic)	96
Pneumatic Tool	85
Pump	76
Rock Drill	98
Roller	74
Scraper	89
Shovel	82
Truck	88

Source: FTA Transit Noise and Vibration Guidance Handbook, May 2006

Equipment	Actual Lmax Noise Level (dBA) at 50 ft from source
Auger drill rig *	84
Compressor *	78
Dump truck *	76
Excavator *	81
Flatbed truck *	74
Front end loader *	79
Vibratory Pile driver *	101
Press Pile	70
Batching Plant	90
Booster pump	80

** Source: Construction Noise Handbook, US FHWA, Aug 2006*

5.3.4.2 Noise due to increased vehicular movement

166 During construction phase, there will be significant increase in vehicular movement for transportation of construction material. In addition to the noise mentioned above, there will also be background noise of the usual traffic resulting due to traffic congestion and confusion arising due to traffic diversion measures. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. Temporary route direction markings will be placed in appropriate locations. During construction phase, the increase in vehicular

movement is expected to increase up to a maximum of 5 to 6 trucks/hour. Table 5.5 presents the typical increase in ambient noise level due to increased vehicular movement if the background noise level is at 36dB(A).

Table 5.5: Increase in Noise Level Due to Increased Vehicular Movement

Distance (m)	Ambient noise level dB (A)	Increase in noise level due to increased vehicular movement dB (A)
10	36	72
20	36	67
50	36	61
100	36	57
200	36	52
500	36	46
1000	36	42

5.3.4.3 Impacts of Noise on Labour

167 The effect of high noise levels on the operating personnel has to be considered as this may be particularly harmful. It is known that continuous exposures to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, should be avoided. To prevent these effects, it has been recommended by Occupational Safety and Health Administration (OSHA) that the exposure period of affected persons is limited (Table 5.6).

Table 5.6: Maximum Exposure Periods Specified By OSHA

Maximum equivalent continuous Noise level dB(A)	Unprotected exposure period per day for 8 hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	½
115	¼
120	No exposure permitted at or above this level

168 To reduce the harmful effects, personnel working at high noise levels would be provided with noise protective gears such as ear mufflers, sound barriers etc. Vehicles used for transportation of construction materials would be equipped with proper silencers. Careful planning has been made to operate the construction equipment to have minimal disturbances. The construction equipment would be run only during the daytime and their noise would be monitored as per CPCB standards. Besides other measures such as use of low-noise equipment and ensuring good maintenance, trying to avoid using high-noise equipment simultaneously at the same section etc. will also be implemented to minimize construction noise.

169 Exposure of workers to high noise levels will be minimized by measures such as the following:

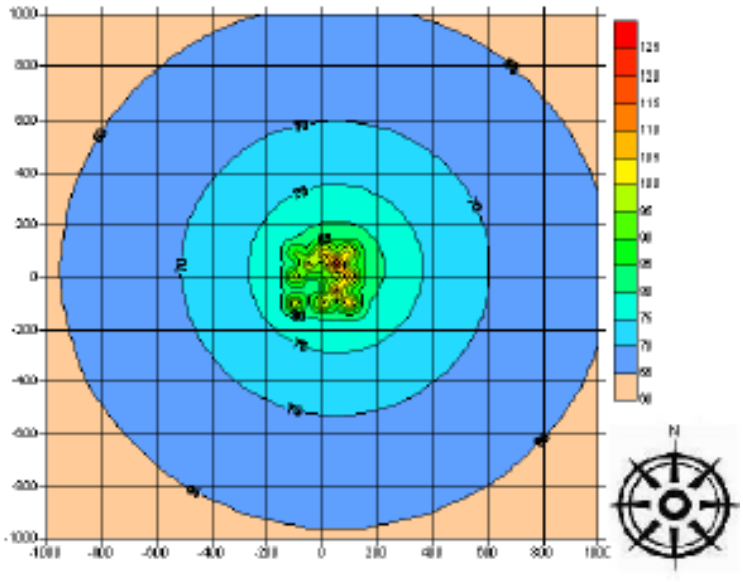
- Personal protective equipment such as passive or active ear-muffs
- Use of electric instead of diesel powered equipment

- Use of hydraulic tools instead of pneumatic tools
- Acoustic enclosures for noise generating construction equipment like DG sets
- Scheduling work to avoid simultaneous activities that generates high noise levels
- Job rotation
- Sound-proof control rooms
- Automation of equipment and machineries, wherever possible.

5.3.4.4 Predicted Noise Level during Construction Stage

170 Noise modelling during construction phase was carried out using CPCB/ MoEF&CC approved noise model "DHWANI" assuming that all the equipment emit noise simultaneously considering as worst-case scenario. The spatial variation of the predicted noise levels at an interval of 5 dB(A) without control around the project site on the area of 1 km x 1 km are shown in Figure 5.3. Modelling result shows that noise level meets the Ambient Noise Quality Standards (ANQS) 55 dB(A) (average between 6 am to 10 pm) at a distance of about 900m. Uncontrolled noise levels generated from construction equipment, in the range of 94-124 dB(A) have been considered for prediction purpose. However, the CPCB standards specify to limit the construction equipment to ensure that noise emission specifications for such equipment should not exceed 75 dB(A). The noise levels predicted here is without mitigation measures. It is assumed that with the adoption of the mitigation measures noise levels will be further restricted within very short distances from the source. With respect to occupational exposure, the permissible threshold is 90 dB(A) (continuous exposure over 8 hours). Thus, based on the modelling results it can be concluded that all sensitive receptors (i.e. labour colonies) should be located beyond 125 meters from the noise generating source location during construction activities.

Figure 5.1: Spatial Variation of Construction Equipment Noise Levels dB(A)



171 Further noise modelling is being conducted, based on the detailed engineering design to inform the incremental impacts and suggest the mitigations accordingly.

5.3.4.5 Vibration

172 Pile driving for viaduct piers and buildings generate vibrations. Apart from distance from the alignment, age and condition of buildings adjacent to the alignment determines extent of damage to such buildings due to vibration. Continuous effect of vibration on the buildings can cause damage to buildings. Buildings subjected to the vibration of more than 150 VdB might be subjected to structural damage. Historic buildings are more susceptible to vibration effect due to type of building material and design.

173 In order to evaluate the construction stage vibration levels from the project construction activities, the Construction Vibration Damage Criteria set by FTA for different building category is referred in Table 5.7 below.

Table 5.7: Construction Vibration Damage Criteria as per FTA guidelines

Building Category	PPV (in/s)	PPV (mm/s)	Approximate Lv, RMS velocity in decibels (VdB) re 1 µin/s.
I. Reinforced-concrete, steel or timber (no plaster)	0.5	12	102
II. Engineered concrete and masonry (no plaster)	0.3	7.6	98
III. Nonengineered timber and masonry buildings	0.2	5	94
IV. Buildings extremely susceptible to vibration damage	0.12	3	90

174 During construction of the underground section, TBM will be used. With a tunnel depth of approximately 25 m (vertical distance between tunnel top and floor of building above ground), the expected vibration level during operation of the TBM is approximately 99VdB in conditions of sandy and clay soil which is dominant in the project area. Attenuation of vibration is expected to be about 16 VdB resulting in a net vibration at the ground floor of the building above ground to be about 83 VdB.

175 According to the FTA manual the threshold level of vibration for beginning to cause annoyance to human beings is about 75VdB and for causing damages to extremely fragile structure is about 90 VdB. Given that the expected vibration level at the ground floor is about 83 VdB, people living in the ground floor of houses located immediately above the tunnel will feel the vibration and may get annoyed when the TBM is operational. However, it is unlikely that any structural damages will take place.

176 In the case of vibrations from road traffic and pile driving, very deep barriers (in excess of 10 m) were found to reduce vibration. In-ground barriers are trenches that are either left open or filled with a material (such as bentonite or concrete) that has stiffness or density significantly different from that of the surrounding soil. However, trenches may be too costly for situations involving houses. They could perhaps be justified for larger buildings with strict vibration limits, such as operating theatres of hospitals or high-tech factories with sensitive processes. An economical alternative to trenches in a residential area could be a row of lime or cement piles of diameter 0.5 m to 1 m and a depth of 15 m in the right-of-way adjacent to the road. However, the effectiveness of such pile-walls has not yet been demonstrated[3]. Cast-in-situ piling will be deployed at locations with sensitive receptors so as to reduce vibration.

177 At locations where the alignment is close to sensitive receptors, the contractor shall implement:

- The detailed noise and vibration analysis (mathematical modeling) at sensitive receptors based on final engineering designs should be carried out, based on which, a set of mitigations should be prepared and shared with all lenders for review, prior to commencement of construction

[3] NRC-CNRC Construction Technology Update No. 39, 2000, Vibrations in Buildings by Osama Hunaidi and A review on the effects of earth borne vibrations and the mitigation measures, BOO Hyun Nam et al, IJR International Journal of Railway, Sept 2013.

- Pre-construction structural integrity inspections, including visual inspections of buildings of cultural or historical significance
- The sensitive receptors have to be isolated from heavy construction noise generated. This is possible by erecting reinforced 2 m tall GI sheet barrier around the area where heavy construction works is undertaken
- Information dissemination about the construction method, probable effects, quality control measures and precautions
- Monitoring during construction

178 Further vibration modelling will be conducted, based on the detailed engineering design to inform the incremental impacts and suggest the mitigations accordingly.

5.3.5 Increased Energy Demand and Impacts on Water

5.3.5.1 Increased Energy Demand

179 Construction employs energy intensive equipment round the clock. High illumination lighting and minor tools and equipment impose increased demand on energy consumption due to construction.

180 The contractor shall use and maintain equipment so as to conserve energy and shall be able to demonstrate the above mentioned upon request of CMRL. Measures to conserve energy include maintenance of energy efficient tools, plant and equipment of; lamps and DG sets to comply with TNPCB norms; Promoting awareness through energy saving trainings.

5.3.5.2 Increased Water Resource and Quality

181 Water for dust suppression (sprinkling) and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater. Used water from tyre washing will be re-used. Water for curing of concrete will be sourced from municipal supply, surface runoff or water from dewatering. Water for concrete batching plant and labour camps will be sourced from treated municipal water. Water consumption during construction is of the order of 448 KLD (for Balance Corridor 5).

182 After precipitation, waste water from construction yards, sites and labour camps will be discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. In view of the distributed nature of the linear construction and quantities of waste water, it is not proposed install sewage and effluent treatment plants by CMRL.

183 Construction yards with aggregate crushing and screening, pre-casting, material and fuel storage and GC plants as well as excavate/waste disposal sites will be located away from inhabited or ecologically sensitive areas.

184 Construction materials, oils and greases from construction sites; used water from the RMC plant; water used for dust suppression at aggregate crushers are sources of pollution of surface water bodies or groundwater. Sewage from labour camp can also pollute surface water bodies or groundwater. Groundwater which seeps into excavations can get contaminated by chemicals used in construction and consequently pollute groundwater outside the excavations upon dewatering.

5.3.6 Impact Due to Supply of Construction Material

185 Metro construction is a material intensive activity. Huge quantity of different construction materials will be required for construction of elevated metro corridor and stations. These shall be sourced from the nearest source. Quarry operations are independently regulated activities and outside the purview of the project proponent. It is, nonetheless, appropriate to give consideration to the environmental implications in selection of quarry sources since poorly run operations create dust problems, contribute noise pollution, ignore safety of their employees, or cause the loss of natural resources. So, the construction material shall be sourced only from legalized and approved quarries.

5.3.7 Disposal of Construction and Demolition Waste

186 Waste construction material, demolition waste and hazardous waste from construction equipment and construction vehicles can pollute air, water and soil. The procedure of demolition will be conducted as per the demolition plan prepared by the Contractor in consultation with CMRL. The existing structures should be demolished one after another cautiously. The Construction and Demolition (C&D) waste needs to be reused/recycled as it has the potential to save natural resources (stone, river sand, soil etc.) and energy. C&D waste generated from metro construction has potential use after processing and grading. The contractor will segregate and temporarily store the C&D waste till the vendor takes it away for recycling and disposal at authorized facilities.

187 C&D waste is part of solid waste that results from land clearing, excavation, construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste has the potential to save natural resources (stone, river sand, soil etc.) and energy, its bulk which is carried over long distances for just dumping, its occupying significant space at landfill sites and its presence impedes processing of bio-degradable waste as well as recyclable waste. C&D waste generated from metro construction has potential use after processing and grading. The contractor will segregate and temporarily store the C&D waste till the vendor takes it away for recycling and disposal at authorized facilities.

188 Mitigation Measures: The C&D waste would be handled and disposed off to waste processing facility or for back filling of low lying areas only if the area is covered afterwards with a good quality layer of topsoil of sufficient thickness, leaving no significant impact on environment. Bentonite slurries used in diaphragm wall construction should be reconditioned and reused wherever practicable. The disposal of residual used bentonite slurry should follow the international good practice.

5.3.8 Disposal of Hazardous Waste

189 Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spent solvents etc.

190 The contractor will ensure that hazardous wastes from construction activity and equipment are labeled, recorded, stored in impermeable containment and for periods not exceeding mandated periods and in a manner suitable for handling storage and transport. The contractor shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection. The contractor shall get Authorized Recyclers to transport and dispose Hazardous Waste, under intimation to the Project Authority.

5.3.9 Dewatering of Excavations

Table 5.8 shows ground water levels upto 10 m below ground in pre-monsoon as well as post-monsoon seasons and rise in water level of upto 4 m in 80% to 90% of observation wells in Chennai district between pre-monsoon and post-monsoon months. It indicates that significant dewatering of excavations might be required. In view of use of cast in situ piles with liner, dewatering of excavations will be very small.

Table 5.8: Ground water level in Chennai District

Month/year	**% of observation wells in each range of water level (m) below ground level**			**Rise (m) in water level**	**Fall (m) in water level**
	0 to 2	**2 to 5**	**5 to10**		
May 2013	*8*	54	38	60% wells <2m, 30% wells 2m to 4m	100% wells <2m
January 2014	*36*	36	29		
May 2014	*14*	33	53	50% wells <2m, 30% wells 2m to 4m, 20% wells >4m	Zero
January 2015	*56*	25	19		
May 2015	*14*	50	36	60% wells <2m, 30% wells 2m to 4m, 10% wells >4m	Nil
January 2016	*41*	47	12		
May 2016	24	*59*	17	83% wells <2m	86% wells <2m
January 2017	14	*79*	7		
May2018	Nil	*25*	75	80% <2m	90% <2m
January 2019	15	*55*	30		
August 2019	5	*18*	42	31% wells seen more than 2m rise	8.2 % wells seen more than 2m fall
January 2020	21	*33*	30		
August 2021	11	*39*	38	<2m rise in 24%; >2m rise 38%	<2m fall in 35%; >2m fall 3.4%
January 2022	44	*39*	13		

(*CGWB Yearbooks 2013-14,2014-15,2015-16,2016-17,2017-18,2018-19, 2019-20, 2021-22 for Tamil Nadu and Puduchery)*

191 Bentonite used to seal infiltration of water through soil is not classified as harmful. This water will be treated and added to groundwater to recharge.

5.3.10 Impacts Due to Batching Plant and Casting Yard

192 During construction phase there would be establishment and operation of Batching Plant and Casting Yard which would be located in an area designated and allotted by CMRL away from habitation. If possible, these facilities will be located at least 500 m away from habitations and at least 1 km away from environmentally or ecologically sensitive area.

193 There would be significant movement of men, material and machinery in batching plant and casting yard. It is expected that both batching and casting yard would be located at same complex. Huge quantity of cement, aggregates and other construction materials would be used in batching plant and casting yard. There would be generation of dust, noise, flue gases and other contaminants from the

working of heavy machinery for handling and transporting the construction materials. The mitigation measures for different aspects, such as the soil and groundwater quality baseline shall be collected by contractor prior to mobilization and shall be monitored during construction, have been elaborated in EMP.

5.3.11 Impacts of Labour Camps

194 During the progress of the work, the construction contractors work activities provides the erection and to maintain the necessary (temporary) living habitats and allied facilities for the workforce up to their living standards and scales up to be approved by CMRL. Improper disposal of municipal solid waste generated by labour camps can pollute surface water bodies and groundwater. Burning of waste can cause air pollution. Construction workers are more prone to infectious diseases due to unsafe sexual activity and lack of sanitation facilities (water supply and human waste disposal) and insect vectors. Problems could arise due to cultural differences between workers from outside and local residents.

195 As per Building & Other Construction Workers (BOCW Regulation of Employment and Conditions of Service) Act, 1996 the employer (contractor) is liable to arrange for sanitation, health care facilities of labours, free of charge. Labour camps will be in full compliance of BOCW Act.

196 It is estimated that about 3000 persons (Staff and workers) will work during peak construction activity on site and casting yards. Estimated total population in the labour camps will be 2500. The water requirement at camps will be KLD, wastewater generation 338 KLD & municipal solid waste generation 0.78 ton per day. This is tentative and will vary depending on the construction schedule during construction.

- **Water supply:** Uncontaminated water for drinking, cooking and washing, health care.

- **Sanitation Facilities:** Construction sites and camps shall be provided sanitary latrines and urinals. Sewerage drains should be provided for the flow of used water outside the camp. Drains and ditches should be treated with bleaching powder on a regular basis. The sewage system for the camp must be properly designed by providing septic tanks, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Garbage bins must be provided in the camp and regularly emptied and the garbage disposed in a hygienic manner. Labour camps should also be provided with proper ventilation and air cooling system.

- **Solid Waste Management:** Solid waste generated will have to be disposed in compliance with Municipal Solid Waste (Management & Handling) Rules, 2000, as amended to date. Municipal solid waste will be collected and taken away and disposed of by municipality. Solid waste management facilities will be arranged by the construction contractors.

5.3.12 Impacts due to the Changes in Design and Alignment

197 **The inclusion of Integrated Grade Separator (GS)** in the MIOT section of length 3.14 km (from Mugalivakkam to Manapakkam) was proposed by Tamilnadu Highways and Minor Ports Department, to reduce the traffic congestion in the area. The proposed grade separator does not additionally require any land acquisition or tree felling for the construction, since it is an integrated structure comprising roads for vehicular transportation on the first level and Metro rail lines on the second level

of the pier as shown in the Figure 3.5 and 3.7. The GS is in the commercial land use area that doesn't include any eco-sensitive areas such as wetlands, waterbodies etc. This inclusion increases the requirement of manpower and construction materials such as cement, reinforcement steel, construction water, energy, diesel etc. The additional impact on air and noise quality is expected to be minimal since the components of grade separator are precast structures and going to integrated with the existing metro structures. During construction there may be some temporary impact such as fugitive dust emissions, road traffic. The construction materials (such as sand, earth, aggregates etc..) shall be brought from authorized source / vendor in compliant with environmental regulations of the country. The EMP covers the mitigation measures required for temporary impacts (from air, noise, traffic etc.,) during the construction stage of the project. During operation, the grade separator facilitates the reduction of the travel time, fuel consumption, noise level and vehicular emissions (especially Carbon Monoxide and NO_x) by easing the flow of traffic in the section. The positive Impacts of the grade separator outweighs the negative impacts which are temporary and minimal.

198 **The change in project alignment** to connect the Elcot Park Station to Sholinganallur station was proposed in 2023, dropping the previous alignment which connected the Elcot park Station (Part of Balance Corridor 5) with the Okkiam Thoraipakkam Station (Part of Corridor 3). The previous alignment had complications such as converting part of water body into land for construction activities, splicing of a high rise building and utility diversions. Therefore, the new alignment of reduced length (up to 800m) has been proposed on the middle of the existing road (Perumbakkam to Sholinganallur Main Road). The adaptation of new alignment eliminated the negative impacts of previous alignment such as disturbances to aquatic ecosystem, noise and vibrations in the commercial area, generation of C&D wastes, Traffic diversions, and fugitive emissions etc. The existing road crosses a water body and there is a risk of contamination if the construction wastes are not handled and disposed of properly. However, the risks are far less than that of the previous alignment.

5.3.13 Health and Safety (H&S)

5.3.13.1 Occupational H&S

Labour Camps

199 Prior to construction, necessary (temporary) living facilities for project workers will be provided by the contractor. The locations of such camps, their layout and level of facilities to minimize health risks will be put up for approval of CMRL, CMDA and Public Health Officer of Greater Chennai Corporation. As per the Building & Other Construction Workers (BOCW Regulation of Employment and Conditions of Service) Act, 1996 the employer (contractor) is liable to arrange for sanitation and health care facilities of labourers free of charge. Labour camps will be in full compliance with the BOCW Act. Uncontaminated water will be provided for drinking, cooking and washing, and health care.

200 Waste water from cooking, bathing and washing including sewage from toilets will be discharged into municipal drains. Such wastewater will be treated by municipal agencies to the Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. In view of the distributed nature of the linear construction and quantities of wastewater, it is not proposed to install sewage treatment plants by CMRL for construction and operation phases. Sewerage drains should be provided for the flow of used water outside the camp. Garbage bins

will be provided in the camp and regularly emptied into municipal bins. Municipal solid waste will be collected and taken away and disposed of by municipality.

201 The Contractor will implement COVID-19 guidelines and Operating Procedures as part of the Contract. Residents of worker camps will be sensitized about need to implement precautions and trained in social distancing, sanitizing, avoiding groups; arrangements for thermal scanners and provision of sanitizers, face masks, gloves etc. will be made by contractor. Site records of COVID-19 hospitals will be maintained and fully equipped ambulances will be available to transport sick camp residents to hospitals. Daily disinfection of camps will be carried out.

Worker Safety in construction areas

202 Construction works will be executed as laid down in the Safety Health and Environment (SHE) Manual as applicable to Balance C5. The applicable sections are i) Control Document; ii) Health and Safety Manual; and iii) Environmental Management Arrangements.

203 Environmental Social Health and Safety **(**ESHS) Requirements comprising sections i),ii) and iii) above are included in the tender documents for contractor to comply with for elevated construction. Compliance with sections i) and ii) is mandatory, section iii) is intended to provide guidance to the contractor. While complying with this SHE Manual, site-specific and construction work-specific procedures will be prepared by the Contractor and approved by CMRL. Hazards and requisite safety measures related to working at height are of primary focus on this corridor.

204 Control comprises: Legal requirements; standards; Contractor`s organisation and interfaces with CMRL; procedures to identify hazards and estimate risk, hazard mitigation measures; emergency response plan; resources; arrangements for training, inspection, communication, compliance, reporting, documentation and audit, review; complaint addressal.

205 Health and Safety Manual covers: Contractor organisation; accidents; hazards and risks; emergency preparedness plan; signage; industrial health and welfare; works - heights, excavations, electrical and mechanical; gases; machinery; equipment; blasting; formwork; piling; PPE; medical facilities; firefighting; traffic management; housekeeping; launching; batching plant; transport; security; explosives; general safety; flooding etc. As part of medical facilities for workers, the Manual mentions support to the HIV/AIDS control agency.

206 The mandatory workplace measures are health care awareness and clinics, first aid facilities, day crèche, shelter at workplace, canteen facilities.

COVID-19

207 WHO has declared COVID-19 as a pandemic which has affected entire world including India. In view of the prevailing COVID-19 pandemic, the Contractor and workers would need to take additional measures to avoid the spread of the disease and shall follow various guidelines/guidance notes issued by the national/state government, WHO, ILO, World Bank/IFC from time to time. As described in these guidelines, the Contractor shall undertake a COVID-19 risk assessment of project area and prepare a COVID-19 Response and Management Plan (C-R&MP) and submit to CMRL and GC for approval. Furthermore, the Standard Operating Procedures (SOPs) and Guidelines for Construction Sites for COVID-19 Outbreak developed by National Real Estate Development Council will be mandatory for contractors to follow.

208 The Contractor will implement COVID-19 guidelines and Operating Procedures as part of the Contract. The procedures are:

- Thermal scanning, hand sanitization and face masking at entry and exit to/from work areas; hand gloves for those who handle material received from outside work area;
- social distancing at toilets and eating areas;
- daily disinfection of site, equipment and vehicles; site record of COVID-19 hospitals; fully equipped ambulances to transport sick workers to hospitals;
- signage and regular awareness sessions;
- staggered hours of work start and close to ensure social distancing at gates;
- all construction material arriving at site should be left idle for 3 days before use to ensure safe usage;
- non-touch garbage bins with biodegradable garbage bag for waste collection;
- proper disposal of garbage bags along with daily cleaning and sanitization of bins;
- In addition fully equipped ambulances will be available to transport the sick to hospitals.

5.3.12.2 Community H&S

209 During construction, the impacts on community H&S are due to exposed to traffic, noise, dust and vibration disturbance and the risk of road traffic accidents are anticipated.

210 To prevent community H&S issues during construction, contractor on coordination with implemented measures such as provide the construction camps with facilities such as health care clinics, places of worship, and occasional entertainment, preparation of implementation of traffic management plan during construction, access to buildings, awareness and information sharing, and implementation of CMRL SHE Manual.

211 Activities such as girder launching will be done during off peak hours of day and night. Tasks involving welding will be taken up with due real-time on-site guidance to road users: barricading is usually inadequate to mitigate this hazard.

212 Any incidence of COVID-19 and similar illnesses will be immediately communicated to the health authorities: suitable channels of communication with citizens located in proximity of worker camps will be maintained.

213 In case of road closure or traffic diversion, the Contractor will ensure that information on the timing of construction works and notifications of road closure (if any) is provided via local media (radio, TV, newspaper etc.) or through the local community heads.

5.4 Impacts and Mitigation Measures due to Project Operation

214 Positive Impacts: Key positive benefits are i) reduced fuel consumption and air pollution; ii) mobility, safety and reduced congestion and accidents; iii) increased employment opportunities and economic activity; and iv) enhanced skyline.

215 Negative Environmental Impacts: Along with many positive impacts, the following negative impacts during operation are anticipated:

- Noise and Vibrations
- Water supply and sanitation at stations

- Energy consumption at stations
- Health and Safety

5.4.1 Noise and Vibrations

216 Airborne noise level increases with train speed, decreases with ballasted tie-welded track with elastic fastenings and absorbing pad and well-maintained wheel and rail condition. Vibration is found to be higher with higher speeds and lower with heavier transit structure. The vibration is generally caused by rail-wheel interaction. This can be reduced by minimizing any surface irregularities on the wheel and rail. To minimize the vibration shock absorbing pad must be provided and there has to be a distance between rail seat assembly and concrete plinth.

217 For elevated corridors, ballast less track structure is supported on two layers of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed up to the rail level so as reduce sound levels. Noise at source will be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc.

218 These noise generations for metro operation activities have been recorded from past experience from existing Metros in India as well as project authorities. The following data includes various noise levels in above activities. During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. Airborne noise is radiated from elevated structures. The noise level at 2 m distance from the rail alignment is about 73 dB(A) which is higher than the CPCB permissible limit of 65 dB(A), and is much higher than the 50 dB (A) daytime limit for silence zone The noise level reduces with distance logarithmically. Refer Tables 5.9 and 5.10.

Table 5.9: Exterior Noise Levels in Metro Stations

S. No	Description	Average Noise Levels dB(A)
		Elevated tracks
1	Background Noise Level	64.0± 1.5
2	Train entering the Platform (Max)	84.0± 1.5
3	Train leaving the Platform (Max)	84.0± 0.5
4	Train stopping in Platform	79.0± 0.0
5	Train stationary in Platform	76.0± 0.5
6	Train starting from Platform	78.5± 1.0
7	Train braking	86.0± 0.0
8	Announcement	74.0± 0.5
Overall		**76.0± 7.0**

Table 5.10: Interior Noise Levels in Metro Trains

S. No	Description	Average Noise Levels dB(A)
		Elevated tracks
1	Train stationary	62.0± 1.0
2	Train starting	62.0± 1.0
3	Train motoring	70.0± 2.5
4	Train coasting	72.0± 2.0
5	Train at max. speed	78.0± 1.0
6	Train decelerating	69.0± 0.5
7	Train stopping	64.4± 1.0

8	Train braking	74.5± 1.0
9	W/R Noise	75.0± 1.5
10	Door operations (max.)	-
Overall		**69.0± 5.0**

Source: Studies carried out by Central Road Research Institute (CRRI) for metro projects in India

219 Noise barriers are recommended with noise reduction possibilities in Table 5.11.

Table 5.11: Noise Barrier for Noise Reduction

Place of Noise Barrier	Height of noise barrier	Noise reduction
On the viaduct	4m (3.5m Absorptive+0.5m transparent) green color	15 dB(A)

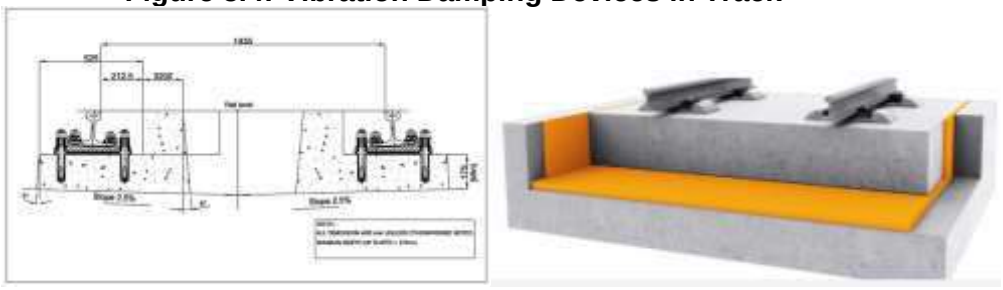
220 The study found that noise reduction is possible around 15 dB(A) after installation of noise barrier. Therefore, study suggested that noise barrier is the best option to reduce the instantaneous noise generated by metro.

221 Furthermore, the noise barriers consisting of 15mm thick UV coated clear transparent polycarbonate sheets meeting the criteria for acoustic performance as per EN 1793 and mechanical and structural performance as per EN 1794 including necessary structural galvanized steelwork and rubber gasket all around, have been included in the tender document. The sound transmission class rating corresponding to sound attenuation of 30dB or above is required.

222 The elastic pad between seat of the rail and the track slab as well as between track slab and the superstructure beneath it will reduce vibration transmitted from the track and superstructure. Indicative pictures are shown in Figure 5.4.

223 The detailed analysis (computer modeling) of noise and vibration is conducted based on the detailed engineering design and finalized prior to contractor's mobilization. The Noise and Vibration Forecasting report is attached as Annexure 11 and Annexure 12.

Figure 5.4: Vibration Damping Devices in Track



Source: Getzner Werkstoffe

5.4.2 Water and Sanitation at Stations

224 Water demand at stations for cleaning is 381 KLD**.** The water requirement for the stations will be met through the public water supply system.

225 Arrangement of water will have to be made at each station separately with proper drainage system for wastewater. Municipal water supply will be supplemented by rainwater harvesting along viaduct and rooftop of elevated stations. Sewage of 324 KLD will be generated. Wastewater will be led into municipal sewage system.

226 Solid waste generation from passengers at stations is likely to be 301 ton per day. Non-hazardous solid waste generated in stations will be collected and transported to local municipal bins for onward disposal to disposal site by municipality.

227 Mitigation Measures: After precipitation, waste water from construction yards, sites and labour camps will be discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. In view of the distributed nature of the linear construction and quantities of waste water, it is not proposed install sewage and effluent treatment plants by CMRL. The water requirement for the stations will be met through the public water supply system. Municipal water supply will be supplemented by rainwater harvesting at elevated stations. As an environmental conservation measure, to conserve and augment the storage of groundwater, it is proposed to construct rainwater harvesting structure of suitable capacity at the elevated stations and in the elevated alignment. Each pillar can have inbuilt downpipes to collect the rainwater from the viaduct and rooftop of elevated stations and then led into underground tanks through layers of sand and gravel. At annual rainfall of 1,541mm, potential for rainwater harvesting is 5.08 lakh cum per year on Corridor 5.

5.4.3 Energy Consumption at Stations

228 Stations impose significant demands on energy. In addition, traction, rolling stock and train control systems also require reliable sources of grid and standby power, high intensity energy, as well as efficient equipment. Table 5.12 presents the power demand of alignment during operation.

Table 5.12: Power Demand

Load	2025		2035		2045		2055	
	Normal	Emergency	Normal	Emergency	Normal	Emergency	Normal	Emergency
Thiruverkadu GSS-Mugalivakkam RSS (Chainage 7186 to 13366) 6.180km								
Traction	2.46	6.34	3.24	8.36	3.90	10.05	4.42	11.39
Auxiliary	5.13	7.70	6.38	9.40	7.18	10.70	7.70	11.55
Total	7.59	14.04	9.62	17.76	11.08	20.75	12.12	22.94
Alandur GSS-St Thomas RSS (Chainage 13366 to 23109) 9.743km								
Traction	3.88	8.59	5.11	11.33	6.15	13.62	6.97	15.44
Auxiliary	2.57	5.13	3.02	6.03	3.53	7.06	3.85	7.70
Total	6.45	13.72	8.13	17.33	9.68	20.68	10.82	23.14
Kadaperi GSS to Medavakkam RSS (Chainage 23109 to 34947) 11.838km								
Traction	4.71	9.22	6.21	12.16	7.47	14.62	8.47	16.57
Auxiliary	2.57	5.13	3.02	6.03	3.53	7.06	3.85	7.70
Total	7.28	14.35	9.23	18.19	11.00	21.68	12.32	24.27
Mambakkam GSS to Perumbakkam RSS (Chainage 34947 to 46272) 11.325km								
Traction	4.51	9.22	5.94	12.16	7.15	14.62	8.10	16.57
Auxiliary	2.57	5.13	3.02	6.03	3.53	7.06	3.85	7.70
Total	7.28	14.35	9.23	18.19	11.00	21.68	12.32	24.27

229 Requirement of electrical energy for facilities at stations will be optimized by proper use of natural day/night light and design of passenger flow inside stations and on streets outside stations. Installations for solar power will be implemented in stations where feasible.

230 **Green Buildings.** In accordance with the IGBC Green Mass Rapit Transit System (MRTS) norms, the following measures will be implemented to a feasible degree in the stations and depots.

- Control annual heat gain through favourable orientation and design of facades
- Site planning according to contours

- Site plan designed to preserve existing vegetation/ existing water bodies / other topographical features like boulders etc.
- Manage storm water on site through rainwater harvesting
- Mitigate heat island effect by ensuring that building surface visible to sky is shaded by trees. Ensure zero SWD post-construction by means of ground water recharge and recharge of groundwater aquifers by rainwater. The building shall be designed to incorporate low ODP materials, indoor air quality and comfort, low-VOC paints and adhesives, reduced landscape water demand, sustainable building materials and renewable energy utilization etc.
- For the utilization of renewable energy, wherever feasible, installations for solar power can be implemented on roof of elevated stations. Installation and maintenance of solar power infrastructure is proposed to be awarded to developer along with Power Purchase Agreement (PPA). The power shall be purchased by CMRL on the basis of the unit rate specified by Power Purchase Agreement (PPA).
- Integration with other modes of public transport, thereby enhancing connectivity

231 In conformity to other corridors in Chennai, the following design elements are proposed which increase energy efficiency and safety:

- High voltage electric traction which have ability to carry high traffic at a reduced cost with higher efficiency of operation
- Rolling Stock is of light weight stainless steel / aluminium resulting in energy efficiency and improved life thus improving resource utilization and environmental quality. Standard Gauge rolling stock results in recurring saving in energy consumption during operation as for the same passenger carrying capacity, gross weight of a metro coach is lower.

5.4.4 Visual Issues

232 The introduction of metro system implies a change in streets through which it will operate. An architecturally well designed elevated section can be pleasing to the eyes of beholders. Recent metro rail projects have attempted to incorporate this objective in their designs. Since a low profile would cause the least intrusion, the basic elevated section has been optimized at this stage itself.

233 During design stage, the stakeholder engagement will be conducted to disclose the station designs and to incorporate the feedbacks.

5.4.5 Health and Safety

5.4.5.1 Occupational H&S

Electromagnetic interference (EMI)

234 Electromagnetic Interference (EMI) in metro railway can disturb electronic circuits in 3 ways:

- EMI in railway infrastructure like signaling caused by rolling stock. Considering the criticality of signaling, such disturbances can cause accidents and safety of staff as well as passengers.
- EMI in environment caused by rolling stock. The railway can impact environment upto at least 10m from the track (Railway EMI impact on train operation and environment, A Morant et al, IEEE, Dec 2012)
- EMI in rolling stock caused by environment.

Electromagnetic radiation

235 It can cause adverse health impacts on people living or working very near the railway. Among other studies, a large U.S. case-control study (638 cases and 620 controls) to test whether childhood acute lymphoblastic leukemia is associated with exposure to 60-Hz magnetic fields was published by Linet et al. (1997). Measurement results are suggestive of a positive association between magnetic fields and leukemia risk. (*ICNIRP Guidelines For Limiting Exposure To Time-Varying Electric, Magnetic And Electromagnetic Fields (Up To 300 Ghz) Published In: Health Physics 74 (4):494-522; 1998)*

COVID-19

236 COVID-19 transmission poses much higher risk during operation than on construction sites due to sealed coaches and density of commuters. passenger densities in stations also pose a grave risk. Social distancing will require increased number of services for a given level of demand.

237 GoI protocols governing COVID-19 precautions shall be fine-tuned; staff shall be trained; staff and commuters shall be informed of precautions such as social distancing, sanitizing; arrangements for stationary and hand-held thermal scanners; provision of sanitizer pedestals, vending machines of face masks and gloves etc. will be provided in stations; site record of COVID-19 hospitals; protected ambulances at stations; daily disinfection of operating rooms, circulation spaces, equipment and vehicles..

5.4.5.2 Community H&S

Electromagnetic Interference and Electromagnetic Radiation

238 Electromagnetic Interference and electromagnetic radiation can adversely impact public safety. Detailed specification and layouts of equipment e.g. power cables, rectifiers, transformer, E&M equipment etc. will be framed to reduce conducted or radiated emissions as per appropriate international standards. Electromagnetic Compatibility and maximum electromagnetic emission levels of whole railway system to the outside world measured at the railway boundary fence will comply with EN50121-2.

Operation related H&S

239 During operation accidents related to train operation like collision, derailment, fire, power outages, or operation stoppage may occur. Administration of safety during operations is governed by Chennai Metro Safety Manual. The Manual defines “Accident” as any occurrence which causes or has the potential to cause death or injury to staff, passengers or other persons or cause damage to the property of the Metro Railway, passengers or other persons. The Manual classifies accidents in Class A to Class L covering the following incidents:

- Failure of signal system, Failure of traction power supply, Failure of rolling stock, Failure of track and structures
- Failure of Platform Screen Doors / car doors
- Natural disasters
- Fire, explosion, security threats
- Theft etc. or any other event which reflects a system failure but has not affected train operation.

240 The Manual prescribes

- Duty Lists of Train Operator, Station Controller, Traffic Controller at OCC, site officers and security personnel
- Accident reporting
- Rescue and Relief Arrangements
- Accident Investigations and Enquiries.

241 Procedures to be implemented during operational emergencies are included in the Emergency Preparedness and Response Plan in this report. Design of the metro system provides for operational safety. Some of such features are mentioned below:

- In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. A standby silent type DG set of adequate capacity at stations will sustain the following: essential lighting, signaling, and telecommunications, fire-fighting system and lift operation. Coaches will be reserved for women, seats in all coaches will be reserved for women, elderly and disabled. Bus stops, pick up drop off points will be well lit and provided with messaging.
- To provide a high level of safety with trains running at close headway ensuring continuous safe train separation, eliminate accidents continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver, and provides safety and enforces speed limit on section having permanent and temporary speed restrictions Automatic Train Protection and Automatic Train Supervision sub-systems will be installed.
- CCTV system will provide video surveillance and recording function for the operations to monitor each station. The monitoring will be possible both locally at each station and remotely from the operation control center. All trains will have public address systems to warn the passengers of any emergency situation.

COVID-19

242 Face protection and hand sanitizing are of critical importance. Testing, transportation and hospital facilities of a much higher order of safety will be provided at stations. Standard Operating Procedure (SOP) for operation of metro services protecting from COVID-19 infection has been prepared by all metro operators in India and attached as Annexure 8. Chennai Metro SOP comprises the following actions:

- Number of passengers will be regulated at entry to station so that social distancing inside stations and on trains is maintained
- Alternate seats on platforms and on trains will be marked out of bounds
- Dwell time of trains at stations will be increased to 50 seconds (instead of 30 seconds pre-COVID-19) to allow more time for boarding/alighting
- Intake of fresh air on trains will be increased; temperature maintained at 24 to 30 degrees Celsius
- Trains will not stop at stations falling in containment zones; such stations will not be open to users
- Some stations may be skipped to ensure social distancing
- Train doors to be open for 2 minutes at terminal stations to let fresh air infusion.

5.5 Chance Finds

243 Balance C5 is in urban areas and there may be possibilities that some artifacts could be found during piling and excavation work.

244 Mitigation Measures: before start of civil work the contractor and CMRL will coordinate with Tamil Nadu State Department of Archaeology to reconfirm that there is presence of buried artifacts along the metro line alignment. No piling or excavation will be allowed unless cleared by the Archeological Department.

245 All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices.

246 A proof of compliance to this requirement to include the name of participants and date and location of briefing will form part of the monthly report to CMRL.

247 The contractor will comply with the FIDIC Sec. 4.24 on Fossils. Recording (including chain of custody) will be made by the contractor to be validated by the GC ~~CSC,~~ and expert verification will be made by the Archaeology Department. Temporary work stoppage in the immediate area of the chance find for up to 72 hours to allow for the on-site representative of Archaeology Department to visit the site to make an assessment and provide instructions. Work in the areas adjacent to the chance find will continue as provided in the detailed design.

5.6 Benefits

248 Metro rail systems have an advantage over other modes of transport because they provide higher carrying capacity, faster, smoother, and safer travel, occupy less space, and are non-polluting and energy-efficient. To summarize the benefits of a metro rail system:

- **Reduced Air Pollution:** Reduction in air pollution level is the single most important indications due to metro rail alignment.
- **Increased Employment Opportunities:** During the period of construction manpower will be needed for various project activities. In post-construction phase, about 841 people will be employed for operation and maintenance of the system. In addition, more people would be indirectly employed in allied activities.
- **Improved Economy:** The project will facilitate movement of people from different parts of Chennai. Corridor 5 will yield benefits in terms of growth in economic activity due to better accessibility, savings in fuel consumption, corresponding reduction in cost of road construction and maintenance, reduction in vehicle operating costs, savings in travel time, improvement in quality of life and reduction in loss of productivity due to health disorders resulting from pollution.
- **Mobility Safety and Reduced Accidents:** The metro network increases the mobility of people at faster rate. The proposed corridor will provide more people connectivity to other parts of the city. Metro journey is safe and result in reduced accidents on roads.
- **Reduced Fuel Consumption:** Based on number of daily vehicle kilometre reduction, daily reduction in fuel (diesel and petrol) consumption has been estimated. The reduction has been estimated based on retiral - without addition - of pre-BS VI vehicles from year 2020 onwards; in accordance with the report commissioned by Niti Aayog, 100% of 3 wheelers and buses and 40% of private 2 wheelers and cars have been assumed to be electric from year 2030 onwards. The benefit is an interplay between shift from road modes to Metro and shift from more polluting pre-BS VI road vehicles to less polluting BS VI road vehicles. Reduction in fuel consumption is reported in Table 5.13. The reduction of air pollution is presented in Table 5.14.

Table 5.13: Reduction in Fuel Consumption (million litre per year)

	2025	**2035**	**2045**
Diesel	57.3	0.1	0.2
Petrol	3.0	2.4	3.7

Table 5.14: Pollution Reduction (ton/year)

Pollutant	**2025**	**2035**	**2045**
CO	1624	231	222
PM	35	1	1
$HC+NO_x$	1495	37	36
CO_2 (net)	104803	209148	127605
Treatment cost (Rs million per year)	368	132	90

6. ANALYSIS OF ALTERNATIVES

6.1 Introduction

249 This section presents the symmetrically compared feasible alternatives to Balance C5. Alternatives such as other sources of transport (road, mono-rail, suburban rail), proposed design etc. have been considered and analyzed for its likely impacts on various environmental parameters. Additionally, an evaluation of potential environmental impacts in terms of 'with' and 'without' project scenario has been considered for the justification of the project. This section also presents a discussion on how environmental parameters were assigned due importance and considered in the analysis of alternatives.

6.2 Different Modes of Transport and Need to Increase Public Transport Share

250 The urban transport model was developed as part of Feasibility Study for travel demand assessment and to arrive at influential mass rapid transit corridors. The need for quantum increase in transport capacity of the current network by means of rapid transit along proposed corridors is indicated by inadequacy of road capacity. Major roads along the composite corridor 5 are forecast to function beyond respective design service volume in absence of the Corridor. The study estimated peak hour peak direction traffic (PHPDT) of 30,850 for composite Corridor 5 with a total daily ridership of 0.90 million passengers in horizon year 2035 in Phase II.

251 The Comprehensive Mobility Plan for CMA 2018 identified 8 mass transport corridors which are forecast to carry peak hour peak direction traffic ranging from 11000 to 35000 which is more than capacity of bus transport in form of discrete buses. One of these 8 corridors is from Madhavaram-Sholinganallur-ECR.

252 The development of the two scenario starts with estimating the traffic and the modal share in these scenarios for the system. As per travel demand forecast on revised network in DPR 2018, composite Corridor 5 (JICA and MDB Section) will cater to daily boarding of 7.2 lakh in 2025 and 18.5 lakh in 2055; maximum sectional PHPDT will correspondingly increase from 17,539 to 35,714. On Balance C5, PHPDT across sections will vary between 14,878 and 2021 in year 2025; 34,503 and 3248 in year 2055.

6.3 Analysis With and Without Project Scenario

253 In case Balance C5 is not constructed, the city will be deprived of the following benefits:

- Economic prosperity
- Mobility and access to economic opportunities
- Comfort and Safety, particularly for women and differently abled people
- Traffic Congestion Reduction, Reduction in Number of Buses
- Reduced Fuel Consumption, Reduced Air Pollution
- Carbon Dioxide and Green House Gases (GHG) Reduction
- Optimality in transportations

254 Benefit in terms of reduction in air pollution due to operation of Metro is estimated in Previous Chapter. In view of the large net positive impacts consideration of 'no development alternative' is a non-starter and has thus not merited any further consideration.

6.4 Comparison of Alternative High Capacity Modes

255 Table 6.1 presents comparison of unit life cycle costs of Metro, Light Rail Transit (LRT) and Bus Rapid Transit (BRT). The costs pertain to traffic demand forecast on MDB project corridors and are based on data for such systems operating or evaluated for Indian conditions.

Table 6.1: Cost Comparison of urban mass transit systems

S.N	**Balance C5**	**Forecast traffic demand in year 2055 PHPDT (length of section)**	**Life Cycle Cost (Rs lakh per seat)** *rounded off*		
			Metro elevated	**Light Rail elevated**	**BRT at grade**
1	CMBT to Sholinganallur (30.002km)	1000 to 10000 (Puzhithivakkam to Sholinganallur elev 12.2km)	>*80 to 36* *	>80 to 33 ** 2c	>36 to 25 ** 2b
2		10000 to 20000 (Alandur to Puzhithivakkam elev 3.8 km)	>29 to 23 ** 4c	33 to 20 ** 4c	25 to <22 ** 2b
3		20000 to 30000 (CMBT to Alandur elev 14.1km)	24 to 18 ** 6c	19 to 15 *	21 to 19 *
Assumed Capacity per coach/bus			270	242	80

** Section 9.3, Life Cycle Cost Analysis of Five Urban Transport Systems, IUT (India), 2012.*
*** Section 9.4, Life Cycle Cost Analysis of Five Urban Transport Systems, IUT (India), 2012, 4c: 4 car set. Average speed: Metro 35kmph, LRT or BRT 25kmph; average station/stop spacing: Metro 1km, LRT or BRT 0.75km, headway: Metro or LRT 2.5minutes, BRT 0.60minutes*

256 The above tabular statement shows that BRT has significantly lower unit life cycle cost from Puzhithivakkam to Sholinganallur. LRT shows no significant advantage to Metro on other sections.

257 Road connectivity is not available along the project alignment to operate BRT between Alandur and Adambakkam; road right of way is not adequate between Adambakkam and Puzhithivakkam on Medavakkam Main Road. In terms of reduced air pollution, benefit of Metro on the project corridors is estimated in previous chapter. of this report; BRT adds to ambient pollution in comparison to Metro.

258 Screening distance recommended for vibration induced by rubber tyred vehicles is 16 m against 67 m and 50 m respectively for rapid rail and light rail (Transit Noise and Vibration Impact Assessment, US FTA, May 2006): this indicates that exposure zone of BRT buses will be smaller than Metro.

259 Screening distance recommended for noise generated by bus on BRT is 70m against 233m and 116m respectively for rapid rail and light rail (Transit Noise and Vibration Impact Assessment, US FTA, May 2006): this indicates that noise exposure zone due to BRT buses will be smaller than Metro.

6.5 Alternatives of Alignment, Stations

260 In order to decrease cost for the same rate of capacity utilization, the metro line was changed from underground to elevated right of way from CMBT to Medavakkam Koot Road Station.

261 Entire Corridor 5 has been planned to provide connectivity between North Chennai and commercial / residential / industrial landuse in East and South Chennai via bus transport hub while providing interchange facilities with Metro corridors in Phase 1 and Phase 2 as well as suburban rail and MRTS.

7. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

7.1 Consultations

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

263 Public consultation and participation are a continuous two way process, involving, promoting of public understanding of the processes and mechanisms through which developmental problems and needs are investigated and solved. The public consultation, as an integral part of environmental and social assessment process throughout the project preparation stage not only minimizes the risks and manages the expectation of the project but also abridges the gap between the community and the project formulators, which leads to timely completion of the project and making the project people friendly.

264 Public consultation/information is an integral part of the Chennai metro project cycle. Public consultations with the people of different sections of the society along the project alignment, shopkeepers, and influential persons of the project area were made. Potential vulnerable people like, squatters, encroachers, schedule caste, and other backward section of society were consulted to make them aware and identify adverse impacts of the project.

265 The consultation process started early in 2017. CMRL held extensive consultation with the local community to share information of potential impacts and mitigation measures etc.

7.2 Stakeholders Engagement

266 Key stakeholders at central, state, district and local level which have been and will be consulted as part of the consultation process are listed as below. The minutes are attached in Annexure 9.

- Ministry of Environment, Forests and Climate Change (MoEF&CC)
- Central Pollution Control Board
- Tamil Nadu State Pollution Control Board
- State Environmental Impact Assessment Authority
- Tamil Nadu Coastal Zone Management Authority
- State Traffic Police Department
- State Public Works Department (PWD)
- Tamilnadu Highways and Minor Ports Department (TNHD).
- State Fisheries Department
- Airport Authority of India (AAI)
- Chennai Municipal Corporation
- Tamil Nadu State Department of Archaeology
- Central Ground Water Board
- District Forest Office

- Indian Meteorological Department
- Non-government organizations
- Women groups
- Shopkeepers associations

267 As a first step CMRL officers met with Principal Chief Conservator of Forests and Head of Forest Force, Tamil Nadu on 20th August 2020 and discussed diversion of Nanmangalam Reserve Forest land. He principally agreed and instructed his office to advise CMRL on the process of application for such diversion. Consultation with the Forest Range Officer in charge of Guindy National Park took place on 23rd October 2020 to seek the Range Officer's guidance on Guindy National Park's status. In 2023, Forest clearance was obtained for the same.

268 CMRL consulted the Defense Estate Officer on 17th October 2020 regarding the alignment adjacent to the Madras War Cemetery. The alignment will use the Highways right of way, hence no NOC will be required. Similar consultation was conducted between CMRL and Airport Authority of India to clarify that no NOC will be required.

269 Regarding the construction in River Adyar and Adambakkam Lake, the Fisheries Department was consulted on 22nd October and confirmed no fishing activities or fishermen in the nearby vicinity. The water conditions are tested and found not congenial for promotion of aqua culture. In October 2020, PWD reviewed the pier locations and arrangement though meetings and site visits, and found it to be satisfactory.

270 The construction along the Mount Poonamallee High Road is close to AAI transmitting station, with the nearest viaduct of 13 m from the boundary and station of 150m away from AAI property. AAI was shared with the alignment drawings. The requirement of NOC would be reconfirmed through their review on the detailed alignment and cross section near AAI.

271 The construction of Integrated Grade Separator in MIOT section was included as per the proposal of Tamilnadu Highways and Minor Ports Department to facilitate traffic decongestion. The Government order, Minutes of the steering committee meeting are attached in Annexure 14

7.3 Public Consultations

272 In order to enhance public understanding about the project and address the concerns of the community pertaining to mitigation of adverse impacts due to the Corridor 5, meetings with groups of persons comprising likely PAPs and other stakeholders in the community were conducted during the field survey that was carried out as part of detailed project report. These consultations are summarized in Table 7.1.

Table 7.1: Summary of Public Consultations Part 1

Location	Date	Number of participants	Suggestion/Opinion
Sholinganallur	27.10.2017	17	The shops should not be affected due to the proposed Metro project. The respondents said that this is an IT corridor and lots of traffic can be seen in the evening after office. So the metro project would be helpful.

Source: Comprehensive DPR for Chennai Metro Phase II, December 2018

273 During March / April 2019 public consultations with 37 participants were conducted at 8 locations. Public consultations and discussions were conducted with likely Project Affected Person (PAPs) as well as general public at identified station locations. The locations where selected so as to cover various socio economic profiles and habitation as well as impacted locations along the corridor. The consultation process involved various sections of affected persons such as traders, women, quarters, kiosks and other inhabitants. In order to hear and address the concerns of women, women were encouraged to participate and opportunity to express their concern was provided during the consultations.

274 During public consultation, benefits due the project and issues related to construction and operation were discussed with the affected communities; their opinions, suggestions and apprehensions were recorded. The consultations are summarized in Table 7.2.

Table 7.2 Summary of Public Consultations Part 2

Place	Date	Number of participants	Issue	Suggestion/opinion
Adambakkam	04.03.2019	4	Easy Travelling	Solve traffic issues and increase no of trips
			Fare	Fare should be comparable
Puzhuthivakkam	04.03.2019	8	Solve traffic issues and increase connectivity	Metro will reduce the traffic jam. The long distance travel will be easy and metro will increase the connectivity.
			Business loss due to construction activity	If construction activities go long more than expected, then it incurred loss to commercial/ shops.
			High ticket cost	The minimum metro ticket price in Chennai metro is Rs.50. The poor and middle class citizens will not be able to afford that money on a regular basis. So, they are using the bus services mostly.
Madipakkam	05.03.2019	5	Time Saving	Time will be saved in comparison with other

				means of transport.
			Traffic and pollution during construction of the project	There is a possibility of pollution and traffic problem during construction of the metro project.
			Reduction of road pollution	Metro train will reduce the existing high level of pollution both noise and air.
			Fare	Costly ticket of metro , Need to consider
Medavakkam Koot Road	27.03.2019	6	Road congestion	Operation of metro to reduce congestion on road
			Fare	Metro should be less expensive
			Reduction in pollution	Metro will reduce the existing traffic load and reduce the level of pollution.
			Metro reduce road side accidents	Metro will reduce the traffic and reduced in road accidents.
Perumpakkam	27.09.2019	5	Travel time	Travel time by metro will be lesser
			Congestion and Pollution	Congestion and Pollution due to road traffic will reduce
Global Hospital	04.04.2019	8	Reduction in Pollution	Metro will reduce the traffic and road accidents.
			Travel time	Travel time by metro will be lesser
			Area development	Due to metro train, other facilities will come such as infrastructure development. Local economy will boost up.
Sholinganallur	04.04.2019	6	Time Save	The metro train facility in Chennai will save time to reach the destinations in comparison with other means.
			Comfortable Travel	It would be easy to reach to the destinations due to the proposed metro project.
			Better connectivity	Metro may improve connectivity with speedy travelling.
			Reduction in pollution and accidents on	There would be reduced pollution and no accidents while travelling in metro

			road and overall	train
			Fare	The metro fare should be as less as possible considering paying power of the people
Velachery	05/04/2019	7	Solve traffic issues and increase connectivity	Metro will reduce the traffic jam. The long distance travel will be easy and metro will increase the connectivity.
			Business loss due to construction activity	If construction activities go long more than expected, then it incurred loss to commercial/ shops.
			High ticket cost	The minimum metro ticket price in Chennai metro is Rs.50. The poor and middle class citizens will not be able to afford that money on a regular basis. So, they are using the bus services mostly.

275 The participants highly appreciated the upcoming phase- 2 metro projects as it will increase connectivity, reduce the traffic load and reduce existing level of pollution.

276 During December 2019 CMRL invited all citizens whose properties could be adversely affected by the project to apprise them of efforts to reduce property acquisition by optimising the project design.

277 Before the commencement of construction of grade separator, the public opinion was collected informally, and it was expressed that the grade separator would greatly reduce the traffic issue of the location. Further, it was requested that work be completed without delay.

278 During 2023, when the change of alignment was proposed at the end of Balance corridor 5 i.e., Sholinganallur, public opinions were collected through informal meetings. The nearby residents and owners of commercial establishments welcomed the change in design, that it avoids the splicing of the high-rise building.

279 Public consultations during construction and operation will form part of semi-annual monitoring reports sent by CMRL to MDBs. These consultations will focus on the impact mitigation measures being implemented and their efficacy.

7.4 Information Disclosure

280 Information disclosure will follow the procedure and disclosure requirements of MDBs' policies for category A projects.

281 All environmental documents are subject to public disclosure, and therefore, will be made available to the public. This EIA and the Executive Summary (in both English and Tamil) was disclosed on CMRL and MDBs' websites. The hard copies of EIA will

be made available at CMRL office and site offices accessible to stakeholders. CMRL will ensure that meaningful public consultations, particularly with project affected persons' are undertaken throughout the design, construction and operation stages.

8. GRIEVANCE REDRESS MECHANISM

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

283 Many minor concerns of peoples are addressed during public consultation process initiated at the beginning of the project. However the most common reason for delay in implementation of projects in urban areas is grievances of people losing their land and residential and commercial structures. Resolving such cases in the Court of Law will be a very time consuming process. Considering this and based on CMRL's past experiences of dealing with PAP grievances, a GRM has already been put in place in order to address the grievances of project affected persons. Such a redress mechanism available at the project level itself will mean that the complainants do not necessarily have to directly approach a Court of Law although availability of Grievance Redress Committee (GRC) mechanism will not bar them from doing so.

284 GRM will be in two layers: a) executing engineer from PIU and b) Grievance Redressal Committee (GRC). The first level of interaction of GRM with the stakeholders will be the executing engineers from PIU to resolve ground level grievances including construction nuisances to PAPs with support from contractor GRM focal. Issues should be resolved within 14 days. Those that cannot be resolved by PIU will be escalated to be examined by the GRC. Alternately complainants aggrieved by inadequacy of actions taken by the executing engineer can escalate to the GRC.

285 The Environmental Health and Safety Expert on the CMRL Project Implementation Unit (PIU) who is an environmental engineer will coordinate the GRC which will report to MD, CMRL and Director Projects, CMRL. The other members of the GRC will be,

- CMRL Project Manager of the package/section
- EMP implementation teams from CMRL and GC
- EMP Manager from construction contractor
- Assisting NGO
- PAPs and representatives
- With a view to Affirmative Action to enhance women inclusivity, one-woman representative of local community from each 5km section of the alignment will be members of the Environmental and Social Grievance Redressal Committee. The representative(s) from the location(s) to which the grievance(s) pertain(s) shall be invited to deliberations of the Committee.

286 Records of the following stages will be maintained on website of CMRL throughout the life of the project:

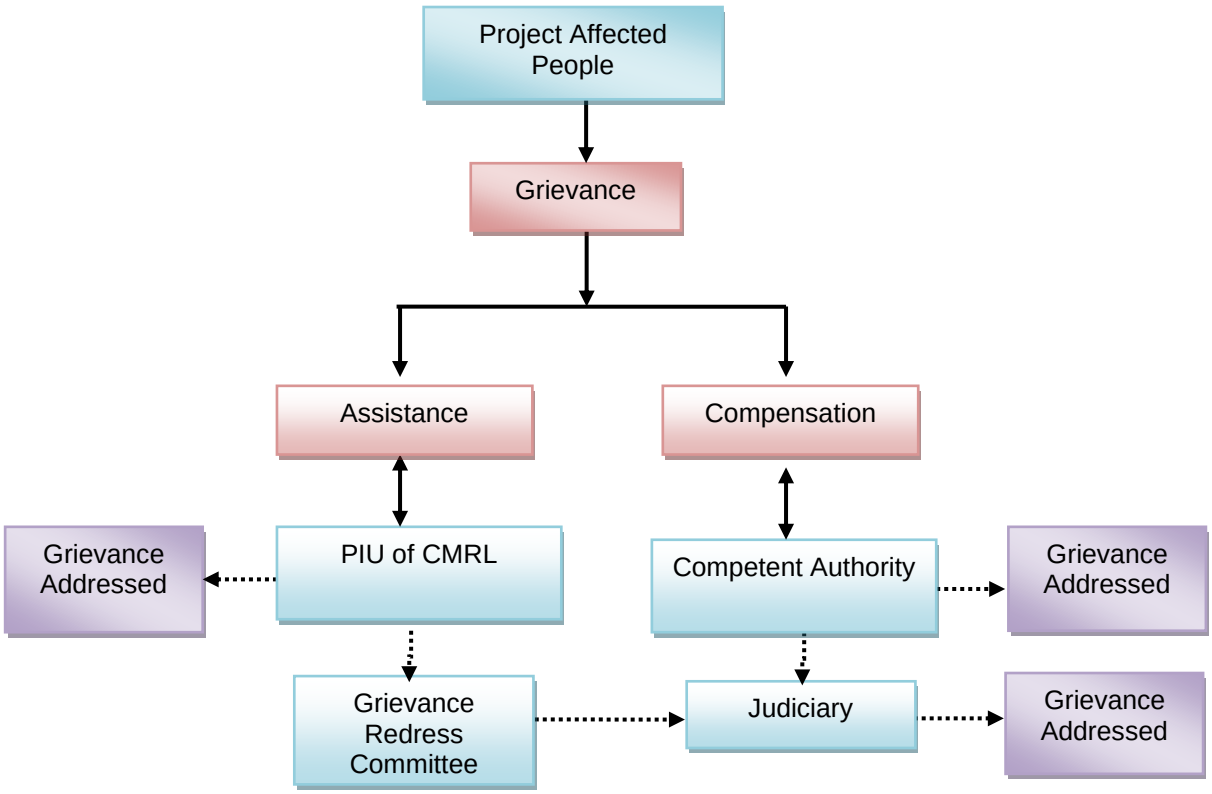
- Complaints received
- Acknowledgement of receipt of complaint by executing engineer PIU

- Actions taken by executing engineer and their efficacy
- Escalation by executing engineer or by aggrieved parties
- Records of further action and closure of complaints.

287 Complaints and escalation by aggrieved parties can be done by paper mode as well as through email. The GRC will deliberate upon time limits for each of the above stages; the time limits will be placed on website of CMRL.

288 The flow chart of GRM is presented in Figure 8.1.

Figure 8.1: Grievance Redress Mechanism



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

- GRC function independently
- All grievances are received in written form by GRCs and a separate record of the same, including contact details, is maintained
- A separate file / processing document is created for each case, based on its category (project, location etc.) and all observations and documents related to the case are maintained in such file
- Cases related to environment pollution, noise, eligibility, entitlements, disputes etc. are promptly handled after consultation with relevant authorities
- GRCs can seek necessary record / information (such as survey details, past written communication etc.)
- Written notices are sent to the aggrieved persons and respondents to appear for hearing along with documents, and further dates are provided in case of genuine inconvenience to the party about the appointed date
- Multiple hearings are conducted as per the requirements of cases and aggrieved persons (including their representatives) and respondents are heard and are provided opportunities to submit further documents / proofs

- Site visit documents submitted by the parties are verified from appropriate sources, as may be considered necessary
- In normal circumstances (excluding those requiring information from external agencies) the entire process is carried out in a time bound manner (On an average, it takes about 1-2 months for disposal of each case in GRC)
- After due consideration of the cases, written and reasoned orders are passed under the signature of Head of concerned GRC
- Any fatality accident should be reported to GRC and MDBs immediately

290 In addition to the above GRM for addressing complaints from the local community, a separate GRM will be constituted for addressing the issues of the workers, forming part of the bidding document for CMRL to review and clear. The clauses in the tender include the following:

- Enquiries, complaints and requests for information can be expected from a wide range of individuals and organisations both private and government. The majority of complaints is likely to be received by CMRL, although the site offices are also likely to be contacted.
- The objective of complaint process is to ensure that public and agency complaints are addressed and resolved consistently and expeditiously.
- The Contractor's Project Manager will be notified immediately on receipt of complaint that may relate to environmental impacts. The Project Manager will immediately inform the Employer's Representative.
- Field investigation should determine whether the complaint has merit, and if so action should be taken to address the impact.
- The outcome of the investigation and the action taken shall be documented on a complaint Performa prepared by the Contractor and submitted for notice by the Employer's Representative in advance of the works.
- Where possible, a formal response to each complaint received shall be prepared by the Contractor within seven days in order to notify the concerned person(s) that action has been taken.
- Grievance log should be prepared and documented in the monitoring report with the resolution details.
- GRM for workers shall be established as early as possible to function no later than construction commencement.
- The GRM information and focal should be disseminated to public.

9. ENVIRONMENTAL MANAGEMENT PLAN

9.1 Introduction

291 The Environmental Management Plan (EMP) consists of a set of mitigation, monitoring and institutional measures to be taken for Balance C5 to avoid, minimize and mitigate adverse environmental and social impacts and enhance positive impacts. The plan also includes the actions needed for the implementation of these measures. The major components of the EMP are:

- Mitigation of potentially adverse impacts;
- Environmental monitoring;
- Emergency response procedures;
- Institutional arrangements and reporting mechanism;
- Implementation Schedule;
- Training and capacity building, and
- Cost estimates.

9.2 Objectives of Environmental Management Plan

292 The main objectives of this EMP are:

- To ensure compliance with MDBs' applicable policies, and regulatory requirements of GoTN and GoI;
- To formulate avoidance, mitigation measures for anticipated adverse environmental impacts during construction and operation, and ensure that socially acceptable, environmentally sound, sustainable and good practices are adopted; and
- To stipulate monitoring and institutional requirements for ensuring safeguard compliance.

9.3 Institutional Arrangement

9.3.1 Executing Agency

293 GoTN created a Special Purpose Vehicle (SPV) for implementing the Chennai Metro Rail Project. This SPV named as "Chennai Metro Rail Limited" was incorporated on December 03, 2007 under the Companies Act. It has now been converted into a Joint Venture of GoI and GoTN with equal equity holding. GoTN and GoI will be the Executing Agency of the proposed MDB Corridor 5-CMRL (Phase-II).

9.3.2 Implementing Agency

294 CMRL is the Implementing Agency responsible for implementation of the metro rail project. Managing Director, CMRL is in charge of the overall project activities. CMRL is accountable to the GoTN (i.e. the EA).

295 Project Implementation Unit (PIU), CMRL headed by the Project Director (PD) is responsible for the overall execution of the project and implementation of the RP. The PIU will be assisted by General Consultant (GC). The safeguard role of GC is to assist CMRL in review of documentation and monitoring of implementation of EMP and monitoring plan during construction and operation by means of scheduled inspections, meetings and reports submitted to CMRL. The terms of reference are attached as Annexure 5.

9.3.3 Implementation of EMP

296 CMRL: EMP is committed by CMRL as part of its agreement with MDB. The responsibility to implement the EMP including Grievance Redressal rests with CMRL. The clearances related to locations and design of the project is secured before start of construction. Permissions/certifications required during operation of the project. Environment monitoring during operation.

297 Contractor: Permits required during construction and those directly related to construction. The EMP will be implemented by the contractors of different packages based on the contract agreement. The contractor SH&E team will be headed by senior Manager assisted by qualified and trained safety professionals and environment engineers along with onsite junior field personnel. This team will be assisted by:

- electrical and mechanical engineers qualified in safety evaluation;
- environment engineer;
- traffic engineer;
- professionals in occupational health and labour welfare.
- Environment monitoring during construction
- Regular monthly reports on implementation will be submitted by contractor to GC.

298 The Employer Requirements for Health, Safety and Environment have been prepared for Corridor 5; they will be issued to the Contractor as part of the contract documentation for construction. The requirements comprise the following 3 documents.

- Volume 1. Control Document
- Volume 2. Health and Safety Manual
- Volume 3. Environmental Management Arrangements

299 CMRL and GC: Supervision and review of implementation is the responsibility of GC. With assistance from GC, CMRL will review and approve specific documents/plans that have to be submitted by contractors (traffic management plan, waste management plan, muck disposal plan etc.). Each MDB project will be monitored by a separate GC: project-wise teams from CMRL will work with the project-wise GC**.** Implementation of EMP will be continuously monitored by the Safety, Health and Environment (SH&E) team of environment experts from the GC and CMRL. Contractor's Safety, Health and Environmental Officer (SHEO) will engage GC-Environment Specialist to discuss EMP, seek clarification and recommend corresponding revisions if necessary; will agree with GC the monthly monitoring template and deadlines for submission; will submit for GC's approval a work plan to secure all permits and approvals needed to be secured during construction; will submit for GC's approval the construction camp layout and management plan before its establishment; will update EIA (in consultation with GC, in case of design changes) and also prepare site-specific EMPs.

300 The CMRL Core environment team and GC Environmental Specialist will be responsible for monitoring of balance corridor 5. During construction CMRL – Assistant Manager /Environment was assigned and charged for this corridor, assisted by safety, environmental, traffic, labour welfare professionals deployed by GC and the Contractor. During operation of metro, the core environment team will continue to monitor implementation of EMP by the metro operations contractors and EMoP by external environment monitoring agencies.

301 GC will contribute,

- Specialists from fields of safety, environment, traffic engineering, occupational and community health, ecology, noise and vibration
- Onsite junior field personnel.
- The visits and review meetings will comprise:
- Weekly site visits independently by CMRL and jointly with contractor;
- Weekly review meetings by CMRL and contractor.
- Periodic quarterly reports will be submitted on implementation of EMP and its internal monitoring by CMRL to MDB.
- Orientation and training of CMRL team in implementation of EMP and environmental monitoring will be undertaken at the beginning of the project.

302 MDBs: Implementation of the EMP is monitored half yearly by MDBs through their experts.

303 External Monitor: An external agency is engaged by CMRL in consultation with MDBs to evaluate the environmental performance of abovementioned parties. The agency reports to CMRL who in turn report it to MDBs. Separate External Monitor will be engaged for MDB Balance Corridor 5. The terms of reference are attached as Annexure 6.

- To conduct third party monitoring of environmental compliance under the project;
- To ensure that the Project is implemented in conformity with the policies of GoI, GoTN, as well as MDBs' policies;
- To Identify any safeguard related implementation issues and necessary corrective actions and reflect these in a time-bound corrective action plan for CMRL to implement;
- Capturing social, environmental and economic benefits and particular potential benefits to the poor and vulnerable groups in the corridor;
- Involving users and stakeholders in the monitoring process; and
- Strengthening the capacity of the CMRL to manage and replicate third-party monitoring with rail users and stakeholders.

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

305 An EMP Matrix is presented in Table 9.2.

9.4 Environmental Monitoring and Reporting Program

306 Environmental Monitoring Plan (EMoP) is a companion document of the EMP. EMoP contain parameters, location, sampling and analysis methods, frequency, and compared to standards or agreed actions that will indicate non-compliances and trigger necessary corrective actions. More specifically, the objectives of the EMoP are:

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

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

308 Monitoring and Reporting Frequency for implementation of the EMP is shown in Table 9.1.

Table 9.1: Monitoring and Reporting for EMP and EMoP

Particulars	Frequency of reporting	Reporting by / Reporting to	Review by/ Monitoring by
Starting from deployment of construction contractor from site selection period a) Implementation of EMP and EMoP b) Monitoring of implementation of EMP and EMoP c) Grievance Redressal	Monthly till completion of construction	a) Contractor / GC b) GC / CMRL SH&E team, CMRL SH&E team/MD, CMRL c) CMRL SH&E team/MD, CMRL	CMRL
a) Implementation of EMP, EMoP and Grievance Redressal and their internal (CMRL) monitoring b) Outcome of continuing public consultations	Bi-annually till completion of construction	All by CMRL / MDBs	• MDBs • TNPCB
Evaluate implementation and internal monitoring of EMP, EMoP, Grievance Redressal and their efficacy	Semiannually during construction	External Expert / CMRL	MDBs
a) Implementation of EMP by CMRL and EMoP by external agency b) Monitoring of EMoP c) Grievance Redressal	Semiannually during first 2 years of operation & maintenance	a) and b) • EMoP Agency / GC • GC / CMRL SH&E team • CMRL SH&E team/MD, CMRL c) CMRL SH&E team/MD, CMRL	CMRL
a) Implementation of EMP, EMoP and Grievance Redressal and Internal (CMRL) monitoring b) Outcome of continuing	Semiannually during first 2 years of operation & maintenance	CMRL / MDBs	• MDBs • TNPCB

public consultations			
Evaluate implementation and EMP, EMoP, Grievance Redressal and their efficacy	Annually during first 2 years of operation & maintenance	External Expert / CMRL	MDBs

Table 9.2: Environmental Management Plan Matrix

309 This EMP Matrix will form part of the contract document together with CMRL's SHE Manual for all contractors. This EMP has been aligned with the SHE Manual wherever possible, and in places, cross referencing has been resorted to.

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
Planning and Design Phase						
1.	Land Acquisition	Social	As per CMRL estimate of April 2020, permanent acquisition of 6.05 ha private land is required affecting 811 families. The final size of land to acquired will be updated based on the optimization of project design.	1. Compensation and Resettlement benefits as well as livelihood restoration measures have been approved by CMRL. based on The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. 2. Land Acquisition is being carried out as per the provision of GoTN and GoI policies. The affected people will be compensated and assisted as per the provisions of Resettlement Action Plan (RAP).	CMRL	Revenue Dept. GoTN
2.	Change in Land use	Land	Land use will be slightly changed	1. CMRL developed the Comprehensive Mobility Plan for CMA in 2015 to identify the present and future mobility patterns of Chennai Metropolitan Area, including development of Corridor 5. 2. Proper clearance/permission/consents will be sought from competent authority before construction.	CMRL	CMDA
3.	Contractor Management	EHS	EHS accidents Reputational Risk	1. Integration of EHS contractor management into broader project management, procurement, human resources, legal, and financial management. 2. "Prevention through design": assessment of what prime contractor does versus what subcontractors do; contractor prequalification (when, if, and for what); use of information technology tools (identification cards and tracking and reporting systems for personnel and training). 3. Prime contractor will be responsible for EHS practices of the subcontractor including human resource policy which complies with applicable labour legislations, including decisions on material supplies and equipment given environmentally friendly priorities, and prepare	Contractor / GC	CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				subcontract agreements accordingly. 4. Contractor management incorporates "adaptive management" to monitor and adapt over time; integration with sustainable procurement approach or concepts. 5. Building culture and commitment by demonstrating the importance of EHS management to the president or director of project-implementing agency and president or director of subcontractor; including EHS aspects in routine senior management project contractor meetings and reports, reflecting both criticisms or suggestions and praise; designating responsibilities of EHS staff (for example, work stoppage); requiring strong and consistent training and participation of managers; acknowledging managers' participation in on-site supervision and resolution of issues; and providing awards, recognition, and incentives. 6. Training and quality control plans.		
4.	Contractor Preparatory Works (Upon issuance of Notice to Proceed)	EHS	Non-compliance with contract conditions and regulatory requirements.	1. The Contractor shall complete the following activities no later than 30 days upon issuance of Notice to proceed, (a) appoint contractor's Safety, Health and Environmental Officer (SHEO); (b) SHEO will engage GC-Environment Specialist to discuss EMP, seek clarification and recommend corresponding revisions if necessary; (c) SHEO will agree with GC the monthly monitoring template and deadlines for submission; (d) SHEO will submit for GC's approval an work plan to secure all permits and approvals needed to be secured during construction stage which include but not limited to: i) operation of crushers and hot mix plants, ii) transport and storage of hazardous materials (e.g. fuel, lubricants, explosives), iii) waste disposal sites and disposal management plan, iv) temporary storage location, iv) water use, and v) emission compliance of all vehicles. Arrangements to link with government	Contractor / GC	CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				health programs on hygiene, sanitation, and prevention of communicable diseases will also be included in the action plan; (e) SHEO will submit for GC's approval of the construction camp layout and management plan before its establishment; and(f) SHEO will update EIA (in consultation with GC, in case of design changes) and also prepare site-specific EMPs. Template of internal weekly environmental inspection, weekly audit by the contractor are placed in Appendix II of Environment Social Health and Safety Requirements which form part of the construction contract documents; template for monthly audit by GC is at Appendix II. Contractor will submit monthly Environmental Quality Reports to CMRL; GC shall submit quarterly monitoring reports to CMRL.		
5.	Labour Management	Labour	Labour right	1. Compliance with GoI labor legislation, ratified International Labour Organization conventions. 2. Prohibition of child labor, including prohibition of persons under 18 years old from working in hazardous conditions (which includes construction activities) and from working at night; medical examinations required to determine that persons above 18 years old are fit to work. 3. Elimination of discrimination with respect to employment and occupation, to be defined as any distinction, exclusion, or preference based on race, gender, religion, political opinion, trade union affiliation, national extraction, or social origin. 4. Human resource policy or plans that establish (a) the rights and responsibilities of project company employees and any contractor employee working in the project regarding remuneration, working conditions, benefits, disciplinary and termination procedures, occupational safety and health, promotion procedures, and training and (b) the rights, responsibilities, and	Contractor	GC / CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				requirements in contractor or subcontractor agreements related to worker rights. 5. Grievance Redress Mechanism for workers should be established as early as possible to function no later than construction commencement. 6. There will be provision for group accidental insurance for the workers.		
		Health and Safety	Accidents and COVID-19	1. Make mandatory the use of safety gears (helmets, safety belts, masks, gloves, Ear plugs/ muffs and boot) by workers depending on nature of work. 2. Necessary planning and safety approach will be made for rescue during emergency. 3. Use of exhaust ventilation for dust control 4. Workers will be provided with first aid and health facilities at the site. 5. There should have facility to deal with medical aspects of HIV/AIDS treatment with specialized services. 6. CMRL COVID-19 protocols forming part of the Environmental Social Health and Safety Requirements contained in the contract document shall be followed: labour shall be trained and informed of precautions such as social distancing, sanitizing, avoiding groups; arrangements for thermal scanners; provision of sanitisers, face masks, gloves etc.; site record of COVID-19 hospitals; protected ambulances at site; daily disinfection of site, equipment and vehicles.	Contractor	GC / CMRL
6.	Obtaining Clearance, Permission and Consents	Regulatory Compliance	Delay of obtaining forest clearance, Tree felling information, Consents to establish labour camps, pre-casting and material yards, depots, establish and operate hot mix plant, crushers, batching plant, DG sets etc. muck/waste disposal.	1. Consultation and coordination with relevant authorities to prepare the documents to obtain clearance, permission and consents. 2. Conditions set in the forest clearance, permission and consents to be incorporated into the site-specific EMPs, with dedicated officers to maintain the regulatory compliance tracker.	CMRL / Contractor	Tamil Nadu Forest Dept., / TNSPCB

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
7.	Site Clearance and Demolition	Tree felling	About 259 trees are affected at alignments, & stations. This number will be updated again during site clearance. Additionally, in some areas, pruning will be required. (Excluding 145 translocated trees)	1. CMRL and Contractor need to conduct a final tree inventory survey (number, type, height) with the final designs of alignment and station. Trees with conservation value should be transplanted. Plan to avoid cutting patrimonial trees, including adjustments in project design to minimize effect on such trees. 2. Revisit the works in public parks or green spaces and potential tree removal, especially involving patrimonial trees of special significance, so minimize the impacts as much as possible. 3. If unavoidable, implementation of acceptable plans for transplanting (to the extent technically and economically viable) or replacing such trees and for their short-term maintenance and care. 4. Adequate coordination with applicable government regulatory authorities. As alignment passes through built land use, green belt development along elevated section is not feasible. Compensatory plantation of 12 saplings for every tree felled will be done in sites to be identified. CMRL to allocate sufficient tree replantation budget. 5. Plan including sites for compensatory plantation and species and identification of trees to be transplanted will be identified by CMRL in consultation with Forest Department and CMDA and Municipal Corporation. 6. CMRL Stakeholder communication to avoid or minimize public concerns or protests. 7. Definition of adequate budget and contingencies as well as financial resources to cover all related costs. This will be finalized before work on relevant section is commenced between CMRL and Contractor.	CMRL / Contractor	Forest Dept. GoTN and CMDA, GCMC
		Forest land	Landuse change from forest to non-forest purpose	1. Diversion of 1.569 Ha scrub forest land will be alienated upon payment of amount as per Forest Land Rules to the TNFD. Notwithstanding non-transfer of ownership, possession charges will be paid as per FC Rules.	CMRL	GoTN Revenue and Forest

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				Normally, compensatory afforestation is to be raised on suitable non-forest land, equivalent to the area proposed for diversion, at the cost to be paid by User Agency. However it will be raised and maintained on degraded forest land twice in extent of the forest area diverted as this is a case of projects implemented by the Central Government/PSUs. As such, compensatory afforestation will be done on 15,140 sqm of degraded parts of Nanmangalam Reserved Forest. Such use of degraded forest land will obviate the need for transfer and mutation of non-forest/ revenue forest land in favour of TNFD. 2. Allocation of adequate budget to support the 1:12 compensatory plantation. 3. Additional measures will be taken to transplant the mature and ecologically important trees.		Departments
		Avifauna Habitats and biodiversity in Nanmangalam Reserve forest and Pallikaranai marsh[1]	Disturbance to nesting and breeding due to noise and other project activities	1. Engage an ornithologist to conduct survey of breeding sites and review the populations of avifauna which may trigger critical habitats. 2. Avifauna habitats and breeding areas avoided as far as possible from project footprints. 3. Before the felling of trees, the trees will be inspected for presence of nests. If any trees have nests, the nests will be transferred to another nearby tree. This activity of transferring the nests will be done under the guidance of the local forestry or wildlife authority. The contractor will be prohibited from killing or hunting animals or birds in the project area. 4. Assessment of actual and potential disturbance effects of project activities and develop the Biodiversity Management Plan (BMP) to ensure no net loss of the	Contractor	GC / CMRL /TNFD

[1] Nanmangalam Reserve Forest is a natural habitat. Pallikaranai Marsh is a modified habitat. Both sites will be further studied before contractor's mobilization to examine the applicability of Critical Habitat. The project will run along the edge of the forest, and will run in parallel with the marshland, hence no significant impacts envisaged if the mitigations will be properly implemented. Furthermore, the forest land to be diverted is devoid of tree felling. The anticipated impacts on the avifauna habitats due to tree felling will be limited. The impacts on avifauna reproduction, nesting and breeding will be assessed during the ecological survey, in order to reflect the mitigation or offset measures in the BMP.

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				target species. The BMP will outline the actions required by the contractor to conserve or enhance biodiversity during site works particularly during piling and construction work. The BMP will be reviewed by lenders prior to contractor's mobilization. 5. Utmost care shall be taken to ensure that no disturbance/damage is caused to the Forest land and Marsh. For instance, use of noise barriers on the elevated line; lighting at stations on this section will be kept to the minimum and of frequencies and brightness which do not affect bird behaviour. 6. Liaison with local government offices to increase awareness of habitat protection and reduce further encroachment problems.		
		Aquatic ecosystem in Adyar River and Adambakkam Lake	Disturbance to the aquatic ecosystem due to the Pier Construction (8 piers in Adyar river, 14 piers in Adambakkam Lake and X Piers in Pallikaranai water body)	1. Fisheries Department confirmed that no fishing activity is carried out at the proposed locations. Engage with PWD and Fisheries Department to identify areas of high biodiversity value and/or areas used by aquatic life for feeding and breeding. 2. The timing of construction should consider seasonal factors such as breeding and growing seasons; timing of feeding and periods of reduced ecosystem resilience (e.g., after extreme weather events); and to minimize the risk of erosion. 3. The construction methods and equipment should be selected to minimize suspension of sediments, minimize destruction of benthic habitat, minimize the noise and vibration. 4. The construction material and waste storage areas should be selected to avoid contamination of river water quality and to avoid disturbance on existing embankments. All wastes are to be removed from site and disposed of at an approved facility. All waste concrete and concrete wastewater must be collected	CMRL / GC/ Contractor	GC / CMRL/ PWD / Fishery Department

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				and disposed of under the supervision of SHEO with records (logs and photos). 5. The primary water quality at construction site of Adyar River and Adambakkam Lake has been collected. During construction, the onsite monitor of water quality will be required. Contractor will compare the parameters with the background water quality. At a minimum, this will involve daily visual inspections; measurements of turbidity, pH, temperature, and conductivity. 6. Ensure the site isolation is monitored on a full-time basis. Inspection and monitoring (such as feedback or adaptive monitoring) of construction activities in Adyar River and Adambakkam Lake should be conducted timely to evaluate the impact of construction, the effectiveness of mitigation measures, and the need for technical adjustments to avoid and minimize impacts to identified sensitive aquatic receptors. The frequency of monitoring should be sufficient based on site specific considerations. 7. Ensure the aquatic habitat is restored to, or as close as possible to, its natural status upon construction completion. 8. Incorporate all the above mitigation measures and any other measures recommended by GC into the BMP for lenders to review prior to contractor's mobilization.		
		Noise	Noise will be generated the use of hand tools such as jackhammers, sledgehammers and picks etc.	1. The procedure of demolition will be conducted as per the demolition plan prepared by the Contractor in consultation with CMRL. 2. The existing structures should be demolished one after another cautiously. 3. Wherever possible demolition will be done manually	Contractor	GC / CMRL
		Physical Cultural Resources	Historic and Cultural Value Loss	1. Contractor to conduct pre-construction structural integrity inspections if there are known or a significant likelihood of archaeological and/or culturally valuable sites or finds in the project's direct area of influence.	Contractor	GC / CMRL / CMDA

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				Prepare a monitoring scheme prior to construction based on the above inspections, with a focus on pre-identified receptors comprising educational, medical and physical cultural buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment , or finds in the project's direct area of impact.. 2. Prepare a monitoring scheme prior to construction based on the above inspections, with a focus on pre-identified culturally valuable sites if any near the alignment, or finds in the project's direct area of impact.. 3. Compliance with applicable legislation (permits and procedures) and good international practice. 4. Adaptive management in site-specific EMP during final design, including site locations (stations and construction staging areas). 5. Chance finds procedure to be prepared by Contractor and reviewed by GC/CMRL before submitting to all lenders. 6. Measures to mitigate noise and vibration are already listed in this EMP. Maximum levels of noise and vibration.		
8.	Severance of utilities	Social EHS	The proposed alignments will cross drains and utility services such as sewer, storm water drains, water and wastewater pipes, roadside lights, telephone cables, electricity power lines, electric poles, natural gas lines and traffic signals etc.	1. Assets and utilities will be maintained without affecting and damages by shifting temporary/ permanently where it is necessary. 2. Based on utility maps and network information, CMRL and Contractor in collaboration with utility owners oversees an investigation of existing utility supply infrastructure using trial pits or mix of 3D imaging and trial pits where pits pose safety hazards in built areas. CMRL and Contractor to conduct on-site inspections and a topographic survey. Even when utilities are far enough below the surface, to avoid damage from construction, they may need to be diverted so that their	Contractor	CMRL / CMWSSB, TANGEDCO, Telecom companies

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				maintenance will not affect the safe and efficient operations of the train system once construction is completed. Utility owners will be involved in providing any new utilities needed for the rail system and in designing the necessary diversions and protection measures to minimize the risk to existing utilities from ground movement and surface settlement. 3. In case gas pipelines are found during detailed utility survey prior to construction, Contractor will conduct the hazardous operation study to ensure the smooth and safe shifting. 4. Utility shifting plan will be developed by CMRL and Contractor in coordination with concern authorities and shifting of utilities will be done as per agreed utility shifting plan prior to construction commenced. The plan will include required EHS management measures, supervision and monitoring of implementation, and final report and confirmation that construction works will be properly closed (for example, all waste will be removed or re-pavement will be completed as required). 5. In case public utilities are required to be shifted to private land in exceptional circumstances, then adequate compensation shall be made by CMRL to the property owner on the same principles as temporary land acquisition. Following completion of construction of metro, such utilities shall be rehabilitated on public land.		
9.	Noise and Vibration Impacts Related Design	Environmental Nuisance	Noise and vibration from construction and train operation	1. The detailed noise and vibration analysis (mathematical modeling) at pre-identified receptors comprising educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (RRT, cat.2) for vibration and 100m (RRT, intervening buildings) for noise on either side of alignment based on final engineering designs is ongoing, based on which, a set of mitigations should be prepared and shared with all lenders for	Contractor	GC / CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				review, prior to commencement of construction. 2. Visual inspections of these buildings shall be done by the contractor so as to serve as baseline to monitor progression of building damage if any due to vibration. 3. Ballast less track structure is supported on two layers of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed up to the rail level so as reduce sound levels. Noise at source will be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc. 4. Noise barriers made of suitable polycarbonate as per tender document will be installed.		
10.	Lighting	Bird Habitat	Impact on bird habitats and nocturnal animals	1. Lighting on viaduct and stations from Velakallu to Medavakkam Koot Road Bus Stop station, Perumbakkam to Sholinganallur stations will be kept at frequencies and brightness which do not affect bird and wildlife behavior.	Contractor	GC / CMRL
11.	Coordinate with the Traffic Department on Traffic Management Plan	Land Occupational safety Community safety	Nuisance from traffic congestion	1. The Contractor shall develop detailed and robust traffic management plans consistent with the Indian Guidelines on Traffic Management in work zones (Indian Road Congress:SP:55-2014), prior to mobilization for respective sections with site- or station-specific plans and measures to minimize the overall impact on traffic throughout the construction and operation periods. 2. At congested sections, the temporary traffic coordinators will be engaged by CMRL to facilitate the traffic management. 3. At the minimum, the traffic management plans will have the following components: construction traffic, ensuring access to properties, accommodating pedestrians, parking, access by construction vehicles, faulty traffic lights and problem interchanges, use of public roads, parking provision during construction, use of residential	Contractor	GC/ CMRL/ Traffic Police

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				streets and traffic diversion due to temporary road closures, and construction and use of temporary access roads. 4. Strengthening impact and risk prevention measures, such as establishing construction site works to minimize the entrance and exit of vehicles at stations during peak traffic. 5. The logistics should be considered to manage transport materials from storage areas outside of the dense urban core to worksites and to return excavated soil and other materials to disposal locations. If needed, construction traffic may be confined to certain routes (based on infrastructure capacity) or restricted to certain off -peak hours (that is, to reduce noise pollution at night or to avoid commuting and school hours during the day). 6. Any diversions of traffic will cause considerable confusion for pedestrians and drivers as they rearrange their itineraries, hence, to minimize the effects of the diversion or reorganization, it is necessary to conduct communication campaigns and disseminate appropriate information to urban residents and taxi and bus drivers in advance of disruptions. Efforts will be given to divert traffic to roads wide enough to accommodate extra traffic. Compliance with scheduled deadlines for the detour is essential. If necessary, bus service and other public and private transport services in the area should be improved to meet residents' transportation needs. 7. Incorporation of community safety considerations into plan design, especially at locations such as CMBT to Porur, St Thomas Mount to Velakallu, Medavakkam Koot road to Perumbakkam where buildings are close to the construction site. 8. In order to avoid risk to life and damage during construction near and above properties which are not proposed for permanent acquisition, such properties		

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				and premises shall be vacated and residents/users temporarily shifted for duration of construction. 9. CMRL and local authorities continue to play an oversight role in approving these plans during construction, evaluating their cumulative impact with other infrastructure projects in the region, and ensuring their dissemination to all relevant stakeholders.		
12.	Construction method, construction material and sites selection	Environment	Pollution and nuisance	1. Contractor is committed to use environmentally friendly construction methods and materials, including cement, sand and aggregate. 2. Construction material shall be sourced from quarries approved by GoTN and CMRL. Extraction from river beds is banned. 3. The contractor shall collect from his material vendor and submit to CMRL valid consents to establish and operate issued by TNSPCB for the quarries from where the vendor sources the material as well as the quarry licence issued by the concerned district authorities. This requirement applies equally to authorized vendor or new vendor.. 4. The contractor shall be responsible to ensure that the vendor adheres to the pollution mitigation measures during loading, transportation and unloading the material as contained in the construction contract documents Again this requirement applies equally to authorized vendor or new vendor. The contractor`s or CMRL`s responsibility shall not extend to verifying that the quarry operator is abiding by the stipulations of the quarrying licence and consents issued to him. 5. Energy saving technologies will be embedded into the Project design wherever possible. For instance, solar panels, rainwater harvesting. Bureau of Energy Efficiency (BEE) certified/ Energy efficient LED lights, automatic signaling, etc. 6. Update of plan based on final contractor-defined	Contractor	GC / CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				estimated volumes and timing for groundwater pumping with intension of minimizing the groundwater consumption. The primary objective shall be to avoid extraction of groundwater for construction. However use of groundwater which has been generated by dewatering of excavations can be used in construction activities. In those instances where extraction of groundwater becomes unavoidable, contractor shall, with consent of CMRL, resort to such extraction. In such instances contractor-defined estimated volumes and timing for groundwater pumping with intention of minimizing the groundwater consumption. 7. Procedures for minimizing waste segregation, reuse, temporary storage, recycling, donation, and disposal. 8. Selection of waste disposal service providers (transport, recycling, and disposal) based on EHS criteria (including compliance with all regulatory requirements, no documented EHS issues related to materials at operation or site facilities, and agreement to provide access for site visits to discuss EHS management). 9. Final selection of disposal or reuse sites for extracted soils from construction and assessment and determination of truck routes from project sites to disposal or reuse site. 10. Focus will be placed on reuse of the extracted soil for enhancement of green space, waste recycle, and storm water runoff. 11. Construction yards with aggregate crushing and screening, pre-casting, material and fuel storage and ready-mix concrete plants will be located away from inhabited or ecologically sensitive areas. Locations will be decided by CMRL and cleared by MDBs before construction commencement in consultation with Municipal Corporation/Municipalities and CMDA. 12. The muck disposal sites shall be identified by		

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				Contractor and will be decided by CMRL before start of construction in consultation with TNPCB, Municipal Corporation/Municipalities and CMDA, to ensure a safe distance from residential areas, water bodies and ecologically sensitive locations as to avoid disrupting natural drainage. The muck shall be filled in the dumping site in layers and compacted mechanically. Suitable slopes will be maintained on the stockpile. Once the filling is complete, it will be protected by low walls, provided with a layer of good earth on the top and covered with vegetation. A muck disposal plan will be prepared by Contractor and approved by CMRL and TNPCB. Hazardous waste will be taken away by licensed vendors who will be responsible for due disposal at permitted sites.		
13.	Climate Designs	Health and Safety	Natural disasters generated health and safety accidents Maintenance Cost	1. Disaster management plan will pay special attention to road drainage from Medavakkam to Sholinganallur, to adapt the disruption of road level access to stations due to rise in mean sea level.. 2. Other climate adaptation designs will be embedded in the final design, such as (a) Increase in capacity of stormwater drainage will be made so as to deal with extreme flooding in addition to demand of future landuse growth along this alignment.. Increased number of pits for rainwater harvesting from elevated metro to cater to flood waters and heavy rains. 3. Climate change mitigation measures will be considered, such as solar panels on station buildings and roofs to reduce the extensive use of grid-generated electricity supplied to the station for operation and maintenance.	Contractor / GC	CMRL
14.	Site-specific Environmental Baseline Collection and Assessment	Environment	Benchmark of assessing project impacts	1. Prior to mobilization, contractor to collect a full set of baseline data of air, water (surface and ground), noise, vibration, soil quality. Special attention to water quality of Adyar River and Adambakkam Lake. 2. Additional investigations in areas identified as having	Contractor	CMRL / GC

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				contaminated soil or groundwater to define the degree and extent of contamination and alternatives for soil and groundwater disposal. Assessment of potentially contaminated soil at site locations where soil work and excavations will be performed to examine the site situation. If there is a reasonable likelihood of contamination, then a specific management plan that includes (a) monitoring during construction consisting of visual inspections, on-site and in-situ monitoring to detect and confirm levels of contamination (and supplemented as needed by laboratory analysis), (b) on-site temporary storage and treatment, (c) final disposal (both for water and soil), and (d) worker health and safety procedures. 3. Assessment and site-specific measures for controlling noise, dust, and illumination during construction (for example, when working 24 hours a day). 4. Confirmation of potential uses of groundwater. Efforts on minimizing the groundwater consumption. 5. Contractor to prepare site-specific EMPs for CMRL to approve before mobilization. 6. Based on detailed construction work plan and associated occupational health and safety risks, strengthening the contractor health and safety management system in site-specific EMPs. 7. CMRL and GC to provide EMP orientation to contractor.		
15.	Documents Review, Stakeholder Engagement and Information Disclosure	EHS	Unanticipated impacts management	1. With the assistance of GC, CMRL will review the above said data collections, surveys and pre-construction plans prepared by Contractor. 2. As part of stakeholder engagement activities, with the assistance of GC, CMRL will consult with all relevant governing authorities regarding the project impacts and mitigations, including but not limited to, Public Works Department, Fisheries Department, Tamil Nadu Forest Department (including potential impacts on Guindy	CMRL	CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				National Park), Tamil Nadu Highways Department, Defense Estate office, Airport Authority of India, Southern Railways. All meetings shall be well documented. 3. CMRL will submit to all lenders to review the documents and disclose in a timely and meaningful manner prior to construction.		
16.	Establishment of Grievance Redress Mechanism	EHS	Complaints not resolved in time	1. Grievance Redress Mechanism for workers and project affected people should be established as early as possible to function no later than ground work commencement. 2. The Grievance Redress Mechanism information and focal should be disseminated to public.	CMRL	GoTN
17.	Community Liaison	Social	Complaints	1. To ensure that Grievance Redress Mechanism to function effectively for affected people on construction nuisance at ground level with grievance log well documented. 2. Contractor to develop a community communication plan per the construction plan, including important measures to reduce community risk, such as fence and related protection around work sites (including strength and visual protection), education and awareness signs and information, and placement of safety risks (explosive and flammable materials, generators).	Contractor	GC/ CMRL
Construction Phase						
18.	Construction Monitoring	EHS	Breach of legislation, EIA, EMP, Contracts Accidents	1. Contractor to collect and monitor the Ambient environmental data of air, water (surface and ground), noise& vibration, soil quality and submit monitoring reports to GC / CMRL on monthly basis. 2. GC / CMRL to review the data compared to baseline data and urge Contractor to take immediate actions over any project generated pollution / contamination. 3. GC to submit monitoring reports on quarterly basis to CMRL. 4. If any unanticipated EHS impacts arise during	Contractor / GC / CMRL	TNSPCB

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				construction, implementation or operation of the Project that were not considered in the EIA / EMP, Contractor and GC to promptly inform CMRL of the occurrence of such risks or impacts, with detailed description of the event and proposed corrective action plan. CMRL will report to all lenders accordingly. 5. CMRL to engage qualified and experienced third party monitor to verify information produced through the Project monitoring process, and facilitate the carrying out of any verification activities by such third party monitor. 6. CMRL to submit the semi-annual monitoring reports (GC's and third party's) using the agreed template to all lenders. 7. CMRL to report all lenders any actual or potential breach of compliance with the measures and requirements set forth in the EMP promptly after becoming aware of the breach.		
		Biodiversity	Breach of legislation and BMP	1. Apart from the abovementioned measures for EHS monitoring, CMRL to ensure the BMP implementation monitoring and wildlife monitoring. If any wildlife species are found in the construction site, they will be carefully transferred to safe locations within the Forest Land or Marsh under the guidance of the biodiversity expert and the local forestry/wildlife agency. 2. Monitor construction (a) to avoid construction activities near critical habitats during migrant and breeding seasons; (b) Minimize construction activities near Nanmangalam forest and Pallikaranai Marsh during the bird migratory season to the extent possible. 3. Monitor noise level to minimize the impacts, for instance, use of rotary drilling rigs which generates less noise in comparison to impact hammer. The Construction Method Statement will follow the Good International Industry Practice.	Contractor	TNFD /CMRL/ Fisheries Dept

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				4. Monitoring habitat enhancement to deliver net benefit to Critical Habitat species.		
19.	Community Liaison	Social	Complaints	1. To ensure that ongoing timely consultations / communications with communities are provided on the progress of the project together with feedbacks on the environmental management performance of the project. 2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented. 3. Contractor will provide a minimum of two (2) weeks notification to directly affected residents, businesses and other relevant groups of the intended construction commencement date. In providing a mechanism for communication between the contractor and the community and informing the public of construction details (timing, expected impacts), CMRL will undertake consultations. 4. Adaptive management that monitors, adjusts, or adds measures to reflect actual community risks. 5. Important measures to reduce community risk, such as fence and related protection around work sites (including strength and visual protection), education and awareness signs and information, and placement of safety risks (explosive and flammable materials, generators).	Contractor	GC/ CMRL
20.	Truck and Driver Management	Environment Social	Community disruption Accidents Reputational risk	1. Contractor's transport vehicles and other equipment shall conform to emission standards. 2. Control, inspection, and documentation of trucks prior to leaving site, including removal of soil on tires. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility,	Contractor	GC / CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. 3. Definition of allowable routes, speeds, and times (day or week). 4. Driver requirements and controls, including prework medical (and blood tests) and physical inspections, ongoing monitoring (of visual and alcohol or drug use), driver training, daily total allowable work time, and allowable deviations. 5. Driver contracts with clearly specified requirements and remedies for noncompliance. 6. Use of electronic monitoring (GPS), driver training, and stops. 7. Procedure for truck maintenance, including selection of service providers considering environmental aspects, application of low-Sulphur fuel, no idling of trucks, routine maintenance (including assurance of proper engine operations related to emissions and noise), and disposal of used oil and other fluids, batteries, and tires etc. 8. Used water shall be collected, subject to precipitation and re-used.		
21.	Leveling of Site	Land	Surface leveling will alter the soil texture and compactness, which will affect the infiltration and soil ecology. Also leveling will involve alteration of natural drainage	1. Interim drainage system will be installed prior to construction. 2. Where feasible, infiltration losses could be countered by installing Rainwater Harvesting pits away from construction site.	Contractor	GC/ CMRL
22.	Mechanical piling and Pier Construction	Air	Construction of Piles Piers will result into fugitive dust generation	1. Fugitive dust could be controlled using water sprinkling. Water sprinkling to be carried out by Contract at regular interval (to be mutually decided by the contractor and CMRL). 2. Every vehicle should be washed to remove any dusty materials from its body and wheels before leaving the construction sites.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				3. Imposition of speed controls for vehicles on unpaved site roads. Ten kilometers per hour is the recommended limit.		
		Noise	During mechanical piling operations, noise will be generated which may go up to 88-90 dB (A) at a distance of 5m	1. At sensitive locations, auger piling will be carried out in place of mechanical (by driven) piling which will generate less noise than mechanical piling (around 70-75 dB(A)). Also 2m high barricade of GI sheet will be installed on all sides of piling operations. This could effectively cut down noise levels by 10-15 dB (A). Piling operations will be restricted during day time hours only. 2. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 3. Use of low-noise equipment and ensuring good maintenance, and trying to avoid using high-noise equipment simultaneously at the same section. 4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards. 5. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 6. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. 7. Monitoring required during construction, including field observations and measurements.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Vibration	Pile driving for viaduct piers and buildings vibrations	1. Cast-in-situ piling will be deployed at locations with sensitive receptors so as to reduce vibration. 2. At locations where the alignment is close to sensitive receptors, the contractor shall implement the pre-construction structural integrity inspections. 3. Contractor to ensure that vibration levels at historically and culturally sensitive Structures, and Structures in poor state condition will not exceed 5.0 mm/s. 4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 5. Monitoring during construction including field observations and measurements.	Contractor	GC/ CMRL
		Waste	Soil and surface/ground water pollution	1. Bentonite slurries used in construction should be reconditioned and reused wherever practicable. 2. The disposal of residual used bentonite slurry should follow the international good practice. 3. Segregation and storage of different types of waste in different containers, skips or stockpiles to enhance reuse or recycling of materials and their proper disposal. 4. Nomination of an approved person, such as a site manager, to be responsible for good site practices, arrangements for collection and effective disposal to an appropriate facility, of all wastes generated at the site.	Contractor	GC/ CMRL
		Aquatic Ecosystem	Construction of piers inside the Adyar River and Adambakkam Lake, marshlands, near the waterbodies in Perumbakkam may result in release of construction materials (concrete, fuel, chemicals etc.) inside the water. Construction	1. Construction of piers inside the waterbodies will be done in a caisson which will contain all the concrete and construction material resulting minimal release of construction material into the water. 2. Constructing the pier will be done by using rotary drilling rigs and no impact hammering. Rotary drilling rig generates far less noise and has negligible impacts on aquatic wildlife in comparison to impact piling which can	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
			activities may also cause excessive siltation inside the river. These impacts will in-turn affect the fishes and other aquatic species, as well as water birds.	startle fishes and damage their auditory organs. 3. Turbidity curtains will be used during pile driving activities if any to reduce the potential for increases in suspended sediment. 4. The contractor will be prohibited from fishing or other aquatic wildlife. 5. Construction works inside the Adyar River and Adambakkam Lake will be timed in the dry season and will be kept at minimal during bird migrating, breeding and feeding season. 6. Construction in the waterbodies will be avoided during the rainy season to minimize construction duration inside the water. 7. Silt fencing will be installed along the banks of the waterbodies wherever necessary. 8. The construction wastes generated near the eco sensitive locations shall be disposed promptly as per standards. 9. Site specific EMP focusing eco-sensitive areas and sensitive receptors shall be prepared and implemented. 10. Water samples shall be collected from the water bodies involved and water quality tests shall be carried out on monthly basis to monitor the quality of surface water.		
		Physical Cultural Resources	Historic and Cultural Value Loss Conflicts with community	1. Before start of piling, Contractor and CMRL will coordinate with Tamil Nadu State Department of Archaeology to reconfirm that there is presence of buried artifacts along the metro line alignment. No piling will be allowed unless cleared by the Archaeological Department. 2. Archeological monitoring during construction stage, including specialists in field with authority to stop work. 3. All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices. 4. A proof of compliance to this requirement to include the	Contractor	GC/ CMRL /Archaeological Survey of India

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				name of participants and date and location of briefing will form part of the monthly report to CMRL. 5. The project will implement, where required, chance finds procedure contained in ESS8 of WBG ESF. It includes requirement to notify relevant authorities; to fence-off the area of finds or sites to avoid further disturbance; to conduct an assessment of found objects or sites by cultural heritage experts; to identify and implement actions consistent with the requirements of this ESS and national law; and to train project personnel and project workers on chance find procedures		
		Health & Safety	Noise and vibration generated during piling will affect the health and safety of the workers	1. Auger piling methods will be used to reduce the impacts of noise. 2m tall screens of GI sheets will be installed between source (pile driver) and receptors (workers & nearby populations). 2. To reduce the harmful effects, personnel working at high noise levels would be provided with noise protective gears such as ear mufflers, sound barriers, job rotations per occupational exposure limits etc. 3. Oversight of project safety is needed to ensure proper support and lining of excavated sections to avoid collapse. 4. Where a site boundary adjoins a road, streets or other areas accessible to the public, hoarding should be provided along the entire length except for a site entrance or exit. 5. Procedure to receive, evaluate, and compensate (if applicable) damages due to construction and establishment of financial resources to cover this expense.	Contractor	GC/ CMRL
23.	Excavation (The quantum of soil excavated soil will be about 1.44 lakh cubic meter)	Air	Excavation will result into fugitive dust generation.	1. Fugitive dust could be controlled using water sprinkling. Water sprinkling to be carried out by Contract at regular interval (to be mutually decided by the contractor and CMRL). Surface runoff, wastewater from construction sites, construction yards and seawater will be used.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				2. Imposition of speed controls for vehicles on unpaved site roads. Ten kilometers per hour is the recommended limit. 3. Every vehicle should be washed to remove any dusty materials from its body and wheels before leaving the construction sites. 4. Excavation machinery will be topped up by low-Sulphur fuel. 5. Water for sprinkling and tire washing will be sourced from treated effluent from ETPs located nearby or seawater or surface runoff; use of municipal treated water shall be minimized. Groundwater will not be used.		
		Noise and Vibration	Nuisance	1. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 2. Use of low-noise equipment and ensuring good maintenance, and trying to avoid using high-noise equipment simultaneously at the same section. 3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards. 4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. 6. Monitoring required during construction, including field	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				observations and measurements. 7. Contractor to ensure that vibration levels at receptors comprising educational, medical and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment will not exceed 5.0 mm/s.		
		Surface water	Dumping of construction waste like concrete, bricks, waste material etc. cause surface water pollution.	1. Proper drainage systems using contour information will be constructed around active and & large construction sites. The wastewater should be discharged after sedimentation in tanks. 2. To avoid water pollution and soil erosion due to flooding, earthwork will be limited during monsoon season.	Contractor	GC/ CMRL
		Groundwater	Dewatering (if done) will adversely affect the groundwater regime.	1. Dewatering due to piling will be small in quantity. It will be done only when required Groundwater will be collected in sedimentation tanks and reused in non-potable uses. Refer to SHE (Addendum to this EIA report). 2. As it is likely to be contaminated with chemicals on construction sites this water after precipitation, will be discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. 3. Groundwater monitoring, including groundwater quality and aquifer status.	Contractor	GC/ CMRL
		Soil	Excavation will adversely affect the soil	1. Soil erosion by runoff will be controlled by installing proper drainage systems using contour information It is suggested to avoid bringing soil from outside the project boundary and to use the excavated mounds for filling low lying area where it is necessary. 2. The topsoil should be preserved (by storing it at appropriate places) so that same can be restored after completion of work.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Physical Cultural Resources	Historic and cultural value loss Conflicts with community	1. Before start of excavation, Contractor and CMRL will coordinate with Tamil Nadu State Department of Archaeology to reconfirm that there is presence of buried artifacts along the metro line alignment. No excavation will be allowed unless cleared by the Archeological Department. 2. Archaeological monitoring during construction stage, including specialists in field with authority to stop work. 3. All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices. 4. A proof of compliance to this requirement to include the name of participants and date and location of briefing will form part of the monthly report to CMRL. 5. The project will implement, where required, chance finds procedure contained in ESS8 of WBG ESF. It includes requirement to notify relevant authorities; to fence-off the area of finds or sites to avoid further disturbance; to conduct an assessment of found objects or sites by cultural heritage experts; to identify and implement actions consistent with the requirements of this ESS and national law; and to train project personnel and project workers on chance find procedures.	Contractor	GC/ CMRL/ Archaeological Survey of India
		Health and Safety	Accidents	1. To specify the number and length of shifts for each worker. 2. Where a site boundary adjoins roads, streets or other areas accessible to the public, hoarding should be provided along the entire length except for a site entrance or exit.	Contractor	GC/ CMRL
		Aesthetics	Loss of aesthetics value due to excavation and related activities.	1. The excavation sites will be barricaded on all sides using GI sheets. Hauling will be carried out in non-peak hours. 2. Aesthetic value of the site will be restored after completion of the works.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
24.	Hauling of excavated material	Air	During transportation of excavated material, fugitive dust will be generated from two sources, (1) from re-suspension of dust from road surface, (2) from the movement of air, against the excavated material being hauled	1. The traffic management plan will be stringently implemented with regular monitoring and inspections. 2. The trucks/dumpers carrying the excavated material will be covered using tarpaulin/similar covering materials. 3. Sprinkling of water should be carried out. 4. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. Used water shall be collected, subject to precipitation and re-used. 5. Water for sprinkling and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater; use of municipal treated water shall be minimized. Groundwater will not be used in view of status in Chennai. 6. Haul roads will be kept in good state of maintenance.	Contractor	GC/ CMRL/ TNSPCB/ Traffic Police
		Noise	Dumper trucks carrying excavated material will result into high noise (typically in excess of 85 dB (A) at one m distance, or 57 dB (A) at 10 m distance). The adverse impacts of noise will be most intense in the residential / urban areas.	1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impacts on noise level. 2. The route selection will avoid any sensitive receptors. 3. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards. 5. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 6. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. 7. Monitoring required during construction, including field observations and measurements.		
		Social	Incessant movement of trucks could create social issues. This will have higher occurrences near depots.	1. The local community has to be taken into confidence before the construction commences. Their advice must be taken and incorporated in decision making. 2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented.	Contractor	GC/ CMRL
		Health & Safety	The movement of trucks will increase the traffic risk of the commuters.	1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impact on occupational and community health and safety.	Contractor	GC/ CMRL
25.	Dumping of excavated materials	Air	The dumping operation of excavated material will generate fugitive dust in the nearby areas	1. Site of dumping shall be selected by contractor in consultation with CMRL and authorities. 2. The disposal plan will be stringently implemented with site monitoring and inspections. 3. It will be located outside of urban habitation. 4. Sprinkling of water should be carried out. Water shall be sourced from surface runoff, wastewater from construction sites, construction yards and seawater. Use of municipal treated water shall be minimized. Groundwater extraction shall be avoided.	Contractor / GC	CMRL /CMDA/ GCMC / TNSPCB
		Soil	Dumping may increase the height of the land and affect the natural drainage pattern of the area	1. The dumping will be done in pre-designated low lying areas identified by CMDA, TNPCB, and CMRL for this specific purpose. 2. The disposal plan will be stringently implemented with regular monitoring and inspections. 3. Field inspections, monitoring, and documentation of dumping excavated materials.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
26.	Traffic diversion	Air	The under construction areas will be restricted for human and vehicular movements. This will result in detouring of vehicles and/or pedestrians, on the project line which passes through busy urban areas. This may also result into traffic congestion and air pollution from stagnated vehicles in urban areas. Primary pollutants will be NOx, CO, NMHC, and VOCs.	1. Permission from Chennai Traffic Police will be sought before commencement of work. Detours will be properly planned and enacted during non-peak hours only, if possible. Traffic marshals will be posted near such detours. Proper signage has to be posted informing motorists about detours following IRC norms. 2. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues 3. The Contractor will discuss and coordinate the implementation of the traffic re-routing scheme particularly at station area when it starts the cut and cover activities and the hauling and disposal of excavated materials to the project sites.	Contractor	GC/ CMRL/ Traffic Police
		Noise	Barricading & detouring may result into traffic congestion in the urban areas. This will result into (a) noise from vehicular movement and (b) honking noise due to congestion.	1. Permission from Traffic police will be sought before commencement of work. Detours will be properly planned and enacted during non-peak hours only, if possible. Traffic marshals could be posted near busy intersections, to oversee the smooth flow of traffic. 2. Detour route selection to avoid sensitive receptors to noise. 3. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues.	Contractor	GC/ CMRL
		Social	Traffic diversion (especially. for public transport) will create inconvenience	1. Implement the traffic management plan. Plans will be made to spare traffic diversion during peak hours (morning and evening peaks). Also separate arrangements for bus, auto and taxi parking bays will be made. Street furniture for pedestrians will be provided wherever possible. 2. Real-time communication to public prior to site-specific work (for example, via signs, radio, and newspaper) and during key periods of traffic interference or peak traffic.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervisior
				3. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues.		
		Resource consumption	Detouring will increase the road length to be travelled by a car, thus, increasing the overall fuel consumption.	1. The detour will be planned to be optimum in terms of road length. The faster completion of works will also tend to reduce enhanced fuel consumption.	Contractor	GC/ CMRL
27.	Restricted pedestrian movement	Social	Restricted pedestrian movement will cause social uproar, esp. in people living near metro stations	1. Safe passage for pedestrians with proper sunshade / fall protection and signage will be planned. Public consensus will be built. Representatives of non-governmental organisation and volunteers from local communities at respective sections of the project shall be invited to participate in meetings with CMRL, GC, and Traffic Police where joint decision on diversion measures will be arrived at. 2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented.	Contractor	GC/ CMRL
		Health & Safety	Movement though constricted space may cause potential health & safety issues amongst pedestrians	1. Safe passage for pedestrians with proper fall protection and signage will be planned.	Contractor	GC/ CMRL
28.	Muck generation & disposal (incl. spent Bentonite & drill fluid and slurry)	Surface water	Muck generated incl. spent Bentonite & slurry from drilling operations will drain with surface runoff and pollute nearby water bodies	1. Muck disposal plan will be stringently implemented with regular monitoring and inspections. 2. The construction sites will be provided with garland drains with intercepting pits to trap silt & muck. 3. Muck will be stored in lined tanks / ponds (if such area is available). Or mechanically dewatered if such area is unavailable. After screening & detention, supernatant liquid from such tanks should be discharged into drainage lines adhering to CPCB standards. Such tank/ ponds could be covered during monsoon to control	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				runoff. 4. The temporary muck storage areas will be maintained by the Contractor at all times until the excavate is re-utilized for backfilling or disposed of as directed by Employer. Dust control activities will continue even during any work stoppage 5. Transportation of muck will be scheduled by time and route to minimize air pollution in habitat areas.		
		Groundwater	Muck, spent bentonite & drill fluids may settle down from pond / tanks and will affect groundwater	1. The tanks/ ponds holding muck will be lined to prevent infiltration into groundwater. It will be passed through precipitation chambers and discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water.. 2. Groundwater quality monitoring.	Contractor	GC/ CMRL
		Aesthetics	Muck generation will create an aesthetic issue	1. The construction site will be covered from all sides to reduce visual impacts.	Contractor	GC/ CMRL
29.	Steel structure preparation	Soil	Steel structure preparation will create steel scraps	1. Steel scrap will be collected, sorted by diameter and sold to scrap dealers on alter date.	Contractor	GC/ CMRL
		Health & safety	Bar bending & other activities (inc. working at heights) might pose a H&S threat to workers	1. Workers will be provided appropriate hand gloves and personal protective equipment (PPE). 2. Skilled workers working at height or doing hot work will be required to seek permission from site	Contractor	GC/ CMRL
30.	Stacking & warehousing of raw material	Surface water	Washed out raw material could pose serious threat to surface water bodies	1. Small dikes and garlanding drains along the periphery of the yard and ploy boundary could be constructed. This will control runoff and washing out of finer material.	Contractor	GC/ CMRL
		Soil	Spillage of materials / mix products on the ground could pollute soil	1. Proper care will be taken. Such spills will be cleared by scraping and disposing the products as road sub-grade material.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Health & Safety	Fine products like cement/ silt/ sand could cause harm to respiratory system.	1. Cement and sand will be stacked under tarpaulin and secured by GI sheet barricading (working & wind break). Shorter work shift and daily medical checkups of workers will be implemented. 2. Dust filters atop cement silos, wet suppression for aggregate crushing and screening will be employed.	Contractor	GC/ CMRL
		Aesthetics	Stacking of raw material will cause aesthetic issues for residential areas located nearby	1. The height of walls between the residential area and RM yard / construction area will be raised using GI sheets.	Contractor	GC/ CMRL
31.	RCC pouring (using concrete pump)	Noise	RCC pouring using concrete pump will generate low frequency rumbling noise. This will be more perceived and irritating in residential areas.	1. RCC pumps will be covered from all sides. 2. Bends and excessive head will be avoided. 3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards.	Contractor	GC/ CMRL
		Soil	Spillage from concrete pouring may contaminate soil	1. The spoils from pouring concrete will be collected and reused as sub-grade material in road construction.	Contractor	GC/ CMRL
		Aesthetics	Spoils from concrete pouring will create unpleasant looking visuals	1. After each pouring cycle, the spoils will be manually collected and reused as sub-grade material in road construction.	Contractor	GC/ CMRL
32.	Setting of concrete (using needle vibrator)	Noise	Needle vibrators generate low frequency noise when dipped in concrete and high frequency noise when raised. Sound level vary between 82-93 dB (A).	1. If the consistency of concrete could be altered, the need for use of vibrator (esp. in low temperature & low thickness casting) could be reduced. Damping could be used to reduce high frequency noise, and thereby reducing the noise levels. Workers should be provided with suitable PPEs. 2. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed per IFC/WB guideline. If baseline noise is below the CPCB	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards.		
		Soil	During setting, spillage from cast could take place.	1. The spoils from pouring concrete will be collected and reused as sub-grade material in road construction.	Contractor	GC/ CMRL
33.	Curing of concrete (use of water)	Surface water	Curing water will drain to the low lying areas and pollute water courses	1. Garland drainage is proposed to be constructed around the construction yard. This will intercept the runoff generated from site. Rainwater harvesting (as a compensatory measure) will be practiced. Curing needs will be met from municipal supply, water resulting from dewatering during piling and surface runoff water. 2. After precipitation it shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water.	Contractor	GC/ CMRL
		Groundwater	Curing water will drain to the low lying areas and pollute water courses	1. In view of low groundwater levels risk of saline water ingress due to proximity of sea coast, use of groundwater will not be resorted to.	Contractor	GC/ CMRL
		Aesthetics	Curing will create water impounding and may lead to vector propagation	1. Garlanding drain will be constructed around the construction area. The curing water impounded will be reused for curing.	Contractor	GC/ CMRL
34.	Use of Crane & Launchers	Noise	Operation of launchers and crane will generate noise which in times may go up to 85-90 dB (A). Legris & Poulin has found that the average daily noise exposure was approx. 84 to 99 dB (A) for heavy equipment, and 74 to 97 dB (A) for the crane operators.	1. The sensitive receptors (workers & external parties, if applicable) have to be isolated from heavy construction noise generated. This is possible by erecting reinforced 2 m tall GI sheet barrier around the area where heavy construction works is undertaken. 2. Workers working inside or near construction equipment should be provided with proper PPEs like ear plugs / muffs complying with IS 4869. 3. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities.		
		Health & Safety	Cranes and launchers are a major safety concern.	1. As per SHE, operation of launchers and cranes should be only done under the strict supervision of a qualified engineer and a safety supervisor. Only qualified & trained crane/ launcher operators should be allowed. Proper examination of crane, launchers, labours& operators should take place before commencement of work.	Contractor	GC/ CMRL
35.	Construction of labour camp(s) and associated environmental issues	Surface water	Sewage from labour camps may be discharged into open slopes thus contaminating surface water	1. Labour camps will be constructed in semi urban / urban set-ups. It shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water..	Contractor	GC/ CMRL
		Groundwater	Surface water on flat terrain could percolate and contaminate groundwater.	1. Contractor to collect the groundwater baseline date prior to construction. 2. Disposal in compliance with applicable regulatory requirements. 3. Groundwater quality monitoring.as per EMoP 4. Water abstracted must be measured/ recorded periodically. 5. After Construction, Contractor will conduct groundwater analysis and be obliged to reinstate the used sites no worse than the conditions of pre-construction.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Soil	Solid waste generated from the labour camps will cause soil pollution	1. Contractor to collect the soil baseline date prior to construction. 2. Municipal solid waste will be collected and taken away and disposed by municipality. 3. Solid waste will have to be disposed in compliance with Municipal Solid Waste (Management & Handling) Rules, 2000, as amended to date. 4. After Construction, Contractor will conduct soil analysis and be obliged to reinstate the used sites no worse than the conditions of pre-construction.	Contractor	GC/ CMRL
		Social	Influx of non-local labours will create a social issue	1. Mixing of skilled non-local labours with local unskilled people will reduce social frictions. 2. To avoid labor influx risk, sensitizing of local community and the non-local workers separately as well as jointly will be done regularly.	Contractor	GC/ CMRL
		Health & safety	Living in congested condition, make-shift temporary arrangement; the labours are prone to diseases.	1. Regular counselling, medical checkups and treatment at separate clinics, coordination with local health authorities will be conducted. 2. Per Building & Other Construction Workers (BOCW Regulation of Employment and Conditions of Service) Act, 1996 the employer (contractor) is liable to arrange for sanitation, health care facilities of labours, free of charge. Labour camps will be in full compliance of BOCW Act. 3. COVID-19 protocols for construction forming part of the Environmental Social Health and Safety Requirements shall be fine-tuned to be adopted for labour camps; camp residents shall be trained and informed of precautions such as social distancing, sanitizing, avoiding groups; arrangements for thermal scanners; provision of sanitisers, face masks, gloves; record of COVID-19 hospitals; protected ambulances at camp; daily disinfection of site, equipment and camp.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Resources	Labours will consume resources like wood for cooking	1. Liquid petroleum Gas cylinders will be made available free of cost to the labourers by the Contractor. 2. Labour camps are provided with canteen systems. They shall be provided with treated water for drinking, bathing and other needs.	Contractor	GC/ CMRL
36.	Loading /unloading of construction material	Air	Loading & unloading of construction material will generate fugitive dust	1. The traffic management plan will be stringently implemented with regular monitoring and inspections. 2. The trucks/dumpers carrying the material will be covered using tarpaulin/similar covering materials. 3. Fugitive dust could be controlled using water sprinkling. Contractors should carry out water sprinkling. 4. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. Used water shall be collected, subject to precipitation and re-used. 5. Water for sprinkling and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater.	Contractor	GC/ CMRL
		Noise	Loading & unloading of construction material will generate noise	1. The RM storage yard will be separately built and enclosed from all sides. This will reduce noise generation at site. 2. Concrete preparation will only take place in casting yards (away from habitation). 3. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards. 4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				to commencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities.		
		Health & safety	Fugitive dust and noise generation will have potential health & Safety implications.	1. Cement and sand will be stacked under tarpaulin and secured by GI sheet barricading (working & wind break). Shorter work shifts and regular health checkups will be implemented. The RM storage yard will be separately built and enclosed from all sides. The worker will be provided with suitable PPEs. Also they will be trained and encouraged in using PPEs.	Contractor	GC/ CMRL
37.	Use of batching plant	Air	Loading & unloading of construction material into batching plant will generate fugitive dust	1. High GI sheet screens and water sprinkling will be employed. 2. Batching plant / casting yard shall be barricaded and made as a compulsory PPE zone. This will effectively reduce the fugitive dust generation.	Contractor	GC/ CMRL
		Noise	Operation of batching plant will generate noise	1. GI sheet barricading around batching area and worker PPE like ear muffs will be used. 2. Batching plant / casting yard shall be barricaded and made as a compulsory PPE zone. This will reduce the impacts of noise generation. 3. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards.	Contractor	GC/ CMRL
		Soil and Groundwater	Runoff of waste can contaminate soil and groundwater	1. Contractor to collect baseline soil and groundwater quality data prior to operate the plants. 2. Municipal water will be used. In view of fragile groundwater status, extraction will be avoided. 3. The construction sites will be provided with drains with intercepting pits in which the cement and sand will settle. After screening & detention, liquid will be discharged into drainage lines. Disposal in compliance	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				with applicable regulatory requirements. After precipitation, it shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water. 4. Soil and Groundwater quality monitoring. 5. After Construction, Contractor will conduct soil and groundwater analysis and be obliged to reinstate the used sites no worse than the conditions of pre-construction.		
		Hazardous waste	Health impacts and soil and groundwater pollution from hazardous water at batching/casting yards	1. The use and storage of hazardous materials at the casting yard and batching plant should adhere to SPCB requirements. 2. The transport, handling and storage of hazardous waste will be done in accordance with the provisions of Hazardous Chemicals (Management & Handling) Rules. Hazardous wastes from construction activity and equipment are labeled, recorded, stored in impermeable containment and for periods not exceeding mandated periods and in a manner suitable for handling storage and transport. 3. The contractor shall maintain a record of sale, transfer, storage of hazardous waste and make these records available for inspection. 4. The contractor shall get Authorized Recyclers to transport and dispose Hazardous Waste. 5. Proper collection and storage facilities will be provided especially for hazardous waste.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Resources	If the batching plant will get its power from DG sets, substantial diesel will be consumed. (A 30 m3/hr. batching plant will require approx. 60 KW/hr. (or, approx. 75 KVA, assuming PF = 0.8) energy. In most cases the Contractor has used DG sets (from 100 – 250 kVA) for batching plant & ancillary facilities. Thus, the diesel req. will range from 30 - 45L/hr, at 100% load)	1. If power from the grid is used, permission from power supply company must be obtained by the Contractor. 2. DG sets, if used, should: (a) conform to height of stack norms as per CPCB rules; (b) conform to emission norms as per E (P) Act, 1986; (c) noise level at 1 m distance from enclosure should not be >75 dB(A). 3. The required permissions from local Environmental Authorities/Pollution Control Board/ CEIG or any other relevant Authority shall be obtained by the Contractor for using DG sets for power supply. 4. Diesel storage if done beyond threshold limit (1000 L) permission should be obtained. Diesel should be stored on pukka platforms and spillages should be avoided. 5. Refer to Activity 42 “Use of DG sets” and Activity 44 “Storage of Diesel” for further measures.	Contractor	GC/ CMRL
38.	Casting of segments and I-beams	Groundwater	Casting will require use of water	1. Chennai Metropolitan Water Supply and Sewerage Board/ Municipal water will be used. In view of fragile groundwater status, extraction will be avoided. 2. The construction sites will be provided with drains with intercepting pits in which the cement and sand will settle. After screening & detention, liquid will be discharged into drainage lines. Disposal in compliance with applicable regulatory requirements. After precipitation, it shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water. 3. Groundwater quality monitoring.	Contractor	GC/ CMRL
		Resources	Casting (incl. operation of gantry and hydraulic pre-stressing units) will consume lot of energy	1. Pre-stressing and casting are basic requirements. However, most of the power should be drawn from approved lines, not from DG sets.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
39.	Curing of segments & I-beams	Groundwater	Curing will require a significant amount of water	1. Garland drainage is proposed to be constructed around the construction yard. This will intercept the runoff generated from site. Stagnation of water (and resultant vector propagation) should be avoided. 2. Groundwater quality monitoring. 3. After precipitation, it shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water. 4. Groundwater will not be used. Water will be sourced from municipal supply, surface runoff or dewater.	Contractor	GC/ CMRL
40.	Hauling of segments to site	Air	During transportation of segments, fugitive dust will be generated from re-suspension of dust from road surface. Plus, there will be air emission from trucks	1. The traffic management plan will be stringently implemented with regular monitoring and inspections. 2. The trucks/dumpers carrying the excavated material will be covered using tarpaulin/similar covering materials. 3. Sprinkling of water should be carried out. 4. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. Used water shall be collected, subject to precipitation and re-used. 5. Water for sprinkling and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater. 6. Haul roads will be kept in good state of maintenance.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Noise	Trucks carrying segments will result into high noise (typically in excess of 85 dB(A) at1 m distance, or 57 dB(A) at 10 m distance). The adverse impacts of noise will be most intense in the residential/urban areas	1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impacts on noise level. The route selection will avoid any sensitive receptors. 2. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 3. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards. 4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. 6. Monitoring required during construction, including field observations and measurements.	Contractor	GC/ CMRL
		Social	Incessant movement of trucks could create social issues	1. The local community has to be taken into confidence. Their advice has to be taken and incorporated in decision making.	Contractor	GC/ CMRL
		Health & safety	The movement of trucks will increase the traffic risk of the commuters	1. The routing, timing and logistics of the haul truck movement will be planned to have minimal impacts on occupational and community health and safety.	Contractor	GC/ CMRL
		Aesthetics	Movement of trucks will create an aesthetic problem	1. Proper housekeeping activities have to be undertaken near the casting yard and nearby areas.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
41.	Construction of Grade Separator	Air	Emission of NO_x, SO_x, CO, PM_{10}, $PM_{2.5}$ from Vehicles due traffic stagnation will create air pollution problems. Fugitive dust emission due to construction activities such as handling of excavate/subgrade /gravel for construction of ramps etc.	1. Traffic management plan will be devised in consultation with Chennai Traffic Police. 2. Traffic diversions will be done to reduce the stagnation of vehicles. Prior permissions will ne obtained from the concerned traffic department for diversions. 3. Traffic marshals will be deployed at the critical traffic intersections to aid the better flow of traffic. 4. Green cover will be created in the centre median and the roadsides. 5. The trucks/dumpers carrying the excavated material will be covered using tarpaulin/similar covering materials. 6. Sprinkling of water should be carried out. 7. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction depots and batching plants. At such a facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt. Used water shall be collected, subject to precipitation and re-used. 8. Water for sprinkling and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater; use of municipal treated water shall be minimized. Groundwater will not be used in view of status in Chennai. 9. Access roads will be kept in good state of maintenance.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Noise	Dumper trucks carrying excavated material will result into high noise (typically in excess of 85 dB (A) at one m distance, or 57 dB (A) at 10 m distance). The adverse impacts of noise will be most intense in the residential / urban areas.	1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impacts on noise level. 2. The route selection will avoid any sensitive receptors. 3. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards. 5. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 6. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. 7. Monitoring required during construction, including field observations and measurements.	Contractor	GC/ CMRL
		Resource	Increase in requirement of construction raw materials such as aggregates, gravel, cement, water etc.	1. The construction raw materials will be procured from TNPCB authorized vendors. 2. Reuse of construction materials will be encouraged wherever possible. 3. Sustainable and eco-friendly products will be preferred. 4. Ground water extraction for construction use will be avoided. 5. The municipal treated water will be procured from the CMWSSB for construction use.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
42.	Use of DG sets	Air	Emission of NO_x, SO_x, CO, PM_{10}, $PM_{2.5}$ from DG sets will create air pollution problems	1. The primary power source will be power distribution company, DG sets will be used only for power back-ups for stations. 2. The required permissions from local Environmental Authorities/Pollution Control Board/ CEIG or any other relevant Authority shall be obtained by the Contractor if using DG sets for power supply. DG sets compliant with CPCB norms will be used. Specification no. GSR 520(E) dt. 1-7-2003 for DG sets rating < 800 KW, and GSR 489(E) dt. 09-07-2002 for DG sets > 800 KW under E (P) Rules, 1986. 3. Stack height of DG sets will be as per CPCB requirement [stack ht. = 0.2*(rating in kVA)0.5] 4. Stack monitoring will be conducted monthly of the criteria pollutants. 5. Compliance monitoring will be done to the regularly and check the monitoring instruments. 6. Fuels used for DG will be High Speed Diesel with low-sulfur content.	Contractor	GC/ CMRL
		Noise & Vibration	Noise & vibration will be generated from the use of DG sets	1. DG sets compliant with CPCB norms will be used. 2. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards 3. Monitoring required during construction, including field observations and measurements. 4. DG sets will be enclosed type, with noise levels approx. 75 dB (A) at a distance of 1m in compliance with GSR 371(E) dt. 17-05-2002. 5. Noise will be controlled using acoustic enclosure. 6. The DG sets will be mounted on damping skids, which will reduce the vibration generated from DG sets.	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
		Resources	DG sets will consume Diesel (and in effect reduce the levels of a non-renewable resource)	1. DG sets should always be use as a power back up, and not the primary sources of power. This should be made mandatory for all Contractors. 2. Refer to Activity 44 “Storage of Diesel” for further measures.	Contractor	GC/ CMRL
		Aesthetics	Operation of DG sets will cause an aesthetic issue	1. Enclosures will be used to keep them off from public views. 2. PM content of DG sets smoke will be as pert the CPCB norms, thus the DG will emit dark smokes only during start-up & shut-down (b) Noise will be controlled using acoustic enclosure.	Contractor	GC/ CMRL
43.	All Construction Activities	Environment	Construction and Demolition (C&D) waste results from land clearing, excavation, construction, demolition, remodeling and repair of structures, roads and utilities	1. Records of movement and loading/unloading of C&D waste and records of waste loaded by vendors. 2. C&D waste will be reused/recycled as it has the potential to save natural resources (stone, river sand, soil etc.) and energy. C&D waste generated from metro construction has potential use after processing and grading. 3. The contractor will segregate and temporarily store the C&D waste till the vendor takes it away for recycling and disposal at authorized facilities. 4. Contractor will adhere with the C&D Waste Management Rules.	Contractor	GC/ CMRL
		Occupational Health and Safety	Accidents All parties’ reputation	1. Worker safety is important on all construction projects. It is important to consider the effects of staffing on worker safety and to provide appropriate training in safety awareness for all labor. 2. The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB(A), the peak sound levels reach 140 dB(C), or the average maximum sound level reaches 110dB(A). Hearing protective devices provided should be capable of reducing sound levels at the ear to at least 85 dB(A).	Contractor	GC/ CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
44.	Storage of Diesel	Groundwater	Diesel spillage (from underground or above ground storage facility) will affect groundwater quality adversely	1. Before it percolates into the groundwater, contaminated runoff water can be run through adsorbents such as bentonite to remove the diesel. The diesel will be quickly collected into steel trays and disposed to authorized recyclers. 2. All bulk diesel tanks shall be properly supported in an elevated position to facilitate gravity discharge. They shall stand within a bund constructed to contain a volume of110% of the volume of the tank. There shall be no breaches in the bund wall, no material shall be stored within the bund and rain water collecting in the bund shall be regularly removed to prevent build-up. 3. Spillage will be controlled using methods mentioned in the environmental contingency plan. 4. Groundwater quality monitoring.	Contractor	GC/ CMRL
		Health & safety	Storage of Diesel will attract the provisions of Hazardous Chemicals (Management & Handling) Rules and Petroleum Rules; as amended to date. It could cause serious damage to health & safety of workers / property if ignited	1. Proper onsite emergency plan will be prepared and will be approved through CMRL. 2. If the diesel storage crosses the threshold limits permissions, proper fire protection norms have to be undertaken as per National Building Code, 2005 (if building)/ Oil Industry Safety Directorate Standard 117 (if installation).	Contractor	GC/ CMRL
45.	Cleanup Operations, Restoration and Rehabilitation	Environment	Aesthetics	1. The clean-up and restoration operations are to be implemented by the Contractor prior to demobilization. All spaces excavated and not occupied by the foundation or other permanent works shall be refilled with earth up to surface of surrounding ground.	Contractor	GC/ CMRL
Operational Phase						

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
46.	Operation of metro trains	Noise and Vibration	The most significant source of noise will be rolling noise from contact between wheel and rail including noise from contact between the brake pad and wheel, followed by engine noise and aerodynamic noise.	1. To minimize operation stage impacts measures such as Ballast less track structure is supported on two layers of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed up to the rail level so as reduce sound levels. Noise at source will be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc. 2. Since the rakes will be air conditioned and enclosed from all side, the impacts of noise on the travelers will be nominal. 3. Noise barriers will be installed at locations based on final design noise prediction analysis. 4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the operation noise has to meet these standards that is, noise level has to be less than level prescribed in these standards. 5. The mitigations suggested based on the detailed noise and vibration analysis, should be strictly followed.	CMRL	CMRL
		Aesthetics	Metro rail will increase the aesthetics of Chennai	1. A proper housekeeping routine will be followed to enhance the aesthetics of metro rail station.	CMRL	CMRL
		Health and Safety	Accidents Reputational risks	1. Detailed specification of equipment e.g. power cables, rectifiers, transformer, E&M equipment etc. shall be framed to reduce conducted or radiated emissions as per appropriate international standards. 2. The Metro system as a complete vehicle (trains, signaling & telecommunication, traction power supply, E&M system etc.) shall comply with the Electromagnetic compatibility (EMC) requirements of international standards viz. EN50121-3-1, EN50123, IEC61000 series etc. EMC requirements of international standards for whole railway system to the outside world shall comply with EN50121-2.	CMRL	CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
				3. A standby silent type DG set of adequate capacity will sustain the following: essential lighting, signaling, and telecommunications, fire-fighting system and lift operation. 4. Automatic Train Protection and Automatic Train Supervision sub-systems will be installed to provide a high level of safety. 5. CCTV system will be installed for local and centralized monitor of operation. 6. In view of the potential hazards from system failure resulting to accidents, both on- site and off-site emergency measures will be implemented. All trains will have public address systems to warn the passengers of any emergency. 7. Emergency team, ambulance, contact number and hospital should be available. Emergency response plan should be implemented during operation periods.		
			Operating Personnel Health risks	1. Operating staff such as drivers and Control Centre staff shall be administered regular medical checkups for musculo-skeletal disorders, fatigue, eye strain. 2. Well designed workstations, lighting in Control Centre. 3. Emotional resilience training, counselling for recovery and rehabilitation	CMRL	CMRL
			Severely contagious diseases such as COVID-19 can impact health of staff thereby affecting operations; can cause economic loss to the country and loss of reputation to the project.	1. Chennai Metro COVID-19 SOP shall be implemented; staff shall be trained; staff and commuters shall be informed of precautions such as social distancing, sanitizing; arrangements for stationary and hand-held thermal scanners; provision of sanitizer pedestals, vending machines of face masks and gloves etc. shall be provided in stations; site record of COVID-19 hospitals; daily disinfection of operating rooms, circulation spaces, equipment and vehicles; protected ambulances at stations.	CMRL	CMRL
47.	Operation of Integrated Grade Separator in MIOT	Traffic	The positive impact is that grade separator eases the flow	1. Periodic maintenance and cleaning shall be carried out. 2. All necessary provisions as per standards shall be	Tamilnadu	Tamilnadu

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
	section		of traffic and reduces the congestion.	ensured.	Highways Dept.	Highways Dept.
		Air	Reduction of fugitive emissions (especially Carbon Monoxide) from Vehicles due to traffic decongestion.	1. All necessary provisions as per standards shall be ensured. 2. Green cover shall be developed in the centre median of road.	CMRL / TNHD	CMRL / TNHD
		Noise	Noise from vehicles	1. All necessary provisions as per standards shall be ensured. 2. Green cover shall be developed in the centre median of road. 3. Noise barriers shall be installed wherever necessary.	CMRL / TNHD	CMRL / TNHD
48.	Track repair	Environment	Spill accidents	1. CMRL to ensure no illegal disposal of solid waste or wastewater.	CMRL	CMRL
49.	Use of DG sets	Air	Emission from DG sets will create air pollution problems	1. DG sets compliant with CPCB norms will be used.	CMRL	CMRL
		Noise	Noise & vibration will be generated from the use of DG sets	1. DG sets compliant with CPCB norms will be used. Monitoring of air quality shall be done as per CPCB norms. 2. Noise enclosures will be used. 3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the operation noise has to meet these standards that is, noise level has to be less than level prescribed in these standards.	CMRL	CMRL
		Groundwater	Diesel spillage (from underground or above ground storage facility) will affect groundwater quality adversely	1. Diesel should be stored in designated sites prior to final relocation. 2. Oil that is mixed in water will be removed in the ETP.	CMRL	CMRL
		Health & safety	Storage of Diesel will attract the provisions of Hazardous Chemicals (Management & Handling) Rules and Petroleum Rules; as amended to date. It could cause serious damage to	3. Diesel should be stored in designated sites prior to final disposal. 4. Fire fighter is equipped at storage site. 5. Proper onsite emergency plan will be prepared by GC and will be approved through CMRL.	CMRL	CMRL

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
			health & safety of workers / property if ignited			
		Aesthetics	Operation of DG sets will cause an aesthetic issue	1. Enclosures will be used.	GC / CMRL	CMRL
		Resources	DG sets will consume Diesel (and in effect reduce the levels of a non-renewable resource)	1. DG sets compliant with CPCB norms will be used only as backup.	CMRL	CMRL
50.	Development of feeder routes	Social	Along with Metro routes, metro feeder routes will be developed. This will have a positive impact in terms of enhanced connectivity and inclusion in the social mainstream	1. CMRL will work with bus operators to implement metro feeder routes along major arterial and sub-arterial routes to reduce travel time to the nearest station. Better quality coaches & comfortable rides should be planned to enhance acceptability.	GoTN	GoTN
		Aesthetics	Better designed coaches will enhance ride pleasure and aesthetics	1. The buses coaches should be properly maintained from time to time in order to enhance the aesthetic value.	GoTN	GoTN
		Health & safety	Better & frequent transport system will reduce risk of traffic accidents	1. The new feeder routes should (a) follow proper timetable; (b) should have frequent services during the morning & evening peak;(c) should have a limited carrying capacity. The feeder buses should arrive and depart from designated bus bays or similar structures. Proper arrangements for road crossing should be established. The appointed personnel should assist passengers to reach their destinations. An easily accessible grievance redressal system should be established by CMRL.	GoTN	GoTN
51.	Generation of employment	Social	The proposed project will result into generation of employment	1. The project will cause direct and indirect employment generation. Economic activity will be stimulated by easier movement of passengers thus leading to indirect employment generation.	GoTN	GoTN

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
52.	Ancillary development along metro route	Social	Ancillary development along the metro alignment will have positive effect on the social environment	1. There should be positive participation of the common people in the ancillary development process. An open, transparent & people-centric outlook has to be adopted.	GC / CMRL	GoTN
		Land	Ancillary developments will take place along with metro corridor	1. Provision for increased density of development along project corridor is available through existing byelaws as well as new ToD norms. Mixed land use of ToD tends to reduce non-work trip length and its higher density promotes increased use of metro for work trips on long distances. 2. Implementation of increased densities is decided by State Government and managed by CMDA in accordance with demand.	GoTN	GoTN

GCMC Greater Chennai Municipal Corporation CMDA Chennai Metropolitan Development Authority TNSPCB Tamil Nadu State Pollution Control Board
GC General Consultant

Table 9.3: Environmental Monitoring Plan

Environmental Features	Aspect to be Monitored	Standard to be complied with	Time and Frequency of Monitoring	Location	Estimated cost (USD)
Pre-Construction stage					
Air	Emission of dust and particulate matter as PM2.5 and PM10, NOx and SOx, CO	GoI and WHO/IFC whichever stringent	Once, 24 hours continuously	Each station, batching plant and casting yard, Muck disposal site	4,658
Water (Surface and Ground)	DO, Turbidity, Conductivity, pH, Heavy metals, E.Coli, TSS, Oil and Grease, VOCs and Volatile Chlorinated Hydrocarbons (groundwater only) and TDS	GoI and WHO/IFC whichever stringent	Once, 3 samples each location	Groundwater at batching plant and casting yard, Muck disposal site, construction camps and 29 excavation sites Surface water at wherever waterbody located within 100m from sites	11,712
Soil	pH, Sulphate (SO3), Chloride, ORP, water Soluble salts EC, Organic Matter (Oil), Heavy metals, Poly-Aromatic Hydrocarbons (PAH), Moisture Content	GoI and WHO/IFC whichever stringent	Once, 3 samples each location	At batching plant and casting yard, Muck disposal site, construction camps and 29 excavation sites	11,096
a) Noise & vibration b) Building condition survey	Noise levels in dB(A) Vibration PPV mm/s Building condition survey	GoI and WHO/IFC whichever stringent Federal Transit Administration (FTA) Guideline Standards or any other internally recognized standards	a) Once Hourly basis for 24 hours (noise & vibration) b) Building Condition Survey: height measurements, crack survey, detailed photographic records etc.	a) At key structure locations b) At pre-identified culturally valuable sites if any near the alignment, or finds in the project's direct area of impact.	a) 11,397 b) To be decided during pre-bid joint site visit of CMRL & Contractor and cost included in bid
Biodiversity (Species, Population, Nests and Breeding sites) survey	Number of nests, breeding sites population size for target species confirmed by Forest Department, Fisheries Department, GoTN If any of above found during site clearance, they will be transferred to a safe place as guided by the biodiversity expert and TNFD/Wildlife/Fisheries.	GoI and IFC EHS Guideline and Guidance Note 6 or any internationally recognized guidelines whichever stringent	Once, prior to site clearance	Nanmangalam reserve forest, Pallikaranai marsh / other affected Marshlands, Adyar River, Adambakkam Lake and any other ecologically sensitive locations	4,110

Environmental Features	Aspect to be Monitored	Standard to be complied with	Time and Frequency of Monitoring	Location	Estimated cost (USD)
Sub-total					42,973
Construction stage					
Air	Emission of dust and particulate matter as PM2.5 and PM10, NOx and SOx, CO	GoI and WHO/IFC whichever stringent	24 hours continuously every month	For each station until civil works completed batching plant and casting yard, Muck disposal site throughout construction phase	112,877
Water (Surface and Ground)	DO, Turbidity, Conductivity, pH, Heavy metals, TN, TP, E.Coli, TSS, Oil and Grease, VOCs (groundwater only) and TDS	GoI and WHO/IFC whichever stringent	Borewells - Quarterly, 3 samples each location Water bodies – Monthly, 3 samples each location	Groundwater at batching plant and casting yard, Muck disposal site, construction camps throughout construction phase, and excavation sites stations until civil works completed Surface water at wherever waterbody located within 100m from sites	100.274
Soil	PH, Sulphate (SO_3), Chloride, ORP, water Soluble salts EC, Organic Matter (Oil), Heavy metals, PAH, Moisture Content	GoI and WHO/IFC whichever stringent	a) Quarterly, 3 samples each location	a) At batching plant and casting yard, Muck disposal site, construction camps throughout construction phase b) 28 excavation sites-once during construction, once post-construction	26,507
a) Noise, b) Vibration c) Building Condition Survey	a) Noise levels in dB(A) b) Vibration PPV mm/s c) Building Condition Survey	GoI and WHO/IFC whichever stringent Federal Transit Administration (FTA) Guideline Standards or any other internally recognized standards	a) Monthly or when complaint is received Hourly basis for 24 hrs (noise) b) Continuous monitoring during piling (vibration) c) Building Condition Survey: crack sensors, tilt sensors, continuous height measurement etc.	a) and b) Key structure locations c) Pre-identified culturally valuable sites if any near the alignment, or finds in the project's direct area of impact.	a) & b) 24,110 c) To be decided during pre-bid joint site visit of CMRL & Contractor and cost included in bid
Biodiversity	Wildlife Species If any species are found in the construction site, they will be	GoI and IFC EHS Guideline and Guidance Note 6 or any internationally recognized	Weekly during construction at the ecologically sensitive locations	Nanmangalam reserve forest, Pallikaranai marsh / other affected Marshlands, Adyar	161,339 (including yearly survey

Environmental Features	Aspect to be Monitored	Standard to be complied with	Time and Frequency of Monitoring	Location	Estimated cost (USD)
	carefully transferred to safe locations within the Forest Land, Marshlands or waterbody under the guidance of the biodiversity expert and the local forestry/wildlife/fisheries agency.	guidelines whichever stringent		River and Adambakkam Lake	15,221)
Occupational and Community Health and Safety	As specified in project ESHS plan prepared by Contractor Sub-section F of Section VII and Part D of PCC	IFC General and Sector EHS Guidelines or any other international recognized guidelines, WHO and GoI guidelines on COVID-19	Weekly	Project Site	NA
Sub-total					425,107
Operation Stage					
Air	Emission from DG sets (SPM, NOx and SOx), Odor	GoI and WHO/IFC whichever stringent	At least 2 times in a year for the first year, annually for another 2 years	DG sets of all stations	15,890
Groundwater	DO, Turbidity, Conductivity, pH, Heavy metals, TP, TN, E.Coli, TSS, Oil and Grease, VOCs and TDS	GoI and WHO/IFC whichever stringent	At least 2 times in a year for the first year, annually for another 2 years	Groundwater at Station locations	11,918
Noise	Noise levels in dB(A)	GoI and WHO/IFC whichever stringent	At least 2 times in a year for the first year, annually for another 2 years	Alignment, Stations	3,178
Vibration	PPV mm/s	Federal Transit Administration (FTA) Guideline Standards or any other internally recognized standards	At least 2 times in a years for the first year, annually for another 2 years	At key structure locations	43,836
Biodiversity	Wildlife Species Carcass	GoI and IFC EHS Guideline and Guidance Note 6 or any internationally recognized guidelines whichever stringent	At least 2 times in a years for the first year, annually for another 2 years	Nanmangalam reserve forest, Pallikaranai marsh / other affected Marshlands, Adyar River and Adambakkam Lake	cost included in bid of GC
Occupational Health and Safety	As specified in project EMP and CMRL's SHE Manual	IFC General and Sector EHS Guidelines or any other international recognized guidelines	Monthly for 3 years	Station	20,548 *
Sub-total					95,370
Grand total					**563,450**

During operation:

Occupational Health and Safety safeguards during operation are not spelt out in the SHE document. Based on experience on other railways, health issues relevant to Chennai metro can be as follows:
a) Musculo-skeletal disorders and fatigue, eye strain due to Display Screens impacting drivers, train controllers and ticketing staff: Well designed workstations, lighting, posture advice and regular health checkups. b) Stress impacting drivers and Train controllers: Risk assessment, changes to job design, task allocation, training, and supervision; emotional resilience training; counselling for recovery and rehabilitation.

* Lumpsum provision Group Insurance premium excluding surgeries and loss of life or limb: Rs five lakh per year

9.5 Emergency Preparedness and Response System

310 An Emergency Preparedness and Response System has been prepared as shown in Table 9.4.

Table 9.4: Emergency Preparedness and Response System

Emergency Situations	Community or individuals impacted	Response procedure	Equipment and resources	Responsibilities	Training need	Accident and emergency records
Damage to utilities: Damage to one of the utilities water supply, sewage, gas pipelines; electric and telecommunication cables while other utilities are being diverted due to lack of clarity in their location or unexpectedly poor state of their maintenance Damage while additional geotechnical investigations are in progress or during pile driving/in-situ casting.	Community In case of live gas lines, the project workforce could also be impacted	• The potential for disruption of utilities during line construction is low as long as proper pre-dig verification procedures are followed. Disruption could range from cable or phone outage to customers, to explosion in gas line with potential risk to human health and life. • Contact utility to clear utility related safety hazard (like deactivating the utility). • Seek assistance of the utility to assess damage • Coordinate with un-impacted utilities. • Vital services and infrastructure recovery activities.	➢For gas utilities • Fire engines to dispense water and foam • Portable extinguishers • Fire protection suits • Breathing apparatus, helmets, goggles and face shield, first aid kits, stretchers, torches, ladders, emergency lighting on standby power ➢For water and sewage utilities • Quick water sealants	Notification: Contractor to CMRL and utility agency CMRL to utility agency Remedial Action by: utility agency	• Mock drills • Use of extinguishers, fire suits, breathing apparatus, first aid kits, water sealants	• Utility location and diversion plans • Record sheet showing type, size and identification number of utility, time of occurrence, time of notifying utility agency, status of other utility lines at the locations, time of repair and resumption of construction activities • Geotagged photographs with date

Collapse or severe degree of damage to existing structures due to unanticipated vibration during construction	Community	• The base document available with the ER Team shows the location of structures which are at risk of damage due to vibration as assessed at start of construction. In case of those structures where damage is expected to be major especially due to age or condition of building, move occupants affected as well as those in their proximity to safer locations *before work is started at those locations.* Arrange for their temporary relocation till the structures are rehabilitated. • In the event of minor damage to non-structural elements of the buildings, the same will be repaired. In case of *unforeseen damage* endangering structural soundness, move occupants of structures affected as well as those in their proximity to safer locations. Arrange for their temporary relocation till the structures are rehabilitated.		Notification: Contractor to CMRL Remedial Action by: Contractor	Mock drills	Vibration records • Record sheet showing type, size and identification number of structure, time of occurrence, type of equipment in use before and when the damage was first noticed, the type of minor repair executed, number of occupants present and evacuated, time of evacuation, status of adjacent structures, type of rehabilitation implemented on each affected structure, date of resumption of construction activities, date of return of occupants • Geotagged photographs with date
Fire accidents at electric installations, fuel storage and fueling facilities	Community and project workforce	• Transformer or Substation fire requires equipment be de-energised. • Use fire water and foam to combat fires of oil. • Immediately cool the equipment and any containers	• Fire engines to dispense water and foam • Portable extinguishers • Fire protection suits	Notification: Contractor to CMRL and Fire Department, Police, hospitals and Tamil Nadu Pollution Control	• Mock drills • First Aid • Use of fire extinguishers, fire suits, breathing apparatus	• Fuel and vapour sample test reports • Maintenance reports of electric and fuel installations • Record sheet showing location and

		to avoid explosion. • Follow designated stand off distance and stand down period. • Administer first aid	• Breathing apparatus, helmets, goggles and face shield, first aid kits, stretchers, torches, ladders, Emergency lighting on standby power	Board Remedial Action by: Contractor	• Evacuation • Search and Rescue	time of occurrence, number of personnel present and evacuated • Geotagged photographs with date
Road accident hazard due to leakage of hazardous waste such as waste fuels, lubricants during transport by vendors	Community and project workforce	• Even if grievous hurt and loss of life to workers and community and property is not caused, if incident occurred in public area posing a hazard, notify Police and alert Pollution Control Board. • Control the leak/flow • Arrange for sampling of any water pollution or potential pollution	• First aid kits, stretchers, torches, ladders, emergency lighting on standby power	Notification: Contractor to CMRL • CMRL to Traffic Police Department and Tamil Nadu Pollution Control Board. Remedial Action by: Contractor	• Mock drills • First Aid • Use of fire extinguishers, fire suits, breathing apparatus	• Waste identification report • Record sheet showing location and time of occurrence, number of personnel present and evacuated • Geotagged photographs with date
Air pollution due to leakage and fire of flammable gases from muck disposal site slope failure of muck stack at disposal site	Community and project workforce	• Even if grievous hurt and loss of life to workers and community and property is not caused, if incident occurred in public area posing a hazard, notify Police and alert Pollution Control Board. • Use fire water	• Fire engines to dispense water and foam • Portable extinguishers • Fire protection suits • Breathing apparatus, gas detectors, helmets, goggles and face shield, first aid kits, stretchers,	Notification: Contractor to CMRL and Fire Department CMRL to Tamil Nadu Pollution Control Board Remedial Action by: Contractor	• Mock drills	• Gas sample test reports • Record sheet showing location and time of occurrence, number of personnel present and evacuated • Geotagged photographs with date

			torches, ladders, Emergency lighting on standby power			
Failed launching of pre-cast girders or segments	Community and project workforce	• Administer first aid • Organise lifting equipment and gas cutters • Even if grievous hurt and loss of life to workers and community and property is not caused, but if collapse occurred in public area posing a hazard, notify Police.	• Lifting equipment and gas cutters • First aid kits, stretchers, torches, ladders, emergency lighting on standby power	Notification: Contractor to CMRL CMRL to Police and district labour Commissioner Remedial Action by: Contractor	• Mock drills • First Aid • Search and Rescue	• Structural drawings of failed elements • Record sheet showing location and time of occurrence, type of lifting equipment used, number of personnel present and evacuated • Geotagged photographs with date
Collapse of temporary works such as scaffolding and excavation support	Community and project workforce	In case of injured worker suspended from his harness, wait for trained emergency personnel.		Notification: Contractor to CMRL CMRL to Police and district labour Commissioner Remedial Action by: Contractor	• Mock drills • First Aid	• Structural drawings of failed temporary works • Record sheet showing location and time of occurrence, number of personnel affected • Geotagged photographs with date
Service disruption and unplanned congestion due to failure of rolling stock doors	Metro Passengers	• As soon as duration of failure approaches disruption period allowed in station design, notify OCC and suspend boarding and alighting at affected station • close entry of passengers into affected stations • Trains arriving in affected duration will pass without	Maintenance equipment, spares and personnel	Notification: CMRL to Emergency Action Committee Remedial Action by: CMRL	• Mock drills	• rolling stock usage log • rolling stock maintenance reports • Record sheet showing location and time of occurrence, number of services affected

		stopping • Affected trains will pass through to maintenance depot for attention				• Geotagged photographs with date
Service disruption and unplanned congestion due to failure of traction power supply or signaling during operation of the metrorail	Metro Passengers	• In case of traction power failure, affected trains reach nearest station on battery. • In case of signalling failure, stop affected trains at nearest station. • Suspend operation of trains bound to pass through affected stations or section; stop trains at stations outside affected section • Close entry of passengers into affected stations	Maintenance equipment, spares and personnel	Notification: CMRL to Emergency Action Committee Remedial Action by: CMRL	• Mock drills	• TPS and S&T log • TPS and S&T maintenance reports • Record sheet showing location and time of occurrence, number of services affected • Geotagged photographs with date
Unplanned congestion in stations due to failure of general power through grid supply for lighting, communication etc	Metro Passengers	• As soon as standby supply is activated, notify OCC and suspend boarding and alighting in affected station; let trains pass through. • Close entry of passengers into affected stations • Switch on battery-powered high-power lamps which have been fixed to stations structure • Use portable hailers to address passengers and employees • Use portable lamps to locate and evacuate passengers and employees.	• Handheld 2 way radios and hailing loudspeakers • Portable handheld lamps • Maintenance equipment, spares and personnel	Notification: CMRL to Emergency Action Committee Remedial Action by: CMRL	• Mock drills	• Standby system maintenance reports • Record sheet showing location and time of occurrence • Geotagged photographs with date
Service disruption, Grievous hurt, loss of life due to natural disasters	Community and Metro Passengers	• Notify Operation Control Centre to suspend operation of trains bound to pass through affected stations or section; stop	• Trained rescue teams • Emergency battery fixed	Notification: CMRL to Emergency Action Committee,	• Mock drills • First Aid • Evacuation	• Magnitude and epicenter of earthquake • Seismic design

such as unanticipated earthquakes		trains at stations outside affected section • Administer first aid • Notify nearby hospitals for ambulances and to standby • Evacuate trains which have been stopped • Close entry of passengers into affected stations • Switch on battery-powered high-power lamps which have been fixed to station structure • Disconnect grid and standby DG power supply with turnstiles in default open mode. • Use portable hailers to address passengers and employees • Use portable lamps to locate and evacuate passengers and employees.	lighting • Hand torches • First Aid Kits • Safety helmets • Ropes and safety harnesses • Stretchers • Ladders • Ambulance • Rail-cum-road Vehicles	hospitals, Police, State Government, Commissioner Metro Rail Safety (CMRS) * Remedial Action by: CMRL	• Search and Rescue	adopted in design of structures • Record sheet showing location and time of occurrence, number of persons affected • Geotagged photographs with date
Unplanned congestion in stations due to terrorism or sabotage or law and order situations on Metro project or outside Metro project	Community, Metro Passengers and employees	• Notify Operation Control Centre to suspend operation of trains bound to pass through affected stations or section; stop trains at stations outside affected section • Administer first aid • Notify nearby hospitals for ambulances and to standby • Evacuate trains which have been stopped • Close entry of passengers into affected stations .	• First Aid Kits • Stretchers • Ambulance	Notification: CMRL to Emergency Action Committee, hospitals, Police, State Government Remedial Action by: CMRL		• Record sheet showing location and time of occurrence, number of persons affected • Geotagged photographs with date
Grievous hurt, loss of life and property due to terrorism or sabotage or law and order situations on				Notification: CMRL to Emergency Action Committee, hospitals, Police, State Government,	• Mock drills • First Aid • Evacuation • Search and Rescue	

Metro project				CMRS* Remedial Action by: CMRL		
Acts of suicide or murder or hurt	Perpetrators and victims	• Notify OCC and suspend operation of trains on affected platform; stop trains at stations outside affected section • Administer first aid • Notify nearby hospitals for ambulance and to standby	• First Aid Kits • Stretchers • Ambulance	CMRL to Emergency Action Committee, hospitals, Police, State Government, CMRS* Remedial Action by: CMRL	• Mock drills • First Aid • Evacuation	

***** *Metro Railway (Operations and Maintenance) Act, 2002 requires reporting of a) collision or derailment of trains or b) accidents attended or usually attended by loss of life or grievous hurt*

9.6 Training and Capacity Building Programs

311 CMRL's current capacity in monitoring of metro projects in adequate. However it is proposed to conduct a training program for CMRL as well as general consultant and contractors environmental, health and safety officials particularly on MDBs' monitoring and reporting requirements. External monitor will undertake training and capacity building activities. Training modules will be discussed and confirmed by CMRL and MDBs. A budget has been allocated in the EMP for the same.

9.7 Environmental Management Budget and Resources

312 The cost of all compensation and rehabilitations works will be an integrated part of the overall project cost, which will be borne by the project. The preliminary estimated cost of the environmental and social management plan is estimated as below. This cost estimate is exclusive of land acquisition and resettlement & resettlement cost.

Table 9.5: Cost of EMP and EMoP Implementation

Item	Amount (Rs in lakh)
Compensatory Plantation	57.60
Diversion of Forest Land	34.80
Rainwater Harvesting	574.25
Environmental Monitoring *	411.32
Training	55.94
Environment Division	97.80
Rooftop Solar Plant	1,228.15
COVID-19 measures (lumpsum)	300.00
Total	**2,759.86**

***** *Cost of building condition survey during construction and capital cost of noise barriers will form part of construction cost*

Adequate budget for ecological / biodiversity monitoring, tree transplantation and mitigation measures other than those in Table 9.5 will be allotted by CMRL.

10 CONCLUSION AND RECOMMENDATION

313 The revised alignment of the Balance C5 is not located in any protected area, except 1.569 ha in the Nanmangalam Reserved Forest between Velakallu and Medavakkam Koot Road, the forest clearance of alienation of forest land to non-forest use has been obtained from the Concerned authorities (Annexure 13). Careful selection of alignment has avoided sites of historical/cultural significance: the impact of proximity of the alignment to Madras War Cemetery will be minimized by mitigation measures.

314 There are no significant negative impacts due to the changes in length, design and alignment in the project scope. And furthermore, the inclusion of Grade Separator in the MIOT section brings the positive impacts by easing the flow of vehicular traffic (during its operation). The change in alignment greatly reduces the negative impacts since the conversion of wetland for construction activity is eliminated. Therefore, no additional mitigation measures are suggested in this report.

315 Significant adverse impacts are a) social impacts due to involuntary resettlement, b) loss of trees, climate change effects of continuous increase in ambient temperature, heavy precipitation events, and sea level rise, utility diversion, air, noise, vibration, water demand, disturbance to bird habitat due to construction, c) noise, vibration, disturbance to bird habitat due to operation, and d) ecological impacts are anticipated due to 259 public trees for felling /145 trees were translocated along the existing roads, and the alignment sharing the right of way of existing road which is crossing the marshland.

316 Making use of extensive available information, measures to mitigate adverse impacts have been recommended while highlighting worker safety, solar power and rainwater harvesting. Roles and responsibilities of CMRL, General Consultant and the Contractor have been sharply delineated in pre-construction and construction phases.

317 EMP and EMoP have been developed to mitigate or minimize significant adverse impacts due to the project. Responsibilities of CMRL and the contractor in securing pre-construction approvals from GoTN.

318 Benefits include reduced air pollution and road accidents, increased benefits to economy and commuters on metro and road. Major roads along the proposed alignments are forecast to function beyond respective design service volume in the year 2035 in absence of the project lines. BRT has significantly lower unit life cycle cost but road right of way is not adequate to operate BRT on Corridor 5. Therefore, continuity of Metro is required. Requirement of acquisition of property was minimized by fine-tuning of locations and footprint of stations.

319 Public consultations highlighted opinions of participants on benefits of Metro in terms of easing connectivity, pollution, congestion, accidents and travel on roads. Public consultations during construction and operation will form part of periodic monitoring reports sent by CMRL to MDBs. These consultations will focus on the efficacy of mitigation measures being implemented.

320 Grievance Redress Mechanism will be developed to assist the citizens, users of the Metro and other stakeholders communicate their queries, complaints and suggestions in connection with implementation of EMP and EMoP. GRM for both workers and communities will be instituted during pre-construction phase to continue through different phases.

321 Institutional arrangement, EMP, reporting and record keeping, emergency response and environment monitoring plan have been developed. A budgetary cost estimate to implement the EMP and EMoP has been prepared.

322 The best available technology and the best management practices are built-in to the project design. All project components will be implemented and monitored in line with the MDBs' applicable policies and standards. A semi-annual environmental and social monitoring report will be submitted to MDBs and will be disclosed publicly at the MDBs' websites. Environmental and social benefits of the project and long-term investment program objectives outweigh the temporary negative impacts.

Updated Environmental Impact Assessment

January 2024
Revision 01

India: Chennai Metro Rail Investment Project

Balance Corridor 5

Annexure 1

Prepared by the Chennai Metro Rail Limited (CMRL) for the Project Lenders.

Annexure 1. Sensitive Receptors on Balance C5

Sl. No	Name of the Sensitive Receptors	Location	Type of Sensitive Receptor	LHS/RHS	Distance from the outer most proposed tracks (m)	Latitude	Longitude
1	MASJID FIRDOUSE	**GRAIN MARKET TO SAI NAGAR BUS STOP**	MOSQUE	RHS	65.90	13º03'54.3"N	80°11'51.6"E
2	PERIYAPALATHAMMAN KOVIL	**GRAIN MARKET TO SAI NAGAR BUS STOP**	TEMPLE	RHS	76.50	13º03'53.2"N	80°11'50.4"E
3	KILASEVALPATTI SIVA TEMPLE	**GRAIN MARKET TO SAI NAGAR BUS STOP**	TEMPLE	LHS	99.60	13º03'46.5"N	80°11'53.2"E
4	MARTHOMA MATRICULATION HIGHER SECONDARY SCHOOL	**GRAIN MARKET TO SAI NAGAR BUS STOP**	SCHOOL	RHS	97.52	13º03'44.9"N	80°11'45.2"E
5	SBS HOSPITAL	**GRAIN MARKET TO SAI NAGAR BUS STOP**	HOSPITAL	RHS	52.71	13º03'34.0"N	80°11'40.8"E
6	INFANT JESUS CATHOLIC CHURCH	**SAI NAGAR BUS STOP TO ELANGO NAGAR BUS STOP**	CHURCH	LHS	72.98	13º03'23.6"N	80°11'40.4"E
7	THARACHAND NAGAR PARK	**SAI NAGAR BUS STOP TO ELANGO NAGAR BUS STOP**	PARK	LHS	143.49	13º03'17.6"N	80°11'40.1"E
8	BALALOK MATRIC HIGHER SECONDARY SCHOOL	**SAI NAGAR BUS STOP TO ELANGO NAGAR BUS STOP**	SCHOOL	LHS	177.90	13º03'15.4"N	80°11'39.8"E
9	MASID AYESHA MASQUE	**SAI NAGAR BUS STOP TO ELANGO NAGAR BUS STOP**	MOSQUE	RHS	21.43	13º03'17.1"N	80°11'33.7"E
10	SEVENTH DAY ADVENTIST CHURCH	**SAI NAGAR BUS STOP TO ELANGO NAGAR BUS STOP**	CHURCH	LHS	11.78	13º02'55.1"N	80°11'27.1"E
11	ADVENT CHRISTIAN CHURCH	**SAI NAGAR BUS STOP TO ELANGO NAGAR BUS STOP**	CHURCH	LHS	6.44	13º03"18.6"N	80°11'35.5"E
12	ANNAI HOSPITAL	**SAI NAGAR BUS STOP TO ELANGO NAGAR BUS STOP**	HOSPITAL	LHS	18.92	13º03'14.0"N	80°11'33.7"E
13	NADATHUR AMMAL VARADHAGURU TEMPLE	**SAI NAGAR BUS STOP TO ELANGO NAGAR BUS STOP**	TEMPLE	LHS	95.80	13º03"11.1"N	80°11'35.1"E
14	MM HOSPITAL	**SAI NAGAR BUS STOP TO ELANGO NAGAR BUS STOP**	HOSPITAL	RHS	28.76	13º03'10.1"N	80°11'30.7"E
15	SWATHI CLINIC	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	HOSPITAL	LHS	183.69	13º02'56.1"N	80°11'37.8"E
16	SRI SUNDRS VARATHARAJA PERUMAL TEMPLE	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	TEMPLE	LHS	1.89	13º02'55.5"N	80°11'32.1"E
17	RADHE KRISHNA TEMPLE	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	TEMPLE	LHS	172.97	13º02'54.9"N	80°11'38.0"E

18	ARULMIGU SRI KALIAMMAN TEMPLE	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	TEMPLE	RHS	2.11	13º02'52.3"N	80°11'32.9"E
19	SHRI SAIBABA TEMPLE	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	TEMPLE	RHS	169.11	13º02'51.6"N	80°11'27.3"E
20	SANTHOSHI MADHA TEMPLE	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	TEMPLE	LHS	74.50	13º02'48.3"N	80°11'33.7"E
21	SUBAM SPECIALITIES HOSPITAL	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	HOSPITAL	RHS	49.69	13º02'49.0"N	80°11'21.8"E
22	SRI AMMAN TEMPLE	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	TEMPLE	LHS	122.76	13º02'43.1"N	80°11'20.5"E
23	VEMBULIAMMAN TEMPLE	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	TEMPLE	LHS	15.21	13º02'47.0"N	80°11'21.6"E
24	CHENNAI MANAGARACHI SERUVAR PARK	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	PARK	LHS	17.85	13º02'42.0"N	80°11'23.0"E
25	CSI CHRIST CHURCH	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	CHURCH	LHS	40.73	13º02'44.7"N	80°11'17.3"E
26	KIRUBASANAM CHURCH OF CHRIST	**ELANGO NAGAR BUS STOP TO ALWARTHIRU NAGAR**	CHURCH	RHS	139.87	13º02'55.1"N	80°11'27.1"E
27	Masjid E-Muhammad	**PORUR TO MUGALIVAKKAM**	Mosque	LHS	7.98	13°02'10.1"N	80°09'29.7"E
28	Parvathy Hospital	**PORUR TO MUGALIVAKKAM**	Hospital	LHS	62.00	13°02'11.5"N	80°09'23.6"E
29	Masjidhul Ahad	**PORUR TO MUGALIVAKKAM**	Mosque	LHS	187.00	13°02'05.3"N	80°09'15.5"E
30	SMK Jain Sthamak	**PORUR TO MUGALIVAKKAM**	Temple	LHS	145.50	13°02'02.0"N	80°09'17.4"E
31	Sivaloga Sivan Adiya Kootam	**PORUR TO MUGALIVAKKAM**	Temple	LHS	139.40	13°01'59.2"N	80°09'19.1"E
32	Balamurugan Temple	**PORUR TO MUGALIVAKKAM**	Temple	LHS	187.28	13°01'57.0"N	80°09'18.9"E
33	Siva Veera Anjaneya Temple	**PORUR TO MUGALIVAKKAM**	Temple	RHS	199.00	13°02'00.2"N	80°09'31.6"E
34	P.K Hospital	**PORUR TO MUGALIVAKKAM**	Hospital	RHS	72.00	13°02'03.0"N	80°09'25.6"E
35	Uragappu Perumal Temple	**PORUR TO MUGALIVAKKAM**	Temple	RHS	53.00	13°02'03.1"N	80°09'24.1"E
36	Vairakya Anjaneyar	**PORUR TO MUGALIVAKKAM**	Temple	RHS	195.70	13°02'08.8"N	80°09'39.0"E
37	Ayyappan Temple	**PORUR TO MUGALIVAKKAM**	Temple	RHS	40.30	13°02'04.2"N	80°09'37.3"E
38	St. Johns Matric Hr. Sec. School	**PORUR TO MUGALIVAKKAM**	School	RHS	123.00	13°02'07.3"N	80°09'38.6"E
39	Arulmigu Sri Muthumariamman Temple	**PORUR TO MUGALIVAKKAM**	Temple	RHS	27.00	13°02'01.5"N	80°09'25.4"E
40	St. Joseph's Church	**PORUR TO MUGALIVAKKAM**	Church	LHS	132.16	13°01'57.8"N	80°09'31.1"E
41	Sri Vigneshwara Temple	**PORUR TO MUGALIVAKKAM**	Temple	LHS	87.85	13°01'58.7"N	80°09'29.7"E

42	Sri Divya Devi Mandir	**PORUR TO MUGALIVAKKAM**	Temple	LHS	54.30	13°02'00.1"N	80°09'30.1"E
43	Govt. Boys School	**PORUR TO MUGALIVAKKAM**	School	LHS	46.03	13°02'01.8"N	80°09'36.0"E
44	ECI First Church Porur	**PORUR TO MUGALIVAKKAM**	Church	LHS	20.72	13°02'01.8"N	80°09'36.9"E
45	The Salvation Army Porur Tamil Cops	**PORUR TO MUGALIVAKKAM**	Church	LHS	76.15	13°01'59.9"N	80°09'37.3"E
46	DMI St. Joseph Hospital	**PORUR TO MUGALIVAKKAM**	Hospital	LHS	52.50	13°01'59.2"N	80°09'40.0"E
47	Mosque	**PORUR TO MUGALIVAKKAM**	Mosque	RHS	47.96	13°02'03.1"N	80°09'39.9"E
48	Vinayaga Shrine	**MUGALIVAKKAM TO DLF IT SEZ**	Temple	LHS	2.32	13°01'56.2"N	80°09'50.8"E
49	New Creation Covenant Church	**MUGALIVAKKAM TO DLF IT SEZ**	Church	RHS	24.22	13°01'56.0"N	80°09'48.0"E
50	Sethu Kshetram	**MUGALIVAKKAM TO DLF IT SEZ**	Temple	LHS	28.00	13°01'49.0"N	80°10'04.0"E
51	Puthu Koyil	**MUGALIVAKKAM TO DLF IT SEZ**	Temple	LHS	85.64	13°01'44.9"N	80°10'15.0"E
52	Karumariamman Temple	**MUGALIVAKKAM TO DLF IT SEZ**	Temple	LHS	78.50	13°01'44.9"N	80°10'14.6"E
53	Shri Vinayagar Temple	**MUGALIVAKKAM TO DLF IT SEZ**	Temple	LHS	51.07	13°01'42.9"N	80°10'16.4"E
54	Nagathamman Koyil	**MUGALIVAKKAM TO DLF IT SEZ**	Temple	LHS	193.00	13°01'45.9"N	80°10'20.4"E
55	Husainy High School	**MUGALIVAKKAM TO DLF IT SEZ**	School	LHS	28.60	13°01'40.9"N	80°10'18.6"E
56	Sabari Nagar Thavamaiyam	**MUGALIVAKKAM TO DLF IT SEZ**	Temple	RHS	156.00	13°01'37.8"N	80°10'11.6"E
57	Sri Ayyappan Temple	**MUGALIVAKKAM TO DLF IT SEZ**	Temple	RHS	193.00	13°01'36.4"N	80°10'11.6"E
58	Shekinah Abundant Life Church	**DLF IT SEZ TO SATHYA NAGAR**	Church	LHS	17.90	13°01'33.7"N	80°10'30.6"E
59	Krishtu Jothi Church	**DLF IT SEZ TO SATHYA NAGAR**	Church	LHS	60.20	13°01'24.4"N	80°10'50.3"E
60	MGR Garden	**DLF IT SEZ TO SATHYA NAGAR**	Memorial Garden	LHS	61.86	13°01'22.3"N	80°10'54.2"E
61	Sri Putru Amman Koyil	**SATHYA NAGAR TO CTC**	Temple	LHS	129.35	13°01'21.0"N	80°11'00.7"E
62	Murali Hospital	**SATHYA NAGAR TO CTC**	Hospital	LHS	178.44	13°01'21.8"N	80°11'02.5"E
63	MIOT Hospital	**SATHYA NAGAR TO CTC**	Hospital	LHS	123.56	13°01'17.8"N	80°11'08.0"E
64	Vinayaga Teple	**SATHYA NAGAR TO CTC**	Temple	LHS	87.68	13°01'10.4"N	80°11'14.4"E
65	Arulmigu Angala Parameswari Temple	**SATHYA NAGAR TO CTC**	Temple	RHS	40.34	13°01'05.0"N	80°11'12.7"E
66	Global Christian Church	**SATHYA NAGAR TO CTC**	Church	LHS	6.63	13°01'03.2"N	80°11'17.2"E
67	Sivan Temple	**SATHYA NAGAR TO CTC**	Temple	RHS	148.51	13°00'57.7"N	80°11'16.3"E

68	Arulmigu Kothandaramar Temple	**SATHYA NAGAR TO CTC**	Temple	LHS	149.73	13°01'02.3"N	80°11'28.5"E
69	Temple	**CTC TO ST. WESLEY CHURCH**	Temple	LHS	68.62	13°00'59.2"N	80°11'28.6"E
70	Vinayagar Temple	**CTC TO ST. WESLEY CHURCH**	Temple	LHS	68.13	13°00'56.4"N	80°11'33.7"E
71	ESI Hospital	**CTC TO ST. WESLEY CHURCH**	Hospital	LHS	70.20	13°00'55.4"N	80°11'35.7"E
72	Global Christian Church	**CTC TO ST. WESLEY CHURCH**	Church	RHS	90.00	13°00'51.8"N	80°11'31.1"E
73	Madras War Cemetry	**CTC TO ST. WESLEY CHURCH**	Cemetry	LHS	6.80	13°00'50.7"N	80°11'37.9"E
74	Nagathamman Koyil	**CTC TO ST. WESLEY CHURCH**	Temple	LHS	95.00	13°00'48.4"N	80°11'42.8"E
75	Amman Temple	**CTC TO ST. WESLEY CHURCH**	Temple	LHS	20.30	13°00'47.0"N	80°11'40.7"E
76	Contonement Board High School	**CTC TO ST. WESLEY CHURCH**	School	LHS	77.93	13°00'46.5"N	80°11'43.3"E
77	Christ English School	**CTC TO ST. WESLEY CHURCH**	School	RHS	72.83	13°00'45.0"N	80°11'38.3"E
78	St. Joseph College	**CTC TO ST. WESLEY CHURCH**	College	RHS	39.00	13°00'48.9"N	80°11'37.2"E
79	St. Joseph's Matric. Hr. Sec. School	**CTC TO ST. WESLEY CHURCH**	School	RHS	173.55	13°00'40.8"N	80°11'37.1"E
80	St. Thomas Hospital	**CTC TO ST. WESLEY CHURCH**	Hospital	LHS	110.22	13°00'43.3"N	80°11'46.4"E
81	St, Thomas Garrison Church Cemetry	**CTC TO ST. WESLEY CHURCH**	Cemetry	LHS	149.84	13°00'46.7"N	80°11'46.0"E
82	Military Hospital	**CTC TO ST. WESLEY CHURCH**	Hospital	RHS	102.75	13°00'41.9"N	80°11'39.1"E
83	Sri Velli Selva Prasanna Vinayagar Koyil	**CTC TO ST. WESLEY CHURCH**	Temple	LHS	146.35	13°00'39.1"N	80°11'49.7"E
84	St Thomas Church, Kerala RCSC Malayalam	**CTC TO ST. WESLEY CHURCH**	Church	LHS	139.29	13°00'37.7"N	80°11'49.6"E
85	Sri Angala Parameswari Amman Alayam	**CTC TO ST. WESLEY CHURCH**	Temple	LHS	29.00	13°00'35.1"N	80°11'46.0"E
86	Contonement Board General Hospital	**CTC TO ST. WESLEY CHURCH**	Hospital	RHS	79.00	13°00'34.8"N	80°11'42.4"E
87	Butt Road Masjid	**CTC TO ST. WESLEY CHURCH**	Mosque	RHS	8.00	13°00'32.8"N	80°11'45.3"E
88	Ruskin's School	**CTC TO ST. WESLEY CHURCH**	School	LHS	20.37	13°00'32.4"N	80°11'47.3"E
89	Marian School	**CTC TO ST. WESLEY CHURCH**	School	RHS	89.94	13°00'30.5"N	80°11'43.9"E
90	St. Patricks's Church	**CTC TO ST. WESLEY CHURCH**	Church	RHS	136.50	13°00'29.3"N	80°11'43.0"E
91	Marian Primary School	**CTC TO ST. WESLEY CHURCH**	School	RHS	114.87	13°00'29.1"N	80°11'44.2"E
92	CSI Wesley Church	**CTC TO ST. WESLEY CHURCH**	Church	RHS	151.50	13°00'27.4"N	80°11'44.5"E
93	JMJ Convent	**CTC TO ST. WESLEY CHURCH**	Church	RHS	190.37	13°00'25.6"N	80°11'45.3"E

94	St. Helen Girls Hr. Sec. School	**CTC TO ST. WESLEY CHURCH**	School	RHS	175.50	13°00'25.4"N	80°11'48.9"E
95	New Vision Bethesda Church	**ST. WESLEY CHURCH TO ALANDUR**	Church	LHS	178.50	13°00'36.8"N	80°11'51.2"E
96	Arulmigu Sri Kasi Viswanadar Alayam	**ST. WESLEY CHURCH TO ALANDUR**	Temple	LHS	15.60	13°00'31.7"N	80°11'52.7"E
97	CSI St. Thomas Matric Hr. Sec. School	**ST. WESLEY CHURCH TO ALANDUR**	School	RHS	102.00	13°00'27.8"N	80°11'52.1"E
98	Bright Light Ministries	**ST. WESLEY CHURCH TO ALANDUR**	Church	RHS	145.13	13°00'26.4"N	80°11'52.1"E
99	Tamil Westley Church CSI	**ST. WESLEY CHURCH TO ALANDUR**	Church	RHS	49.70	13°00'29.6"N	80°11'57.5"E
100	Arulmigu Sri Bala Vinayagar	**ST. WESLEY CHURCH TO ALANDUR**	Temple	LHS	109.20	13°00'34.9"N	80°12'03.2"E
101	National Matric. Hr. Sec. School	**ST. WESLEY CHURCH TO ALANDUR**	School	LHS	56.00	13°00'32.3"N	80°12'14.7"E
102	Raadha Rajendran Hospital	**ST. WESLEY CHURCH TO ALANDUR**	Hospital	LHS	97.00	13°00'20.9"N	80°12'15.3"E
103	Hindustan Institute of Engg. & Tech.	**ST. WESLEY CHURCH TO ALANDUR**	College	RHS	107.32	13°00'23.7"N	80°12'08.1"E
104	Hindustan InternationalSchool CAIE	**ST. WESLEY CHURCH TO ALANDUR**	School	RHS	102.50	13°00'23.0"N	80°12'07.4"E
105	Sri Prasanna Venkatesa Perumal Temple	**ST. WESLEY CHURCH TO ALANDUR**	Temple	LHS	106.30	13°00'19.6"N	80°12'14.3"E
106	Sivan Koyil	**ST. WESLEY CHURCH TO ALANDUR**	Temple	LHS	134.00	13°00'17.6"N	80°12'13.0"E
107	Arulmigu Tirpura Sundari temple	**ST. WESLEY CHURCH TO ALANDUR**	Temple	LHS	150.15	13°00'16.8"N	80°12'13.0"E
108	Sri Prasanna Venkatesa Sami Temple	**ST. WESLEY CHURCH TO ALANDUR**	Temple	LHS	146.30	13°00'16.7"N	80°12'12.5"E
109	Sri Kothanda Ramar Sannidhi	**ST. WESLEY CHURCH TO ALANDUR**	Temple	LHS	147.62	13°00'16.4"N	80°12'12.5"E
110	Vinayagar Koyil	**ALANDUR TO ST. THOMBAS MRTS**	Temple	LHS	135.90	13°00'12.9"N	80°12'10.4"E
111	Arulmigu Sri Nagathamman Alayam	**ALANDUR TO ST. THOMBAS MRTS**	Temple	RHS	34.90	13°00'09.7"N	80°12'03.0"E
112	Battle Ground	**ALANDUR TO ST. THOMBAS MRTS**	Historic Landmark	RHS	116.40	13°00'14.1"N	80°12'01.8"E
113	Elite School of Optometry	**ALANDUR TO ST. THOMBAS MRTS**	College & Hospital	RHS	32.90	13°00'03.9"N	80°12'00.5"E
114	Navanitha Salini Alayam	**ALANDUR TO ST. THOMBAS MRTS**	Temple	RHS	141.26	13°00'03.5"N	80°11'56.8"E
115	Salaf Council Mosque	**ALANDUR TO ST. THOMBAS MRTS**	Mosque	LHS	198.32	13°00'02.3"N	80°12'07.9"E
116	Monfort Higher Secondary School	**ALANDUR TO ST. THOMBAS MRTS**	School	LHS	119.35	13°00'02.6"N	80°12'05.4"E
117	St. Antony's Church	**ALANDUR TO ST. THOMBAS MRTS**	Church	LHS	22.50	13°00'00.1"N	80°12'02.1"E

118	Masjid-E-Azeemjahi Golandazi	**ALANDUR TO ST. THOMBAS MRTS**	Mosque	LHS	109.03	12°59'58.3"N	80°12'05.0"E
119	Masjid E Ahle Hadees Alandur	**ALANDUR TO ST. THOMBAS MRTS**	Mosque	LHS	155.64	12°59'55.4"N	80°12'06.6"E
120	Arulmigu Sri Padaveettu Amman Koyil	**ALANDUR TO ST. THOMBAS MRTS**	Temple	RHS	11.00	12°59'51.8"N	80°12'01.4"E
121	Madha Church	**ALANDUR TO ST. THOMBAS MRTS**	Church	RHS	57.24	12°59'51.6"N	80°11'59.8"E
122	Nesarin Karam Church	**ALANDUR TO ST. THOMBAS MRTS**	Church	RHS	38.29	12°59'50.5"N	80°12'00.6"E
123	Vinayagar Temple	**ALANDUR TO ST. THOMBAS MRTS**	Temple	RHS	30.34	12°59'49.9"N	80°12'00.9"E
124	Indra Gandhi Matriculation School	**ALANDUR TO ST. THOMBAS MRTS**	School	LHS	197.29	12°59'44.4"N	80°12'07.1"E
125	Grama Devadai Palandi Amman Temple	**ALANDUR TO ST. THOMBAS MRTS**	Temple	LHS	140.24	12°59'42.8"N	80°12'03.3"E
126	Lord Nandheeswarar Temple	**ALANDUR TO ST. THOMBAS MRTS**	Temple	LHS	167.34	12°59'40.8"N	80°12'01.7"E
127	Bringi Munivarukku Nandhiroobama Temple	**ALANDUR TO ST. THOMBAS MRTS**	Temple	LHS	188.00	12°59'40.7"N	80°12'02.6"E
128	Ganesh Institute of Engineering	**ST. THOMBAS MRTS TO ADAMBAKKAM MRTS**	College	LHS	151.64	12°59'37.6"N	80°11'51.5"E
129	Vinayagar Temple	**ST. THOMBAS MRTS TO ADAMBAKKAM MRTS**	Temple	RHS	73.26	12°59'39.2"N	80°11'43.3"E
130	Adambakkam Christian Assembly	**ST. THOMBAS MRTS TO ADAMBAKKAM MRTS**	Church	LHS	9.80	12°59'30.7"N	80°11'44.2"E
131	Right Choice Sms	**ST. THOMBAS MRTS TO ADAMBAKKAM MRTS**	Church	LHS	157.45	12°59'26.2"N	80°11'49.3"E
132	Shri Selva Gajamugan Aalayam Temple	**ST. THOMBAS MRTS TO ADAMBAKKAM MRTS**	Temple	LHS	115.04	12°59'19.9"N	80°11'47.9"E
133	Devi Karumariamman Temple	**ST. THOMBAS MRTS TO ADAMBAKKAM MRTS**	Temple	RHS	37.34	12°59'20.2"N	80°11'42.9"E
134	Lakshmi Narasimar Temple	**ST. THOMBAS MRTS TO ADAMBAKKAM MRTS**	Temple	RHS	67.73	12°59'20.5"N	80°11'41.9"E
135	Shirdi Sai Baba Temple	**ST. THOMBAS MRTS TO ADAMBAKKAM MRTS**	Temple	RHS	156.35	12°59'19.9"N	80°11'38.9"E
136	Arogyakshamaday Sai Baba Temple	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Temple	LHS	96.88	12°59'09.1"N	80°11'50.1"E
137	Ayyappan Temple	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Temple	RHS	86.42	12°59'09.7"N	80°11'43.7"E
138	Sri Angala Parameshwari Amman Temple	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Temple	RHS	63.70	12°59'06.2"N	80°11'44.9"E
139	Sri LakshmiNarayana Perumal Temple	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Temple	RHS	74.45	12°59'06.1"N	80°11'44.5"E
140	Sri Varasakthi Vinayagar	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Temple	RHS	84.89	12°59'03.5"N	80°11'44.2"E

141	Aanandha Vinayagar Temple	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Temple	RHS	75.93	12°58'59.6"N	80°11'44.4"E
142	Sri Venkatesa Perumal Temple	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Temple	RHS	6.94	12°58'58.7"N	80°11'46.5"E
143	KALPANA HOSPITAL	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Hospital	LHS	1.00	12°58'57.4"N	80°11'46.3"E
144	Palandi Amman Temple	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Temple	LHS	111.45	12°58'53.4"N	80°11'48.3"E
145	St.Jude's Shrine	**ADAMBAKKAM MRTS TO MEDAVAKKAM MAIN ROAD**	Church	LHS	19.37	12°58'53.5"N	80°11'44.9"E
146	The Pison Ministries	**MEDAVAKKAM MAIN ROAD TO IBACO**	Church	LHS	166.73	12°58'48.6"N	80°11'47.9"E
147	Sri Vembuli Amman Temple	**MEDAVAKKAM MAIN ROAD TO IBACO**	Temple	LHS	47.17	12°58'48.3"N	80°11'43.3"E
148	Noorul Hudha Masjid	**MEDAVAKKAM MAIN ROAD TO IBACO**	Mosque	RHS	134.61	12°58'49.9"N	80°11'37.3"E
149	Amman Temple	**MEDAVAKKAM MAIN ROAD TO IBACO**	Temple	RHS	1.20	12°58'48.0"N	80°11'41.2"E
150	Draubathi Amman Temple	**MEDAVAKKAM MAIN ROAD TO IBACO**	Temple	RHS	11.07	12°58'47.7"N	80°11'40.7"E
151	Ebenezer Evangelical Church	**MEDAVAKKAM MAIN ROAD TO IBACO**	Church	RHS	173.35	12°58'49.7"N	80°11'35.8"E
152	Zion PM Church	**MEDAVAKKAM MAIN ROAD TO IBACO**	Church	LHS	107.53	12°58'41.9"N	80°11'41.6"E
153	CSI St. James Church	**MEDAVAKKAM MAIN ROAD TO IBACO**	Church	LHS	16.87	12°58'41.5"N	80°11'38.5"E
154	Amman Temple	**MEDAVAKKAM MAIN ROAD TO IBACO**	Temple	LHS	1.12	12°58'38.1"N	80°11'37.3"E
155	AG church (Glad Tidings)	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Church	LHS	87.37	12°58'21.2"N	80°11'32.2"E
156	Amman Temple	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Temple	RHS	172.44	12°58'28.8"N	80°11'26.0"E
157	Prarthanalaya	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Church	RHS	21.35	12°58'20.3"N	80°11'28.0"E
158	Gideon's Army of Worship Centre	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Church	LHS	1.47	12°58'16.8"N	80°11'27.3"E
159	Murugan Temple	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Temple	LHS	2.59	12°58'14.1"N	80°11'26.2"E
160	Jain Temple	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Temple	LHS	16.67	12°58'12.2"N	80°11'25.9"E
161	Pathala Vigneswarar Temple	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Temple	RHS	5.83	12°58'15.9"N	80°11'26.7"E
162	Bathala vinayagar kovil	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Temple	RHS	46.00	12°58'14.2"N	80°11'24.5"E
163	Temple	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Temple	RHS	178.34	12°58'16.1"N	80°11'20.5"E
164	Sibi Hospital	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Hospital	LHS	23.24	12°58'11.3"N	80°11'25.7"E

165	Shri Aayee Mataji Mandir	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Temple	RHS	38.39	12°58'12.0"N	80°11'23.8"E
166	Sai Matriculation Higher Secondary School	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	School	LHS	185.00	12°58'05.4"N	80°11'29.0"E
167	Masjid-E-Hameem	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	Mosque	RHS	120.50	12°58'07.2"N	80°11'18.6"E
168	Kalaimagal Vidhya Mandhir Matric. School	**IBACO TO MADIPAKKAM KOOT ROAD BUS STOP**	School	RHS	147.00	12°58'05.7"N	80°11'17.0"E
169	Anjakha Hospital	**MADIPAKKAM KOOT ROAD BUS STOP TO VENKATESWARA NAGAR**	Hospital	LHS	11.00	12°57'50.1"N	80°11'16.5"E
170	Divya Hospital	**MADIPAKKAM KOOT ROAD BUS STOP TO VENKATESWARA NAGAR**	Hospital	RHS	9.00	12°57'51.7"N	80°11'16.3"E
171	Ganesh Temple	**MADIPAKKAM KOOT ROAD BUS STOP TO VENKATESWARA NAGAR**	Temple	RHS	47.30	12°57'49.8"N	80°11'14.4"E
172	Shirdi Shri Bhairava Sai Baba tem	**MADIPAKKAM KOOT ROAD BUS STOP TO VENKATESWARA NAGAR**	Temple	RHS	81.87	12°57'48.8"N	80°11'13.0"E
173	Our Lady Of Lourdes Church	**MADIPAKKAM KOOT ROAD BUS STOP TO VENKATESWARA NAGAR**	Church	LHS	190.67	12°57'42.7"N	80°11'21.0"E
174	Shri Selva Vinayagar Aalayam	**MADIPAKKAM KOOT ROAD BUS STOP TO VENKATESWARA NAGAR**	Temple	LHS	135.96	12°57'35.6"N	80°11'17.9"E
175	Holy family school	**MADIPAKKAM KOOT ROAD BUS STOP TO VENKATESWARA NAGAR**	School	RHS	50.23	12°57'37.1"N	80°11'11.9"E
176	Temple	**MADIPAKKAM KOOT ROAD BUS STOP TO VENKATESWARA NAGAR**	Temple	RHS	161.78	12°57'35.6"N	80°11'08.0"E
177	Ravindra Bharti Global School	**VENKATESWARANAGAR-ECHANKADU BUS STOP**	School	LHS	42.64	12°57'06.1"N	80°11'08.5"E
178	Shri Sapthakannimar Temple	**VENKATESWARANAGAR-ECHANKADU BUS STOP**	Temple	RHS	96.67	12°57'12.4"N	80°11'14.8"E
179	Grace Hospital	**VENKATESWARANAGAR-ECHANKADU BUS STOP**	Hospital	RHS	196.49	12°57'17.9"N	80°11'19.0"E
180	Vinayagar Temple	**ECHANKADU BUS STOP-KOVILAMBIKAM BUS STOP**	Temple	RHS	41.24	12°57'01.6"N	80°11'09.5"E
181	CSI Nalmaiper Church	**KOVILAMBIKAM BUS STOP-VELAKALLU BUS STOP**	church	LHS	126.34	12°56'26.3"N	80°10'53.5"E
182	Vinayagar Temple	**KOVILAMBIKAM BUS STOP-VELAKALLU BUS STOP**	Temple	RHS	83.79	12°56'10.4"N	80°10'59.3"E
183	Arun Hospital	**KOVILAMBIKAM BUS STOP-VELAKALLU BUS STOP**	Hospital	RHS	61.07	12°56'27.3"N	80°10'58.2"E
184	sri Muthumariamman Alayam	**VELAKALLU BUS STOP-MEDAVAKKAM KOOT ROAD BUS STOP**	Temple	LHS	65.49	12° 55' 58.3104" N	80°10 48.6" E
185	V.S Hospital	**VELAKALLU BUS STOP-MEDAVAKKAM KOOT ROAD BUS STOP**	Hospital	LHS	184.32	12° 56' 2.148" N	80°10'52.1" E
186	Makkah Masjid	**VELAKALLU BUS STOP-MEDAVAKKAM KOOT ROAD BUS STOP**	Mosque	RHS	33.48	12° 55' 43.4964" N	80°10'52.1" E
187	Srivarasidhi vinayagar kovil	**VELAKALLU BUS STOP-MEDAVAKKAM KOOT ROAD BUS STOP**	Temple	RHS	23.05	12° 55' 52.2768" N	80°10'54.2" E

188	Sri Baktha Anjanayar temple	**VELAKALLU BUS STOP-MEDAVAKKAM KOOT ROAD BUS STOP**	Temple	RHS	19.77	12° 55' 23.88" N	80°10'59.2" E
189	Quaide Millath College	**MEDAVAKKAM KOOT ROAD BUS STOP-KAMARAJ GARDEN**	College	LHS	185.41	12°55'14.9"N	80°10'54.8"E
190	Hindu Temple	**MEDAVAKKAM KOOT ROAD BUS STOP-KAMARAJ GARDEN**	Temple	LHS	122.62	12° 55' 10.6" N	80°11'00.8"E
191	Vinayagar Temple	**MEDAVAKKAM KOOT ROAD BUS STOP-KAMARAJ GARDEN**	Temple	LHS	184.30	12° 55' 7.6" N	80°11'02.5"E
192	Perumal	**MEDAVAKKAM KOOT ROAD BUS STOP-KAMARAJ GARDEN**	Temple	LHS	184.40	12° 55' 7.1112" N	80°11'08.5"E
193	Seedplayschool	**MEDAVAKKAM KOOT ROAD BUS STOP-KAMARAJ GARDEN**	School	RHS	158.07	12°55'19.3"N	80°11'05.6"E
194	The Christ Matriculation school	**MEDAVAKKAM KOOT ROAD BUS STOP-KAMARAJ GARDEN**	School	RHS	167.90	12°55'17.3"N	80°11'12.9"E
195	Annai Therasa Hospitals Pvt Ltd	**MEDAVAKKAM KOOT ROAD BUS STOP-KAMARAJ GARDEN**	Hospital	RHS	89.36	12°55'06.4"N	80°11'20.9"E
196	Primary Health Care	**KAMARAJ GARDEN-MEDAVAKKAM BUS STOP**	Hospital	LHS	189.03	12°54'51.7"N	80°11'34.5"E
197	Vidhya Matric High Sec. School	**KAMARAJ GARDEN-MEDAVAKKAM BUS STOP**	School	RHS	98.04	12°54'45.8"N	80°11'45.5"E
198	Masjid-e-Muhammadhiya	**KAMARAJ GARDEN-MEDAVAKKAM BUS STOP**	Mosque	LHS	24.09	12°54'46.2"N	80°11'41.4"E
199	Renuka Parameswari Amman Temple	**KAMARAJ GARDEN-MEDAVAKKAM BUS STOP**	Temple	RHS	142.61	12°54'45.7"N	80°11'46.4"E
200	Masjide Ayesha	**MEDAVAKKAM BUS STOP-PERUMBAKKAM BUS STOP**	Mosque	LHS	115.12	12°54'26.2"N	80°11'51.5"E
201	Samithoppu Sri Vaigundar Ayya Temple	**MEDAVAKKAM BUS STOP-PERUMBAKKAM BUS STOP**	Temple	LHS	23.16	12°54'29.4"N	80°11'52.6"E
203	Perumbakkam Advent Christian Church	**PERUMBAKKAM BUS STOP-GLOBAL HOSPITAL**	Chruch	LHS	34.91	12°54'26.2"N	80°12'00.9"E
204	St Gregorios Jacobite Syrian Orthodox Church	**PERUMBAKKAM BUS STOP-GLOBAL HOSPITAL**	Chruch	LHS	151.41	12°54'20.4"N	80°12'14.9"E
205	Angala Parameshwari Temple	**PERUMBAKKAM BUS STOP-GLOBAL HOSPITAL**	Temple	RHS	24.07	12°54'27.5"N	80°12'06.6"E
206	Bharathi Vidyalaya Senior Secondary School	**PERUMBAKKAM BUS STOP-GLOBAL HOSPITAL**	School	RHS	101.08	12°54'30.9"N	80°12'13.2"E
207	Panjamuga Vinayagar Temple	**PERUMBAKKAM BUS STOP-GLOBAL HOSPITAL**	Temple	RHS	76.75	12°54'27.3"N	80°12'18.3"E
208	Maranatha Calvary Telugu Church	**GLOBAL HOSPITAL- HCL ELCOT**	Church	LHS	200.00	12°54'11.6"N	80°12'18.5"E
209	LLM church - LifeLine Ministries	**GLOBAL HOSPITAL- HCL ELCOT**	Church	LHS	64.43	12°54'19.7"N	80°12'23.6"E
210	Central Institute of Classical Tamil	**GLOBAL HOSPITAL- HCL ELCOT**	college	RHS	73.09	12°54'17.8"N	80°12'39.7"E
211	Shri Shirdi Selva Sai Baba Mandir	**HCL ELCOT**	Temple	RHS	126.40	12°54'09.2"N	80°13'25.8"E

212	Living Spring English Church	**HCL ELCOT**	Church	RHS	201.60	12°54'04.5"N	80°13'34.8"E
213	Masjid-ur-Rahman		Mosque	RHS	96.06	12°54'06.4"N	80°13'23.7"E

Updated Environmental Impact Assessment

January 2024
Revision 01

India: Chennai Metro Rail Investment Project

Balance Corridor 5

Annexure 2 - 6

Prepared by the Chennai Metro Rail Limited (CMRL) for the Project Lenders.

Annexure 2. CMRL and MRTS Coordination Plan

Date: 23.10.2020

Sub: Construction of CMRL & MRTS structures along the common alignment after St. Thomas Mount Metro station from Ch.31300 to Ch. 31700 (CMRL chainage).

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Southern Railways and CMRL agreed to take up their structures constructed within the same ROW available with MRTS for the above section which enables utilizing the same ROW. The works of CMRL will also be executed by Southern Railway as a deposit work.

To have a closer association and review the works and to ensure timely completion as per the specifications etc., it is agreed to have a joint meeting by CMRL and MTP/Southern Railways every quarter after the commencement of works. The review will be made on the following aspects.

1. Work progress visa vis., the timelines
2. Review the quality documents.
3. Review the safety and environmental issues.
4. Finalization of as built documents at the end of the project.
5. Sharing the documents for the purpose of CMRL for their portion of work for submission to CMRS.

(Thiru M. Ilampooranan)
CE /CN/Central/ MS,
Southern Railways

(S. Ashok Kumar) 23/X/20
General Manager (T &EC)
CMRL

MTP, Southern Railways

Annexure 3. Acceptable Vibration Impact Criteria

Table 8-1. Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria for General Assessment

Land Use Category	GBV Impact Levels (VdB re 1 micro-inch /sec)			GBN Impact Levels (dB re 20 micro Pascals)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB[4]	65 VdB[4]	65 VdB[4]	N/A[5]	N/A[5]	N/A[5]
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

Notes:

1. "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

(Transit Noise and Vibration Impact Assessment, FTA, May 2006)

Vibration Category 3 - Institutional: Vibration Category 3 includes schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference.

Acceptable Vibration Impact Criteria

(Metro Rail Transit System Guidelines for Noise and vibrations, RDSO India, Sept 2015)

Table 3.7. Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria for General Assessment

Land Use Category	GBV Impact Levels (VdB ref 25.4 micro-mm /sec)			GBN Impact Levels (dB ref 20 micro Pascals)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB[4]	65 VdB[4]	65 VdB[4]	N/A[4]	N/A[4]	N/A[4]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

Notes:

1. " Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration sensitive equipment is generally not sensitive to ground-borne noise. DIN 4150-2 can also be referred for guidelines values for evaluating human exposure to vibration in dwellings and similar spaces.

Annexure 4. Affected Utilities

Sewage pipelines

104	5	31000	33600	2600	LHS	1.2M DIA	BGL-2.5M	PARALLEL	U/G	YES
105	5	33600	34500	900	RHS	1.2M DIA	BGL-2.5M	PARALLEL	U/G	YES
106	5	31430	31430	30	CROSSING(LHS)	0.4M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
107	5	31950	31950	30	CROSSING(LHS)	0.4M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
108	5	32650	32650	30	CROSSING(LHS)	0.4M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
109	5	33000	33000	30	CROSSING(LHS)	0.4M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
110	5	33750	33750	30	CROSSING(RHS)	0.4M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
111	5	33820	33820	30	CROSSING(RHS)	0.4M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
112	5	34020	34020	30	CROSSING(RHS)	0.4M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
113	5	34180	34180	30	CROSSING(LHS)	0.4M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
114	5	34180	34180	30	CROSSING(RHS)	0.4M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
115	5	39400	39400	30	CROSSING(LHS)	1.6M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
116	5	39400	41100	1700	LHS	1.6M DIA	BGL-2.5M	PARALLEL	U/G	YES

Water pipelines

S. No	Corridor	From Ch. (m)	To Ch. (m)	Affected Length (M)	LHS/RHS	Dia/Size	Depth (BGL in m)	Position from Alignment	Metro Alignment	Diversion required
60	5	14660	14660	30	CROSSING(RHS)	0.5M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
61	5	15140	15140	30	CROSSING(LHS)	0.3M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
62	5	27850	27850	30	CROSSING(LHS)	1.0M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
63	5	27850	27850	30	CROSSING(RHS)	1.0M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
64	5	29000	29000	30	CROSSING(LHS)	1.0M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
65	5	29000	29200	200	LHS	1.0M DIA	BGL-2.5M	PARALLEL	U/G	YES
66	5	30970	30970	30	CROSSING(LHS)	1.0M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
67	5	30970	44200	13230	LHS	1.0M DIA	BGL-2.5M	PARALLEL	U/G	YES
68	5	31430	31430	30	CROSSING(LHS)	0.6M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
69	5	32050	32050	30	CROSSING(RHS)	0.3M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
70	5	32520	32520	30	CROSSING(RHS)	0.3M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
71	5	33050	33050	30	CROSSING(LHS)	0.3M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
72	5	34180	34180	30	CROSSING(RHS)	0.6M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
73	5	34950	34950	30	CROSSING(LHS)	1.5M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
74	5	37350	37350	30	CROSSING(LHS)	0.5M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
75	5	39550	39550	30	CROSSING(RHS)	0.6M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
76	5	40980	40980	30	CROSSING(RHS)	0.3M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
77	5	41870	41870	30	CROSSING(RHS)	0.2M DIA	BGL-2.5M	PERPENDICULAR	U/G	NO
78	5	43450	43450	30	CROSSING(RHS)	0.6M DIA	BGL-2.5M	PERPENDICULAR	ELEVATED	YES
79	5	43450	44200	750	RHS	0.6M DIA	BGL-2.5M	PARALLEL	ELEVATED	YES

A large number of Telecommunication cables of various providers

Above ground electric lines

48	LT LINE	25163	25163	CROSSING(RHS)	PERPENDICULAR	6.6KV
49	LT LINE	26100	26100	CROSSING(LHS)	PERPENDICULAR	440V
50	LT LINE	26100	26520	LHS	PARALLEL	440V
51	LT LINE	26520	26520	CROSSING(LHS)	PERPENDICULAR	440V
52	LT LINE	26740	26740	CROSSING(LHS)	PERPENDICULAR	6.6KV
53	LT LINE	26740	27040	LHS	PARALLEL	6.6KV

54	LT LINE	27040	27040	CROSSING(LHS)	PERPENDICULAR	6.6KV
55	LT LINE	28570	28570	CROSSING(LHS)	PERPENDICULAR	440V
56	LT LINE	28570	29010	LHS	PARALLEL	440V
57	LT LINE	29010	29010	CROSSING(LHS)	PERPENDICULAR	440V
58	LT LINE	30970	30970	CROSSING(LHS)	PERPENDICULAR	11KV
59	LT LINE	30970	31430	LHS	PARALLEL	11KV
60	LT LINE	31430	31430	CROSSING(LHS)	PERPENDICULAR	11KV
61	LT LINE	31960	31960	CROSSING(LHS)	PERPENDICULAR	11KV
62	LT LINE	31960	34190	LHS	PARALLEL	11KV
63	LT LINE	34190	34190	CROSSING(LHS)	PERPENDICULAR	11KV
64	HT LINE	34950	34950	CROSSING(LHS)	PERPENDICULAR	33KV
65	HT LINE	34950	34950	CROSSING(RHS)	PERPENDICULAR	33KV
66	LT LINE	35690	35690	CROSSING(LHS)	PERPENDICULAR	6.6KV
67	LT LINE	35690	36240	LHS	PARALLEL	6.6KV
68	LT LINE	36240	36240	CROSSING(LHS)	PERPENDICULAR	6.6KV
69	LT LINE	36500	36500	CROSSING(LHS)	PERPENDICULAR	6.6KV
70	LT LINE	36500	37630	LHS	PARALLEL	6.6KV
71	LT LINE	37630	37630	CROSSING(LHS)	PERPENDICULAR	6.6KV
72	LT LINE	39240	39240	CROSSING(LHS)	PERPENDICULAR	6.6KV
73	LT LINE	39240	39400	LHS	PARALLEL	6.6KV
74	LT LINE	39400	39400	CROSSING(LHS)	PERPENDICULAR	6.6KV
75	LT LINE	39400	39400	CROSSING(RHS)	PERPENDICULAR	6.6KV
76	LT LINE	39920	39920	CROSSING(LHS)	PERPENDICULAR	6.6KV
77	LT LINE	39920	41100	LHS	PARALLEL	6.6KV
78	HT LINE	41100	41100	CROSSING(LHS)	PERPENDICULAR	33KV
79	HT LINE	41100	42700	LHS	PARALLEL	33KV
80	HT LINE	42700	42700	CROSSING(LHS)	PERPENDICULAR	33KV
81	LT LINE	43270	43270	CROSSING(LHS)	PERPENDICULAR	6.6KV
82	LT LINE	43270	44224	LHS	PARALLEL	6.6KV

Annexure 5
Terms of Reference of General Consultant in Implementation of EMP and EMoP

i. Review and update EIA including EMP and EMoP as appropriate; incorporate necessary technical specifications following design and contract documentation;
ii. Assist CMRL in preparation of documents and taking necessary procedures in accordance with in the EIA Report for the Project, if any;
iii. Assist CMRL in dissemination and explanation of additionally confirmed and identified environmental issues to public including holding public consultations;
iv. Assist CMRL in obtaining necessary permits from relevant authorities and/or departments in accordance with the planned implementation schedule stated in the EIA Report;
v. During the preparation of bidding documents, clearly include environmental responsibilities as explained in the EIA Report and EMP as "Environmental Contract Specifications (ECS)";
vi. Ensure that designs and construction methods provide for, as per the EMP, environment-friendly building materials, reuse, resource saving and climate adaptation elements like natural ventilation, solar power installations and rain water harvesting; piling methods and track design which minimize noise and vibration;
vii. Ensure the primary baseline data of environmental elements are in place prior to mobilization;
viii. Assist CMRL in reviewing the Contractor's Environmental Program (CEP) to be prepared by the contractor in accordance with EIA, EMP, ECC (Environmental Compliance Certificate) and ECS, relevant plans, conditions set out in relevant permits and clearances and Funding Agencies' Environmental Policy and to make recommendations to CMRL regarding any necessary amendments for its approval;
ix. Assist CMRL to implement the measures identified in the EMP;
x. Monitor the effectiveness of EMP and negative impacts on environment caused by the construction works and provide technical advice, including a feasible solution, so that CMRL can carry out improvement when necessary;
xi. Monitor compliance with the requirements under EMP and Funding Agencies' Environmental Policy. Submit the Environmental Monitoring Report to CMRL at every month after the commencement of the services until the completion of the Project. After the completion of the Project, the Report will be submitted **semiannually for two (2) years**. The Environmental Monitoring as per Funding Agencies E&S templates will be filled and attached to the Report;
xii. After verifying the Environmental Monitoring Report by CMRL, assist submitting the report to Funding Agencies as part of the Progress Status Report at every **three months** after the commencement of the services until the completion of the Project and **semiannually for two (2) years**

after the completion of the Project;

xiii. Assist CMRL in preparation of the answer to the request from Funding Agencies for environmental considerations if necessary;

xiv. Assist CMRL in facilitating stakeholder's participation (including focus group discussions for vulnerable PAPs) and providing feedbacks on their comments regarding EMP and EMoP;

xv. Supervise Contractor's activities to check compliance with CEP and prepare periodic monitoring reports;

xvi. Assist CMRL to establish a multi-layer Grievance Redress Mechanism (GRM) including Grievance Redress Committee (GRC) to resolve the Grievances of environment, health and safety matters in a timely manner;

xvii. Assist CMRL in the capacity building of CMRL staff on environmental management through on-the-job training on environmental assessment techniques, mitigation measure planning and implementation, supervision and monitoring, and reporting;

xviii. At the completion of project, (a) undertake final environmental monitoring and evaluation against the set indicators, (b) evaluate sustainability of environmental benefits associated with the project, taking into account both positive and negative impacts associated with the project, and (c) prepare an evaluation report for the project;

Annexure 6
Terms of Reference for External Monitoring Agency/Expert

Background

1. **Project Description.** The Chennai Metro Corridor 5 from CMBT to Sholinganallur 30.125km is all elevated with 29 stations.

2. **Project Category.** The Project is assigned as category A for Environment and Involuntary Resettlement as the project is likely to have significant adverse environment and social (E&S) impacts. Chennai Metro Rail Limited (CMRL) will retain external monitor to conduct the third party monitoring and verify the monitoring information submitted by General Consultant (GC).

Objective(s) of the Assignment

3. To conduct third party monitoring of implementation of the E&S requirements under the project;

4. To ensure that the Project will be implemented in conformity with the policies of Government of India (GoI), Government of Tamil Nadu (GoTN), as well as the lenders' E&S policies; and

5. To identify any environment and social related implementation issues and necessary corrective actions and reflect these in a time-bound corrective action plan for CMRL to implement.

6. Capturing social, environmental and economic benefits and particular potential benefits to the poor and vulnerable groups in the corridor;

7. Involving users and stakeholders in the monitoring process; and

8. Strengthening the capacity of the CMRL to manage and replicate third-party monitoring with rail users and stakeholders

Scope of Services, Tasks and Expected Deliverables

9. **Scope of Services.** Monitor the implementation of the Environmental Management Plan (EMP), Resettlement Action Plan (RAP), Gender Action Plan (GAP), Vulnerable Communities Plan (VCP) / Indigenous Peoples Development Plan (IPDP) as applicable and monitoring activities by the respective contractors and supervision consultants. Provide technical guidance and feedback to the respective contractors and supervision consultants. Monitor operational stage and residual impacts during project implementation.

10. **The Tasks** include but not limited to the following,

    1) Review the Social Impact Assessment with a focus on (RAP), and the Environmental Impact Assessment (EIA) with a focus on EMP;

    2) Review the Environmental, Health and Safety clauses included in the civil works contract agreement;

    3) Review the internal E&S monitoring reports;

4) Undertake independent field inspections to verify the implementation of RAP GAP, VCP / IPDP and consult community and affected people;

5) Review the Grievances register logs at project sites;

6) Visit the project sites, oversee quantitative environmental monitoring activities of CMRL to confirm appropriate methodologies being used and results correctly interpreted, and consult potentially affected people about the environmental nuisances;

7) Randomly interview the labors about health and safety compliance;

8) Assess EMP implementation performance, qualitatively or by conducting additional quantitative environmental monitoring as required;

9) Discuss findings of assessment with CMRL and provide recommendations to resolve any issues or problems on implementing EMP RAP, GAP and VCP / IPDP;;

10) Prepare the external E&S monitoring reports, which should confirm the project's compliance with the EMP, RAP GAP, VCP / IPDP, and reflect in the time-bound corrective action plan for any non-compliances;

Deliverables. The following are the key outputs expected from the consultants:

11. External SMP monitoring reports:
    a. Once upon payment of compensation and entitlements
    b. Implementation of livelihood restoration and its efficacy: semi annually during construction stage
    c. Implementation of gender action plan and its efficacy: annually during first 2 years of operation and maintenance

12. External EMP monitoring reports:
    d. Implementation of EMP, EMoP, Grievance Redressal and their efficacy: semi-annual during construction stage
    e. Implementation of EMP, EMoP, Grievance Redressal and their efficacy: annually during operation & maintenance during first 2 years of operation and maintenance.

Team Composition & Qualification Requirements

13. One environmental expert and one social expert would be required with E&S related disciplines and with at least 10 years of work experience in E&S management of linear projects, preferably in transport sector.
14. Total estimated man-days for both experts during construction stage: (25 person x day / report) x (2 reports / year) x 4 years = 200 person x day.
15. Total estimated man-days during O&M stage: (20-person x day / report) x (1 report / year) x 2 years = 40-person x day.

Updated Environmental Impact Assessment

April 2024

Revision 01

India: Chennai Metro Rail Investment Project

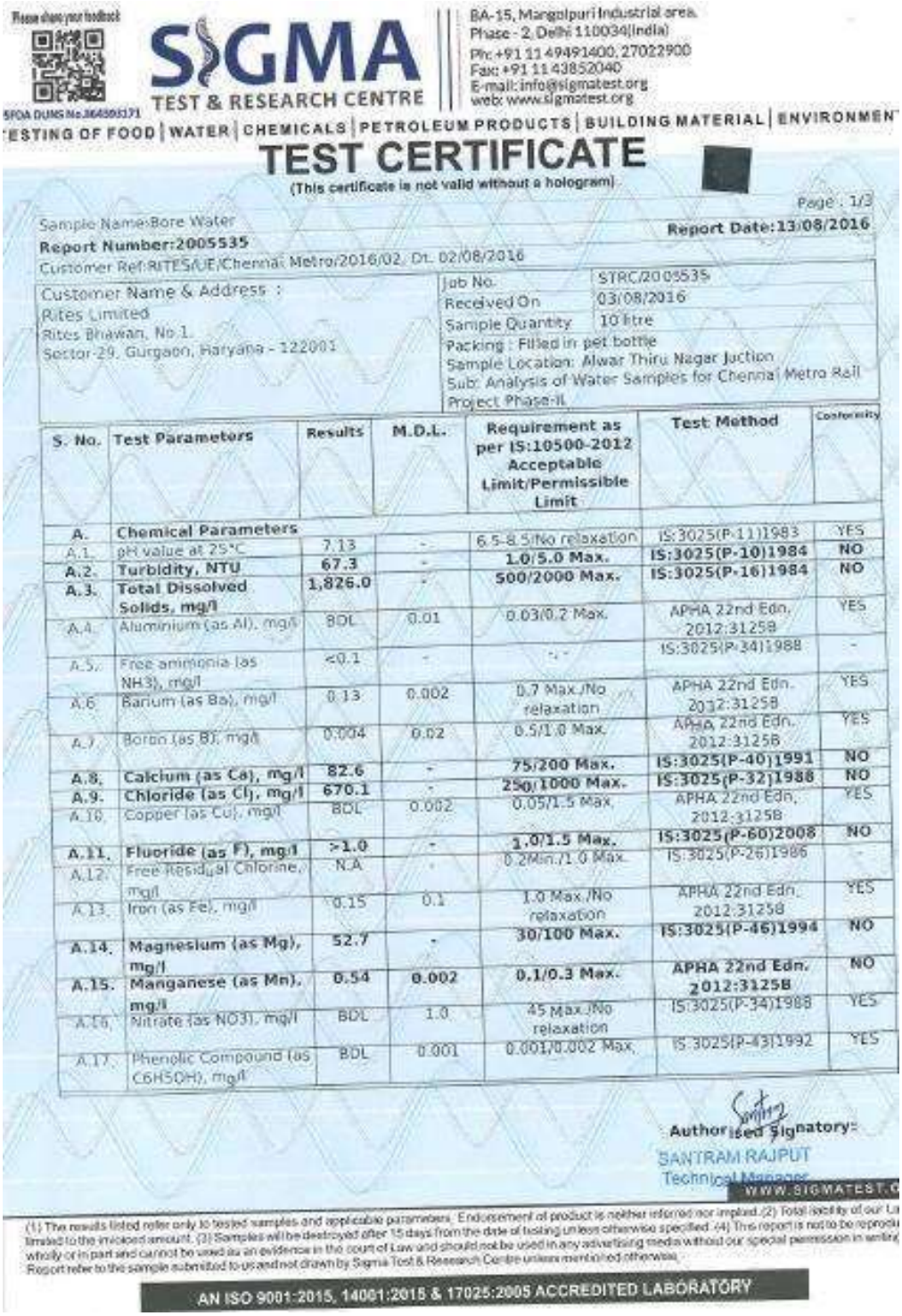
Balance Corridor 5

Annexure 7

Prepared by the Chennai Metro Rail Limited (CMRL) for the Project Lenders.

Annexure 7. Laboratory Data of the Water, Air, Noise and Soil

7-1. Water



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Page : 1/3

Sample Name:Bore Water

Report Date:13/08/2016

Report Number:2005535

Customer Ref:RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

Customer Name & Address : Rites Limited, Rites Bhawan, No.1, Sector-29, Gurgaon, Haryana - 122001	Job No. STRC/2005535 Received On 03/08/2016 Sample Quantity 10 litre Packing : Filled in pet bottle Sample Location: Alwar Thiru Nagar Juction Sub: Analysis of Water Samples for Chennai Metro Rail Project Phase-II

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.	**Chemical Parameters**					
A.1.	pH value at 25°C	7.13	-	6.5-8.5/No relaxation	IS:3025(P-11)1983	YES
A.2.	**Turbidity, NTU**	**67.3**	-	**1.0/5.0 Max.**	**IS:3025(P-10)1984**	**NO**
A.3.	**Total Dissolved Solids, mg/l**	**1,826.0**	-	**500/2000 Max.**	**IS:3025(P-16)1984**	**NO**
A.4.	Aluminium (as Al), mg/l	BDL	0.01	0.03/0.2 Max.	APHA 22nd Edn, 2012:3125B	YES
A.5.	Free ammonia (as NH3), mg/l	<0.1	-	-,-	IS:3025(P-34)1988	-
A.6	Barium (as Ba), mg/l	0.13	0.002	0.7 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.7	Boron (as B), mg/l	0.004	0.02	0.5/1.0 Max.	APHA 22nd Edn. 2012:3125B	YES
A.8.	**Calcium (as Ca), mg/l**	**82.6**	-	**75/200 Max.**	**IS:3025(P-40)1991**	**NO**
A.9.	**Chloride (as Cl), mg/l**	**670.1**	-	**250/1000 Max.**	**IS:3025(P-32)1988**	**NO**
A.10.	Copper (as Cu), mg/l	BDL	0.002	0.05/1.5 Max.	APHA 22nd Edn, 2012:3125B	YES
A.11.	**Fluoride (as F), mg/l**	**>1.0**	-	**1.0/1.5 Max.**	**IS:3025(P-60)2008**	**NO**
A.12.	Free Residual Chlorine, mg/l	N.A	-	0.2Min./1.0 Max.	IS:3025(P-26)1986	-
A.13.	Iron (as Fe), mg/l	0.15	0.1	1.0 Max./No relaxation	APHA 22nd Edn, 2012:3125B	YES
A.14.	**Magnesium (as Mg), mg/l**	**52.7**	-	**30/100 Max.**	**IS:3025(P-46)1994**	**NO**
A.15.	**Manganese (as Mn), mg/l**	**0.54**	**0.002**	**0.1/0.3 Max.**	**APHA 22nd Edn. 2012:3125B**	**NO**
A.16.	Nitrate (as NO3), mg/l	BDL	1.0	45 Max./No relaxation	IS:3025(P-34)1988	YES
A.17.	Phenolic Compound (as C6H5OH), mg/l	BDL	0.001	0.001/0.002 Max.	IS:3025(P-43)1992	YES

Authorised Signatory:
SANTRAM RAJPUT
Technical Manager

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(1) The results listed refer only to tested samples and applicable parameters. Endorsement of product is neither inferred nor implied. (2) Total liability of our Li limited to the invoiced amount. (3) Samples will be destroyed after 15 days from the date of testing unless otherwise specified. (4) This report is not to be reproduc wholly or in part and cannot be used as an evidence in the court of Law and should not be used in any advertising media without our special permission in writing Report refer to the sample submitted to us and not drawn by Sigma Test & Research Centre unless mentioned otherwise.

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Sample Name:Bore Water

Report Number:2005535

Report Date:13/08/2016

Customer Ref:RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.18.	Selenium (as Se), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.19.	Silver (as Ag), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.20.	Sulphate (as SO4), mg/l	46.1	5.0	200/400 Max.	IS:3025(P-24)1986	YES
A.21.	Sulphide (as S), mg/l	BDL	0.05	0.05 max./No relaxation	IS:3025(P-29)1986	YES
A.22.	**Total alkalinity (as CaCO3), mg/l**	**460.6**	**-**	**200/600 Max.**	**IS:3025(P-23)1986**	**NO**
A.23.	**Total Hardness (as CaCo3), mg/l**	**422.3**	**-**	**200/600 Max.**	**IS:3025(P-21)2009**	**NO**
A.24.	Zinc (as Zn), mg/l	BDL	0.02	5.0/15.0 Max.	APHA 22nd Edn. 2012:3125B	YES
A.25.	Cadmium (as Cd), mg/l	BDL	0.002	0.003 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.26.	Cyanide (as CN), mg/l	BDL	0.02	0.05 Max./No relaxation	IS:3025(P-27)1986	YES
A.27.	Lead (as Pb), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.28.	**Mercury (as Hg), mg/l**	**0.006**	**0.0002**	**0.001 Max./No relaxation**	**APHA 22nd Edn. 2012:3125B**	**NO**
A.29.	Nickel (as Ni), mg/l	BDL	0.002	0.02 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.30.	Total Arsenic (as As), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.31.	Total Chromium (as Cr), mg/l	BDL	0.002	0.05 max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.32.	Total suspended solids, mg/l	21.0	-	-, -	IS:3025(P-17)1984	-
A.33.	Vanadium (as V), mg/l	BDL	0.002	-, -	APHA 22nd Edn. 2012:3125B	-
A.34.	Ammonical Nitrogen (as N)	<0.1	-	0.5 max./No relaxation	IS:3025(P-34)1988	YES
A.35.	Total kjeldahl nitrogen (as N)	0.2	-	-, -	IS:3025(P-34)1988	-
A.36.	Chromium (as hexavalent chromium), mg/l	BDL	0.1	-, -	IS:3025(P-52)2003	-

Authorised Signatory:
SANTRAM RAJPUT
Technical Manager

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Sample Name:Bore Water

Report Number:2005535 **Report Date:13/08/2016**

Customer Ref:RITES/UE/Chennai Metro/2016/07, Dt. 02/08/2016

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.37.	Oil & Grease, mg/l	<1.0	-	-,-	IS:3025(P-39)1991	-
A.38.	Dissolved oxygen, mg/l	4.6	-	-,-	IS:3025(P-38)1989	-
A.39.	Chemical oxygen demand, mg/l	64.0	-	-,-	IS:3025(P-58)2006	-
A.40.	Biochemical oxygen demand, mg/l	23.0	-		IS:3025(P-44)1993	-
A.41.	Total phosphate, mg/l	0.9	0.1	-,-	IS:3025(P-31)1988	-
A.42.	Dissolved phosphate (as P), mg/l	0.9	0.1	-,-	IS:3025(P-31)1988	-
A.43.	Sodium (as Na), mg/l	575.0	2.0	-,-	IS:3025(P-45)1993	-
A.44.	Potassium (as K), mg/l	15.0	2.0	-,-	IS:3025(P-45)1993	-
A.45.	Nitrate nitrogen, mg/l	BDL	0.2	-,-	IS:3025(P-34)1988	-
A.46.	Total nitrogen, mg/l	0.2	-	-,-	IS:3025(P-34)1988	-
A.47.	Organic phosphorus, mg/l	BDL	0.00001	-,-	USEPA 8141 A	-
B.	**Microbiological Examination**					
B.1.	Coliform count, MPN/100ml	<1	-	Shall not be detectable in any 100ml sample	IS:1622-1981	Yes
B.2.	FaeCal coliform, MPN/100ml	<1	-	-,-	IS:1622-1981	-
B.3.	Total coliform organism, cfu/100ml	<1	-	-,-	IS:1622-1981	-

Remarks : Protocol:- IS: 10500-2012 for Acceptable limit/Permissible limit.
Note:- According to IS:10500-2012 ,it is recommended that the acceptable limit is to be implemented. Values greater than the acceptable limits render the water is not suitable, but still may be tolerated in the absence of an alternate source but upto permissible limits.
BDL = Below detection limit, MDL = Method detection limit.

***** End of Report *****

Authorised Signatory:
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Sample : Drinking Water	Report Number:2009361
Sample Description :Said to be "Ground Water (Bore-Well)"	Report Issue Date: 28/05/2018
Customer Ref:RITES/UE/CHENNAI METRO-C4/2018, 16/05/2018	Page : 1/4

Customer Name & Address :		
Rites Limited	Job code	STRC/2009361
Rites Bhawan, No.1,	Sample received on	16/05/2018
Sector-29, Gurgaon, Haryana - 122001	Date of Testing	16/05/2018-28/05/2018
	Sample Quantity	10 litre
	Sample condition: Filled in PET bottle	
Agreement Number: -	Sample Location: Polur Juction	

Name of Work:Chennai Metro, C4 Extension Project.

S. No.	Test Parameters	Test Results	M.D.L.	Requirements As Per IS:10500:2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.	**Chemical Parameters**					
A.1.	pH value at 25°C	6.62	-	6.5-8.5/No relaxation	IS:3025(P-11)1983	Yes
A.2.	Turbidity, NTU	<0.1	-	1.0/5.0 Max.	IS:3025(P-10)1984	Yes
A.3.	**Total Dissolved Solids, mg/l**	**675.0**	**-**	**500/2000 Max.**	**IS:3025(P-16)1984**	**No**
A.4.	Aluminium (as Al), mg/l	BDL	0.01	0.03/0.2 Max.	APHA 23rd Edn. 2017:3125B	Yes
A.5.	Free ammonia* (as NH3), mg/l	<0.1	-	--	IS:3025(P-34)1988	-
A.6.	Barium (as Ba), mg/l	BDL	0.002	0.7 Max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes
A.7.	Boron (as B), mg/l	BDL	0.02	0.5/1.0 Max.	APHA 23rd Edn. 2017:3125B	Yes
A.8.	**Calcium (as Ca), mg/l**	**76.2**	**-**	**75/200 Max.**	**IS:3025(P-40)1991**	**No**
A.9.	Chloride (as Cl), mg/l	123.2	-	250/1000 Max.	IS:3025(P-32)1988	Yes
A.10.	Copper (as Cu), mg/l	BDL	0.002	0.05/1.5 Max.	APHA 23rd Edn. 2017:3125B	Yes
A.11.	**Fluoride (as F), mg/l**	**>1.0**	**-**	**1.0/1.5 Max.**	**IS:3025(P-60)2008**	**No**
A.12.	Free Residual Chlorine, mg/l	N.A.	-	0.2Min./1.0 Max.	IS:3025(P-26)1986	-
A.13.	Iron (as Fe), mg/l	BDL	0.1	1.0 Max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes
A.14.	Magnesium (as Mg), mg/l	19.5	-	30/100 Max.	IS:3025(P-46)1994	Yes

Santram Rajput
Technical manager

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Sample : Drinking Water — **Report Number:2009361**

Sample Description : Said to be "Ground Water (Bore-Well)" — Report issue Date: 26/05/2018

Customer Ref:RITES/UE/CHENNAI METRO-C4/2018, 16/05/2018 — Page : 2/4

S. No.	Test Parameters	Test Results	M.D.L.	Requirements As Per IS:10500:2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.15.	Manganese (as Mn), mg/l	BDL	0.002	0.1/0.3 Max.	APHA 23rd Edn. 2017:3125B	Yes
A.16.	Nitrate (as NO_3), mg/l	21.6	1.0	45 Max./No relaxation	IS:3025(P-34)1988	Yes
A.17.	Phenolic Compound (as C_6H_5OH), mg/l	BDL	0.001	0.001/0.002 Max.	IS:3025(P-43)1992	Yes
A.18.	Selenium (as Se), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes
A.19.	Silver (as Ag), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes
A.20.	Sulphate (as SO_4), mg/l	50.8	5.0	200/400 Max.	IS:3025(P-24)1986	Yes
A.21.	Sulphide* (as S), mg/l	BDL	0.05	0.05 max./No relaxation	IS:3025(P-29)1986	Yes
A.22.	**Total alkalinity (as $CaCO_3$), mg/l**	**310.0**	-	**200/600 Max.**	**IS:3025(P-23)1986**	**No**
A.23.	**Total Hardness (as $CaCO_3$), mg/l**	**270.0**	-	**200/600 Max.**	**IS:3025(P-21)2009**	**No**
A.24.	Zinc (as Zn), mg/l	BDL	0.02	5.0/15.0 Max.	APHA 23rd Edn. 2017:3125B	Yes
A.25.	Cadmium (as Cd), mg/l	BDL	0.002	0.003 Max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes
A.26.	Cyanide (as CN), mg/l	BDL	0.02	0.05 Max./No relaxation	IS:3025(P-27)1986	Yes
A.27.	Lead (as Pb), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes
A.28.	Mercury (as Hg), mg/l	0.00093	0.0002	0.001 Max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes
A.29.	Nickel (as Ni), mg/l	BDL	0.002	0.02 Max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes
A.30.	Total Arsenic (as As), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes

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Sample : Drinking Water	**Report Number:2009361**
Sample Description :Said to be "Ground Water (Bore-Well)"	Report Issue Date: 28/05/2018
Customer Ref: RITES/UE/CHENNAI METRO-C4/2018, 16/05/2018	Page : 3/4

S. No.	Test Parameters	Test Results	M.D.L.	Requirements As Per IS:10500:2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.31.	Total Chromium (as Cr), mg/l	BDL	0.002	0.05 max./No relaxation	APHA 23rd Edn. 2017:3125B	Yes
A.32.	Total suspended solids, mg/l	7.0	-	--	IS:3025(P-17)1984	-
A.33.	Vanadium* (as V), mg/l	BDL	0.002	--	APHA 23rd Edn. 2017:3125B	-
A.34.	Ammonical Nitrogen* (as N), mg/l	<0.1	-	0.5 max./No relaxation	IS:3025(P-34)1988	Yes
A.35.	Total kjeldahl nitrogen* (as N), mg	27.8	0.03	--	IS:3025(P-34)1988	-
A.36.	Chromium* (as hexavalent chromium), mg/l	BDL	0.1	--	IS:3025(P-52)2003	-
A.37.	Oil & Grease, mg/l	<5.0	-	--	IS:3025(P-39)1991	-
A.38.	Dissolved oxygen, mg/l	6.6	-	--	IS:3025(P-38)1989	-
A.39.	Chemical oxygen demand, mg/l	16.0	-	--	IS:3025(P-58)2006	-
A.40.	Biochemical oxygen demand, mg/l	6.0	-	--	IS:3025(P-44)1993	-
A.41.	Total phosphate*, mg/l	1.3	0.1	--	IS:3025(P-31)1988	-
A.42.	Dissolved phosphate* (as P), mg/l	1.3	0.1	--	IS:3025(P-31)1988	-
A.43.	Sodium (as Na), mg/l	110.0	2.0	--	IS:3025(P-45)1993	-
A.44.	Potassium (as K), mg/l	24.3	2.0	--	IS:3025(P-45)1993	-
A.45.	Nitrate nitrogen*, mg/l	4.9	0.2	--	IS:3025(P-34)1988	-
A.46.	Total nitrogen*, mg/l	27.8	0.03	--	IS:3025(P-34)1988	-
A.47.	Organic phosphorus*, mg/l	BDL	0.00001	--	USEPA 8141 A	-

Ashok Sharma
Technical Manager

Santram Rajput
Technical manager

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Sample : Drinking Water — **Report Number:2009361**

Sample Description :Said to be "Ground Water (Bore-Well)" — Report Issue Date: 28/05/2018

Customer Ref:RITES/UE/CHENNAI METRO-C4/2018, 16/05/2018 — Page : 4/4

S. No.	Test Parameters	Test Results	M.D.L.	Requirements As Per IS:10500:2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
B.	**Microbiological Examination**					
B.1.	**Coliform count, MPN/100ml**	**40**	**-**	**Shall not be detectable in any 100ml. sample**	**IS:1622-1981**	**No**
B.2.	Faecal coliform*, MPN/100ml	10	-	--	IS:1622-1981	-
B.3.	Total coliform organism*, cfu/100ml	80	-	--	IS:1622-1981	-

Note: **According to IS:10500-2012, it is recommended that the acceptable limit is to be implemented. Values greater than the acceptable limits render the water is not suitable, but still may be tolerated in the absence of an alternate source but upto permissible limits.**

- **BDL = Below detection limit, MDL = Method detection limit. N.A=Not Applicable**
- **The parameter marked with an * are not accredited by NABL.**

***** **End of Report** *****

Ashit Tyagi

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SIGMA TEST & RESEARCH CENTRE

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Sample Name:Bore Water

Report Number:2005534 **Report Date:13/08/2016**

Customer Ref:RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

Customer Name & Address :
Rites Limited
Rites Bhawan, No.1,
Sector-29, Gurgaon, Haryana - 122001

Job No.	STRC/2005534
Received On	03/08/2016
Sample Quantity	10 litre

Packing : Filled in pet bottle
Sample Location: MIOT Hospital
Sub: Analysis of Water Samples for Chennai Metro Rail Project Phase-II.

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.	**Chemical Parameters**					
A.1.	pH value at 25°C	7.82	-	6.5-8.5/No relaxation	IS:3025(P-11)1983	YES
A.2.	Turbidity, NTU	<0.1	-	1.0/5.0 Max.	IS:3025(P-10)1984	YES
A.3.	**Total Dissolved Solids, mg/l**	**1,528.0**	**-**	**500/2000 Max.**	**IS:3025(P-16)1984**	**NO**
A.4.	Aluminium (as Al), mg/l	BDL	0.01	0.03/0.2 Max.	APHA 22nd Edn. 2012:3125B	YES
A.5.	Free ammonia (as NH3), mg/l	<0.1	-	-, -	IS:3025(P-34)1988	-
A.6.	Barium (as Ba), mg/l	0.146	0.002	0.7 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.7.	Boron (as Bl), mg/l	BDL	0.02	0.5/1.0 Max.	APHA 22nd Edn. 2012:3125B	YES
A.8.	**Calcium (as Ca), mg/l**	**210.5**	**-**	**75/200 Max.**	**IS:3025(P-40)1991**	**NO**
A.9.	**Chloride (as Cl), mg/l**	**310.4**	**-**	**250/1000 Max.**	**IS:3025(P-32)1988**	**NO**
A.10	Copper (as Cu), mg/l	BDL	0.002	0.05/1.5 Max.	APHA 22nd Edn. 2012:3125B	YES
A.11.	**Fluoride (as F), mg/l**	**>1.0**	**-**	**1.0/1.5 Max.**	**IS:3025(P-60)2008**	**NO**
A.12.	Free Residual Chlorine, mg/l	N.A	-	0.2Min./1.0 Max.	IS:3025(P-26)1986	-
A.13.	Iron (as Fe), mg/l	BDL	0.1	1.0 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.14.	**Magnesium (as Mg), mg/l**	**32.6**	**-**	**30/100 Max.**	**IS:3025(P-46)1994**	**NO**
A.15	Manganese (as Mn), mg/l	0.02	0.002	0.1/0.3 Max.	APHA 22nd Edn. 2012:3125B	YES
A.16.	Nitrate (as NO3), mg/l	9.5	1.0	45 Max./No relaxation	IS:3025(P-34)1988	YES
A.17	Phenolic Compound (as C6H5OH), mg/l	BDL	0.001	0.001/0.002 Max.	IS:3025(P-43)1992	YES

Authorised Signatory:
SANTRAM RAJPUT
Technical Manager

Please share your feedback

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Sample Name:Bore Water

Report Number:2005534

Report Date:13/08/2016

Customer Ref:RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.18.	Selenium (as Se), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.19.	Silver (as Ag), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.20.	Sulphate (as SO4), mg/l	158.2	5.0	200/400 Max.	IS:3025(P-24)1986	YES
A.21.	Sulphide (as S), mg/l	BDL	0.05	0.05 max./No relaxation	IS:3025(P-29)1986	YES
A.22.	**Total alkalinity (as CaCO3), mg/l**	**411.6**	**-**	**200/600 Max.**	**IS:3025(P-23)1986**	**NO**
A.23.	**Total Hardness (as CaCo3), mg/l**	**659.2**	**-**	**200/600 Max.**	**IS:3025(P-21)2009**	**NO**
A.24.	Zinc (as Zn), mg/l	0.032	0.02	5.0/15.0 Max.	APHA 22nd Edn. 2012:3125B	YES
A.25.	Cadmium (as Cd), mg/l	BDL	0.002	0.003 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.26.	Cyanide (as CN), mg/l	BDL	0.02	0.05 Max./No relaxation	IS:3025(P-27)1986	YES
A.27.	Lead (as Pb), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.28.	**Mercury (as Hg), mg/l**	**0.006**	**0.0002**	**0.001 Max./No relaxation**	**APHA 22nd Edn. 2012:3125B**	**NO**
A.29.	Nickel (as Ni), mg/l	BDL	0.002	0.02 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.30.	Total Arsenic (as As), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.31.	Total Chromium (as Cr), mg/l	BDL	0.002	0.05 max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.32.	Total suspended solids, mg/l	5.0	-	-,-	IS:3025(P-17)1984	-
A.33.	Vanadium (as V), mg/l	BDL	0.002	-,-	APHA 22nd Edn. 2012:3125B	-
A.34.	Ammonical Nitrogen (as N)	<0.1	-	0.5 max./No relaxation	IS:3025(P-34)1988	YES
A.35.	Total kjeldahl nitrogen (as N)	11.6	-	-,-	IS:3025(P-34)1988	-
A.36.	Chromium (as hexavalent chromium), mg/l	BDL	0.1	-,-	IS:3025(P-52)2003	-

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TEST CERTIFICATE

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Sample Name:Bore Water

Report Number:2005534 **Report Date:13/08/2016**

Customer Ref:RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.37.	Oil & Grease, mg/l	<1.0	-	-, -	IS:3025(P-39)1991	-
A.38.	Dissolved oxygen, mg/l	5.1	-	-, -	IS:3025(P-38)1989	-
A.39.	Chemical oxygen demand, mg/l	36.0	-	-, -	IS:3025(P-58)2006	-
A.40.	Biochemical oxygen demand, mg/l	11.0	-		IS:3025(P-44)1993	-
A.41.	Total phosphate, mg/l	0.3	0.1	-, -	IS:3025(P-31)1988	-
A.42.	Dissolved phosphate (as P), mg/l	0.3	0.1	-, -	IS:3025(P-31)1988	-
A.43.	Sodium (as Na), mg/l	352.5	2.0	-, -	IS:3025(P-45)1993	-
A.44.	Potassium (as K), mg/l	3.4	2.0	-, -	IS:3025(P-45)1993	-
A.45.	Nitrate nitrogen, mg/l	2.1	0.2	-, -	IS:3025(P-34)1988	-
A.46.	Total nitrogen, mg/l	11.8	-	-, -	IS:3025(P-34)1988	-
A.47.	Organic phosphorus, mg/l	BDL	0.00001	-, -	USEPA 8141 A	-
B.	**Microbiological Examination**					
B.1.	**Coliform count, MPN/100ml**	**35**	**-**	**Shall not be detectable in any 100ml. sample**	**IS:1622-1981**	**No**
B.2.	Faecal coliform, MPN/100ml	<1	-	-, -	IS:1622-1981	-
B.3.	Total coliform organism, cfu/100ml	12	-	-, -	IS:1622-1981	-

Remarks :Protocol-: IS: 10500-2012 for Acceptable limit/Permissible limit.
Note:- According to IS:10500-2012 ,it is recommended that the acceptable limit is to be implemented. Values greater than the acceptable limits render the water is not suitable, but still may be tolerated in the absence of an alternate source but upto permissible limits.
BDL = Below detection limit, MDL = Method detection limit.

***** End of Report *****

Authorised Signatory:
SANTRAM RAJPUT
Technical Manager

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015 & ISO 14001:2015

Report No	: PCE/TR-W-4420	**Report Date**	: 16.12.2019
ULR No.	: ULR-TC244619000343IP		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method	: -		
Sampled by	: Customer		
Sample Collected Date	: 11.12.2019	**Sample Reference No**	: PCES/W-4033-12-19
Sample Description	: **Water**	**Sample Received On**	: 12.12.2019
Qty of Sample Received	: 2.5 Litre	**Test Commenced On**	: 12.12.2019
Sample Condition	: Fit for Analysis	**Test Completed On**	: 16.12.2019
Sampling Location	: **Borewell Water - Near Adambakkam MRTS**		

S.No	Parameters	Units	Test Method	Results
1	pH @ 25°C	-	IS 3025 (Part 11) 1983 (RA 2017)	6.97
2	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.1)
3	Total Dissolved Solids (TDS) @ 180°C	mg/L	IS 3025 (Part 16) 1984 (RA 2014)	823
4	Dissolved Oxygen	mg/L	IS 3025 (Part 38) 1989 (RA 2019)	7.1
5	Aluminium (as Al)	mg/L	IS 3025 (Part 55) 2003 (RA 2014)	BDL(DL:0.01)
6	Ammonia (as total Ammonia - N)	mg/L	IS 3025 (Part 34) 1988 (RA 2003)	BDL(DL:1.0)
7	Total Suspended Solids @ 105°C	mg/L	IS 3025 (Part 17) 1984 (RA 2017)	4.6
8	Barium (as Ba)	mg/L	IS 13428:2014 (Annex K)	BDL(DL:0.01)
9	Boron (as B)	mg/L	IS 3025 (Part 57) 2005 (RA 2017)	0.08
10	Calcium (as Ca)	mg/L	IS 3025 (Part 40) 1991 (RA 2014)	109
11	Chloride (as Cl)	mg/L	IS 3025 (Part 32) 1988 (RA 2014)	147
12	Copper (as Cu)	mg/L	IS 3025 (Part 42) 1992 (RA 2014)	BDL(DL:0.01)
13	Fluoride (as F)	mg/L	APHA 23rd Edition 4500 F-D	0.46
14	Iron (as Fe)	mg/L	IS 3025 (Part 53) 2003 (RA 2014)	0.38
15	Magnesium (Mg)	mg/L	IS 3025 (Part 46) 1994 (RA 2014)	32
16	Manganese (as Mn)	mg/L	IS 3025 (Part 59) 2006 (RA 2017)	BDL(DL:0.01)
17	Nitrate Nitrogen	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	32
18	Total Nitrogen	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	47
19	Oil & Grease	mg/L	IS 3025 (Part 39) 1991 (RA 2014)	BDL(DL:5.0)
20	Hexavalent Chromium (as Cr^{+6})	mg/L	IS 3025 (Part 52) 2003 (RA 2014)	BDL(DL:0.01)
21	Biochemical Oxygen Demand (BOD)(3 days at 27°C)	mg/L	IS 3025 (Part 44) 1993 (RA 2014)	BDL(DL:2.0)
22	Chemical Oxygen Demand (COD)	mg/L	IS 3025 (Part 58) 2006 (RA 2017)	BDL(DL:4.0)
23	Organic Phosphorous	mg/L	APHA 23rd Edition 4500 P	0.21

Verified by

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015 & ISO 14001:2015

Report No		: PCEI/TR/18-4120	Report Date	: 16.12.2018
S.No	Parameters	Units	Test Method	Results
24	Vanadium (as	mg/L	IS 3025 (Part 2)	0.21
25	Nitrate (as NO_3)	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	0.14
26	Phenolic Compounds (C_6H_5OH)	mg/L	IS 3025 (Part 43) 1992(RA 2008)	BDL(DL:0.001)
27	Selenium (as Se)	mg/L	IS 3025 (Part 56) 2003 (RA 2014)	BDL(DL:0.002)
28	Silver (as Ag)	mg/L	IS 13428:2005 (Annex J)	BDL(DL:0.001)
29	Sulphates (as SO_4)	mg/L	IS 3025 (Part 24) 1986 (RA 2014)	2.7
30	Sulphide (as H_2S)	mg/L	IS 3025 (Part 29) 1986 (RA 2022)	BDL(DL:1.0)
31	Ammonical Nitrogen (as N)	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
32	Total Kjeldahl Nitrogen (as N)	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
33	Zinc (as Zn)	mg/L	IS 3025 (Part 49) 1994 (RA 2014)	3.9
34	Cadmium (as Cd)	mg/L	IS 3025 (Part 41) 1992 (RA 2014)	BDL(DL:0.01)
35	Cyanide (as CN)	mg/L	IS 3025 (Part 27) 1986 (RA 2014)	BDL(DL:0.01)
36	Lead (as Pb)	mg/L	IS 3025 (Part 47) 1994 (RA 2014)	BDL(DL:0.01)
37	Mercury (as Hg)	mg/L	IS 3025 (Part 48) 1994 (RA 2014)	BDL(DL:0.0001)
38	Nickel (as Ni)	mg/L	IS 3025 (Part 54) (RA 2003)	BDL(DL:0.01)
39	Total Phosphate	mg/L	IS 3025 (Part 31) 1988 (RA 2019)	0.62
40	Dissolved Phosphate (as PO_4)	mg/L	IS 3025 (Part 31) 1988 (RA 2019)	0.38
41	Arsenic (as As)	mg/L	IS 3025 (Part 37) 1988 (RA 2014)	BDL (DL:0.5)
42	Chromium (as Cr)	mg/L	IS 3025 (Part 52) 2003 (RA 2014)	BDL (DL:0.5)
43	Total Hardness (as $CaCO_3$)	mg/L	IS 3025 (Part 21) 2009 (RA 2014)	402
44	Sodium (as Na)	mg/L	IS 3025 (Part 45) 1993 (RA 2014)	86
45	Potassium (as K)	mg/L	IS 3025 (Part 45) 1993 (RA 2014)	11.6
46	Total Alkalinity (as $CaCO_3$)	mg/L	IS 3025 (Part 23) 1986 (RA 2014)	268
Micro-Biological Parameters				
47	Escherichia coli (MPN)	MPN/100ml	IS 1622:1981 (RA 2009)	6
48	Total coliform (MPN)	MPN/100ml	IS 1622:1981 (RA 2009)	23
49	Fecal Coliform	MPN/100ml	IS 1622:1981 (RA 2009)	11

Note: BDL - Below Detection Limit; DL - Detection Limit

All the above test parameters are carried with the samples "as received condition"

..... End of Report .....

Verified by

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015 & ISO 14001:2015

Report No	: PCEI/TR-W-442I	**Report Date**	: 16.12.2019
ULR No.	: ULR-TC744619000343AP		
Issued to	: M/s Chennai Metro Rail Limited CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method	: -		
Sampled by	: Customer		
Sample Collected Date	: 11.12.2019	**Sample Reference No**	: PCEI/W-N334-12-19
Sample Description	: Water	**Sample Received On**	: 12.12.2019
Qty of Sample Received	: 2.5 Litre	**Test Commenced On**	: 12.12.2019
Sample Condition	: Fit for Analysis	**Test Completed On**	: 16.12.2019
Sampling Location	: Borewell Water - Madipakkam Koot Road Junction		

S.No	Parameters	Units	Test Method	Results
1	pH @ 25°C	-	IS 3025 (Part 11) 1983 (RA 2017)	7.21
2	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.1)
3	Total Dissolved Solids (TDS) @ 180°C	mg/L	IS 3025 (Part 16) 1984 (RA 2014)	225
4	Dissolved Oxygen	mg/L	IS 3025 (Part 38) 1989 (RA 2019)	7.1
5	Aluminium (as Al)	mg/L	IS 3025 (Part 55) 2003 (RA 2014)	BDL(DL:0.01)
6	Ammonia (as total Ammonia - N)	mg/L	IS 3025 (Part 34) 1988 (RA 2003)	BDL(DL:1.0)
7	Total Suspended Solids @ 105°C	mg/L	IS 3025 (Part 17) 1984 (RA 2017)	BDL(DL:2.0)
8	Barium (as Ba)	mg/L	IS 13428:2014 (Annex K)	BDL(DL:0.01)
9	Boron (as B)	mg/L	IS 3025 (Part 57) 2005 (RA 2017)	BDL(DL:0.01)
10	Calcium (as Ca)	mg/L	IS 3025 (Part 40) 1991 (RA 2014)	24.2
11	Chloride (as Cl)	mg/L	IS 3025 (Part 32) 1988 (RA 2014)	43.5
12	Copper (as Cu)	mg/L	IS 3025 (Part 42) 1992 (RA 2014)	BDL(DL:0.01)
13	Fluoride (as F)	mg/L	APHA 23rd Edition 4500 F-D	0.68
14	Iron (as Fe)	mg/L	IS 3025 (Part 53) 2003 (RA 2014)	0.11
15	Magnesium (Mg)	mg/L	IS 3025 (Part 46) 1994 (RA 2014)	10.3
16	Manganese (as Mn)	mg/L	IS 3025 (Part 59) 2006 (RA 2017)	0.03
17	Nitrate Nitrogen	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
18	Total Nitrogen	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
19	Oil & Grease	mg/L	IS 3025 (Part 39) 1991 (RA 2014)	BDL(DL:5.0)
20	Hexavalent Chromium (as Cr^{+6})	mg/L	IS 3025 (Part 52) 2003 (RA 2014)	BDL(DL:0.01)
21	Biochemical Oxygen Demand (BOD)(3 days at 27°C)	mg/L	IS 3025 (Part 44) 1993 (RA 2014)	BDL(DL:2.0)
22	Chemical Oxygen Demand (COD)	mg/L	IS 3025 (Part 58) 2006 (RA 2017)	BDL(DL:4.0)
23	Organic Phosphorous	mg/L	APHA 23rd Edition 4500 P	0.05

Verified by

Authorised Signatory
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Designation: Technical Manager

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TEST REPORT

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Report No		: PCEI/TR-W-1421	Report Date	: 16.12.2019
S.No	Parameters	Units	Test Method	Results
24	Vanadium (as	mg/L	IS 3025 (Part 2)	BDL(DL:0.01)
25	Nitrate (as NO_3)	mg/L	IS 3025 (Part 34) 1988 (RA 2019)	58
26	Phenolic Compounds (C_6H_5OH)	mg/L	IS 3025 (Part 43) 1992(RA 2009)	BDL(DL:0.001)
27	Selenium (as Se)	mg/L	IS 3025 (Part 56) 2003 (RA 2014)	BDL(DL:0.002)
28	Silver (as Ag)	mg/L	IS 13428:2005 (Annex J)	BDL(DL:0.001)
29	Sulphates (as SO_4)	mg/L	IS 3025 (Part 24) 1986 (RA 2014)	42.3
30	Sulphide (as H_2S)	mg/L	IS 3025 (Part 29) 1986 (RA 2003)	BDL(DL:1.0)
31	Ammonical Nitrogen (as N)	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
32	Total Kjeldahl Nitrogen (as N)	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
33	Zinc (as Zn)	mg/L	IS 3025 (Part 49) 1994 (RA 2014)	2.3
34	Cadmium (as Cd)	mg/L	IS 3025 (Part 41) 1992 (RA 2014)	BDL(DL:0.01)
35	Cyanide (as CN)	mg/L	IS 3025 (Part 27) 1986 (RA 2014)	BDL(DL:0.01)
36	Lead (as Pb)	mg/L	IS 3025 (Part 47) 1994 (RA 2014)	BDL(DL:0.01)
37	Mercury (as Hg)	mg/L	IS 3025 (Part 48) 1994 (RA 2014)	BDL(DL:0.0001)
38	Nickel (as Ni)	mg/L	IS 3025 (Part 54) (RA 2003)	BDL(DL:0.01)
39	Total Phosphate	mg/L	IS 3025 (Part 31) 1988 (RA 2019)	0.42
40	Dissolved Phosphate (as PO_4)	mg/L	IS 3025 (Part 31) 1988 (RA 2019)	0.11
41	Arsenic (as As)	mg/L	IS 3025 (Part 37) 1988 (RA 2014)	BDL (DL:0.5)
42	Chromium (as Cr)	mg/L	IS 3025 (Part 52) 2003 (RA 2014)	BDL (DL:0.5)
43	Total Hardness (as $CaCO_3$)	mg/L	IS 3025 (Part 21) 2009 (RA 2014)	103
44	Sodium (as Na)	mg/L	IS 3025 (Part 45) 1993 (RA 2014)	48
45	Potassium (as K)	mg/L	IS 3025 (Part 45) 1993 (RA 2014)	13.2
46	Total Alkalinity (as $CaCO_3$)	mg/L	IS 3025 (Part 23) 1986 (RA 2014)	92
Micro-Biological Parameters				
47	Escherichia coli (MPN)	MPN/100ml	IS 1622:1981 (RA 2009)	2
48	Total coliform (MPN)	MPN/100ml	IS 1622:1981 (RA 2009)	17
49	Fecal Coliform	MPN/100ml	IS 1622:1981 (RA 2009)	4

Note: BDL - Below Detection Limit; DL - Detection Limit
All the above test parameters are carried with the sample's "as received condition"

.... End of Report ....

Verified by

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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TEST REPORT

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Report No	: PCEI/TR-W-4122	**Report Date**	: 18.12.2019
ULR No.	: ULR-TC744819000034?5P		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method	: -		
Sampled by	: Customer		
Sample Collected Date	: 11.12.2019	**Sample Reference No**	: PCEI/W-K036-12-19
Sample Description	: **Water**	**Sample Received On**	: 12.12.2019
Qty of Sample Received	: 2.5 Litre	**Test Commenced On**	: 12.12.2019
Sample Condition	: Fit for Analysis	**Test Completed On**	: 16.12.2019
Sampling Location	: **Borewell Water - Vellakal Bus Stop**		

S.No	Parameters	Units	Test Method	Results
1	pH @ 25°C	-	IS 3025 (Part 11) 1983 (RA 2017)	7.61
2	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.1)
3	Total Dissolved Solids (TDS) @ 180°C	mg/L	IS 3025 (Part 16) 1984 (RA 2014)	179
4	Dissolved Oxygen	mg/L	IS 3025 (Part 38) 1989 (RA 2019)	7.6
5	Aluminium (as Al)	mg/L	IS 3025 (Part 55) 2003 (RA 2014)	BDL(DL:0.01)
6	Ammonia (as Total Ammonia - N)	mg/L	IS 3025 (Part 34) 1988 (RA 2003)	BDL(DL:1.0)
7	Total Suspended Solids @ 105°C	mg/L	IS 3025 (Part 17) 1984 (RA 2017)	BDL(DL:2.0)
8	Barium (as Ba)	mg/L	IS 13428:2014 (Annex K)	BDL(DL:0.01)
9	Boron (as B)	mg/L	IS 3025 (Part 57) 2005 (RA 2017)	BDL(DL:0.01)
10	Calcium (as Ca)	mg/L	IS 3025 (Part 40) 1991 (RA 2014)	44.4
11	Chloride (as Cl)	mg/L	IS 3025 (Part 32) 1988 (RA 2014)	14.5
12	Copper (as Cu)	mg/L	IS 3025 (Part 42) 1992 (RA 2014)	BDL(DL:0.01)
13	Fluoride (as F)	mg/L	APHA 23rd Edition 4500 F-D	0.72
14	Iron (as Fe)	mg/L	IS 3025 (Part 53) 2003 (RA 2014)	0.33
15	Magnesium (Mg)	mg/L	IS 3025 (Part 46) 1994 (RA 2014)	11.3
16	Manganese (as Mn)	mg/L	IS 3025 (Part 59) 2006 (RA 2017)	BDL(DL:0.01)
17	Nitrate Nitrogen	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
18	Total Nitrogen	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
19	Oil & Grease	mg/L	IS 3025 (Part 39) 1991 (RA 2014)	BDL(DL:5.0)
20	Hexavalent Chromium (as Cr^{6+})	mg/L	IS 3025 (Part 52) 2003 (RA 2014)	BDL(DL:0.01)
21	Biochemical Oxygen Demand (BOD)(3 days at 27°C)	mg/L	IS 3025 (Part 44) 1993 (RA 2014)	BDL(DL:2.0)
22	Chemical Oxygen Demand (COD)	mg/L	IS 3025 (Part 58) 2006 (RA 2017)	BDL(DL:4.0)
23	Organic Phosphorous	mg/L	APHA 23rd Edition 4500 F	0.06

Verified by

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015 & ISO 14001:2015

Report No	: POEI/TR-W-4422	Report Date	: 16.12.2019

S.No	Parameters	Units	Test Method	Results
24	Vanadium (as	mg/L	IS 3025 (Part 2)	BDL(DL:0.01)
25	Nitrate (as NO_3)	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	19
26	Phenolic Compounds (C_6H_5OH)	mg/L	IS 3025 (Part 43) 1992(RA 2008)	BDL(DL:0.001)
27	Selenium (as Se)	mg/L	IS 3025 (Part 56) 2003 (RA 2014)	BDL(DL:0.002)
28	Silver (as Ag)	mg/L	IS 13428:2005 (Annex J)	BDL(DL:0.001)
29	Sulphates (as SO_4)	mg/L	IS 3025 (Part 24) 1986 (RA 2014)	10.1
30	Sulphide (as H_2S)	mg/L	IS 3025 (Part 29) 1986 (RA 2003)	BDL(DL:1.0)
31	Ammonical Nitrogen (as N)	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
32	Total Kjehdahl Nitrogen (as N)	mg/L	IS 3025 (Part 34) 1988 (RA 2014)	BDL(DL:1.0)
33	Zinc (as Zn)	mg/L	IS 3025 (Part 49) 1994 (RA 2014)	1.9
34	Cadmium (as Cd)	mg/L	IS 3025 (Part 41) 1992 (RA 2014)	BDL(DL:0.01)
35	Cyanide (as CN)	mg/L	IS 3025 (Part 27) 1986 (RA 2014)	BDL(DL:0.01)
36	Lead (as Pb)	mg/L	IS 3025 (Part 47) 1994 (RA 2014)	BDL(DL:0.01)
37	Mercury (as Hg)	mg/L	IS 3025 (Part 48) 1994 (RA 2014)	BDL(DL:0.0001)
38	Nickel (as Ni)	mg/L	IS 3025 (Part 54) (RA 2003)	BDL(DL:0.01)
39	Total Phosphate	mg/L	IS 3025 (Part 31) 1988 (RA 2019)	0.36
40	Dissolved Phosphate (as PO_4)	mg/L	IS 3025 (Part 31) 1988 (RA 2019)	0.14
41	Arsenic (as As)	mg/L	IS 3025 (Part 37) 1988 (RA 2014)	BDL (DL:0.5)
42	Chromium (as Cr)	mg/L	IS 3025 (Part 52) 2003 (RA 2014)	BDL (DL:0.5)
43	Total Hardness (as $CaCO_3$)	mg/L	IS 3025 (Part 21) 2009 (RA 2014)	157
44	Sodium (as Na)	mg/L	IS 3025 (Part 45) 1993 (RA 2014)	28
45	Potassium (as K)	mg/L	IS 3025 (Part 45) 1993 (RA 2014)	8.6
46	Total Alkalinity (as $CaCO_3$)	mg/L	IS 3025 (Part 23) 1986 (RA 2014)	72
Micro-Biological Parameters				
47	Escherichia coli (MPN)	MPN/100ml	IS 1622:1981 (RA 2009)	7
48	Total coliform (MPN)	MPN/100ml	IS 1622:1981 (RA 2009)	22
49	Fecal Coliform	MPN/100ml	IS 1622:1981 (RA 2009)	9

Note: BDL - Below Detection Limit; DL - Detection Limit
All the above test parameters are carried with the sample's "as received condition"

..... End of Report .....

Verified by

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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Sample Name:Bore Water

Report Number:2005537 **Report Date:13/08/2016**

Customer Ref:RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

Customer Name & Address Rites Limited Rites Bhawan, No.1, Sector-29, Gurgaon, Haryana - 122001	Job No. STRC/2005537 Received On 03/08/2016 Sample Quantity 10 litre Packing : Filled in pet bottle Sample Location: Medavakkam Junction Sub: Analysis of Water Samples for Chennai Metro Rail Project Phase-II

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.	**Chemical Parameters**					
A.1.	pH value at 25°C	7.99	-	6.5-8.5/No relaxation	IS:3025(P-11)1983	YES
A.2.	Turbidity, NTU	<0.1	-	1.0/5.0 Max.	IS:3025(P-10)1984	YES
A.3.	**Total Dissolved Solids, mg/l**	**1,256.0**	-	**500/2000 Max.**	**IS:3025(P-16)1984**	**NO**
A.4.	Aluminium (as Al), mg/l	BDL	0.01	0.03/0.2 Max.	APHA 22nd Edn. 2012:3125B	YES
A.5.	Free ammonia (as NH3), mg/l	<0.1	-	-,-	IS:3025(P-34)1988	-
A.6.	Barium (as Ba), mg/l	0.046	0.002	0.7 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.7.	Boron (as B), mg/l	0.04	0.02	0.5/1.0 Max.	APHA 22nd Edn. 2012:3125B	YES
A.8.	**Calcium (as Ca), mg/l**	**206.4**	-	**75/200 Max.**	**IS:3025(P-40)1991**	**NO**
A.9.	**Chloride (as Cl), mg/l**	**280.9**	-	**250/1000 Max.**	**IS:3025(P-32)1988**	**NO**
A.10.	Copper (as Cu), mg/l	BDL	0.002	0.05/1.5 Max.	APHA 22nd Edn. 2012:3125B	YES
A.11.	**Fluoride (as F), mg/l**	**>1.0**	-	**1.0/1.5 Max.**	**IS:3025(P-60)2008**	**NO**
A.12.	Free Residual Chlorine, mg/l	N.A	-	0.2Min./1.0 Max.	IS:3025(P-26)1986	-
A.13.	Iron (as Fe), mg/l	BDL	0.1	1.0 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.14.	Magnesium (as Mg), mg/l	27.6	-	30/100 Max.	IS:3025(P-46)1994	YES
A.15.	Manganese (as Mn), mg/l	BDL	0.002	0.1/0.3 Max.	APHA 22nd Edn. 2012:3125B	YES
A.16.	Nitrate (as NO3), mg/l	17.2	1.0	45 Max./No relaxation	IS:3025(P-34)1988	YES
A.17.	Phenolic Compound (as C6H5OH), mg/l	BDL	0.001	0.001/0.002 Max.	IS:3025(P-43)1992	YES

Authorised Signatory:
SANTRAM RAJPUT
Technical Manager

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Sample Name:Bore Water

Report Date:13/08/2016

Report Number:2005537

Customer Ref:RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.18.	Selenium (as Se), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.19.	Silver (as Ag), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.20.	Sulphate (as SO4), mg/l	11.7	5.0	200/400 Max.	IS:3025(P-24)1986	YES
A.21.	Sulphide (as S), mg/l	BDL	0.05	0.05 max./No relaxation	IS:3025(P-29)1986	YES
A.22.	**Total alkalinity (as CaCO3), mg/l**	**382.2**	-	**200/600 Max.**	**IS:3025(P-23)1986**	**NO**
A.23.	**Total Hardness (as CaCo3), mg/l**	**628.3**	-	**200/600 Max.**	**IS:3025(P-21)2009**	**NO**
A.24.	Zinc (as Zn), mg/l	BDL	0.02	5.0/15.0 Max.	APHA 22nd Edn. 2012:3125B	YES
A.25.	Cadmium (as Cd), mg/l	BDL	0.002	0.003 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.26.	Cyanide (as CN), mg/l	BDL	0.02	0.05 Max./No relaxation	IS:3025(P-27)1986	YES
A.27.	Lead (as Pb), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2g12:3125B	YES
A.28.	Mercury (as Hg), mg/l	0.0008	0.0002	0.001 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.29.	Nickel (as Ni), mg/l	0.002	0.002	0.02 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.30.	Total Arsenic (as As), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.31.	Total Chromium (as Cr), mg/l	BDL	0.002	0.05 max./No relaxation	APHA 22nd Edn 2012:3125B	YES
A.32.	Total suspended solids, mg/l	3.0	-	-,-	IS:3025(P-17)1984	-
A.33.	Vanadium (as V), mg/l	BDL	0.002	-,-	APHA 22nd Edn. 2012:3125B	-
A.34.	Ammonical Nitrogen (as N)	<0.1	-	0.5 max./No relaxation	IS:3025(P-34)1988	YES
A.35.	Total Kjeldahl nitrogen (as N)	21.5	-	-,-	IS:3025(P-34)1988	-
A.36.	Chromium (as hexavalent chromium), mg/l	BDL	0.1	-,-	IS:3025(P-52)2003	-

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Sample Name:Bore Water

Report Number:2005537 **Report Date:13/08/2016**

Customer Ref:RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.37.	Oil & Grease, mg/l	<1.0	-	-,-	IS:3025(P-39)1991	-
A.38.	Dissolved oxygen, mg/l	4.5	-	-,-	IS:3025(P-38)1989	-
A.39.	Chemical oxygen demand, mg/l	60.8	-	-,-	IS:3025(P-58)2006	-
A.40.	Biochemical oxygen demand, mg/l	23.0	-		IS:3025(P-44)1993	-
A.41.	Total phosphate, mg/l	1.1	0.1	-,-	IS:3025(P-31)1988	-
A.42.	Dissolved phosphate (as P), mg/l	1.1	0.1	-,-	IS:3025(P-31)1988	-
A.43.	Sodium (as Na), mg/l	150.0	2.0	-,-	IS:3025(P-45)1993	-
A.44.	Potassium (as K), mg/l	6.0	2.0	-,-	IS:3025(P-45)1993	-
A.45.	Nitrate nitrogen, mg/l	3.9	0.2	-,-	IS:3025(P-34)1988	-
A.46.	Total nitrogen, mg/l	21.5	-	-,-	IS:3025(P-34)1988	-
A.47.	Organic phosphorus, mg/l	BDL	0.00001	-,-	USEPA 8141 A	-
B.	**Microbiological Examination**					
B.1.	Coliform count, MPN/100ml	<1	-	Shall not be detectable in any 100ml sample	IS:1622-1981	Yes
B.2.	Faecal coliform, MPN/100ml	<1	-	-,-	IS:1622-1981	-
B.3.	Total coliform organism, cfu/100ml	<1	-	-,-	IS:1622-1981	-

Remarks : Protocol:- IS: 10500-2012 for Acceptable limit/Permissible limit.
Note:- According to IS:10500-2012 ,it is recommended that the acceptable limit is to be implemented. Values greater than the acceptable limits render the water is not suitable, but still may be tolerated in the absence of an alternate source but upto permissible limits.
BDL = Below detection limit, MDL = Method detection limit.

***** End of Report *****

Authorised Signatory:
SANTRAM RAJPUT
Technical Manager

Please share your feedback

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Sample Name:Surface Water

Report Number:2005538

Report Date:13/08/2016

Customer Ref.RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

Customer Name & Address		
Rites Limited Rites Bhawan, No.1, Sector-29, Gurgaon, Haryana - 122001	Job No.	STRC/2005538
	Received On	03/08/2016
	Sample Quantity	10 litre
	Packing - Filled in pet bottle Sample Location: Near Global Hospital Sub: Analysis of Water Samples for Chennai Metro Rail Project Phase-II.	

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.	**Chemical Parameters**					
A.1.	pH value at 25°C	8.15	-	6.5-8.5/No relaxation	IS:3025(P-11)1983	YES
A.2.	**Turbidity, NTU**	**76.5**	**-**	**1.0/5.0 Max.**	**IS:3025(P-10)1984**	**NO**
A.3.	**Total Dissolved Solids, mg/l**	**4,386.0**	**-**	**500/2000 Max.**	**IS:3025(P-16)1984**	**NO**
A.4.	**Aluminium (as Al), mg/l**	**0.054**	**0.01**	**0.03/0.2 Max.**	**APHA 22nd Edn. 2012:3125B**	**NO**
A.5.	Free ammonia (as NH3), mg/l	>0.5	-	-, -	IS:3025(P-34)1988	-
A.6.	Barium (as Ba), mg/l	0.23	0.002	0.7 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.7.	Boron (as B), mg/l	BDL	0.02	0.5/1.0 Max.	APHA 22nd Edn. 2012:3125B	YES
A.8.	**Calcium (as Ca), mg/l**	**123.8**	**-**	**75/200 Max.**	**IS:3025(P-40)1991**	**NO**
A.9.	**Chloride (as Cl), mg/l**	**1,995.7**	**-**	**250/1000 Max.**	**IS:3025(P-32)1988**	**NO**
A.10.	Copper (as Cu), mg/l	BDL	0.002	0.05/1.5 Max.	APHA 22nd Edn. 2012:3125B	YES
A.11.	**Fluoride (as F), mg/l**	**>1.0**	**-**	**1.0/1.5 Max.**	**IS:3025(P-60)2008**	**NO**
A.12.	Free Residual Chlorine, mg/l	N.A	-	0.2Min./1.0 Max.	IS:3025(P-26)1986	-
A.13.	Iron (as Fe), mg/l	0.14	0.1	1.0 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.14.	**Magnesium (as Mg), mg/l**	**188.1**	**-**	**30/100 Max.**	**IS:3025(P-46)1994**	**NO**
A.15.	**Manganese (as Mn), mg/l**	**0.21**	**0.002**	**0.1/0.3 Max.**	**APHA 22nd Edn. 2012:3125B**	**NO**
A.16.	Nitrate (as NO3), mg/l	1.1	1.0	45 Max./No relaxation	IS:3025(P-34)1988	YES
A.17.	Phenolic Compound (as C6H5OH), mg/l	BDL	0.001	0.001/0.002 Max.	IS:3025(P-43)1992	YES

Authorised Signatory:
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Technical Manager

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Sample Name:Surface Water

Report Number:2005538 **Report Date:13/08/2016**

Customer Ref:RITES/UE/Chennai Metro/2016/92, Dt. 02/08/2016

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.18.	Selenium (as Se), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.19.	Silver (as Ag), mg/l	BDL	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.20.	Sulphate (as SO4), mg/l	155.6	5.0	200/400 Max.	IS:3025(P-24)1986	YES
A.21.	Sulphide (as S), mg/l	BDL	0.05	0.05 max./No relaxation	IS:3025(P-29)1986	YES
A.22.	**Total alkalinity (as CaCO3), mg/l**	**225.4**	**-**	**200/600 Max.**	**IS:3025(P-23)1986**	**NO**
A.23.	**Total Hardness (as CaCo3), mg/l**	**1,081.5**	**-**	**200/600 Max.**	**IS:3025(P-21)2009**	**NO**
A.24.	Zinc (as Zn), mg/l	BDL	0.02	5.0/15.0 Max.	APHA 22nd Edn. 2012:3125B	YES
A.25.	Cadmium (as Cd), mg/l	BDL	0.002	0.003 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.26.	Cyanide (as CN), mg/l	BDL	0.02	0.05 Max./No relaxation	IS:3025(P-27)1986	YES
A.27.	Lead (as Pb), mg/l	0.009	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.28.	Mercury (as Hg), mg/l	BDL	0.0002	0.001 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.29.	Nickel (as Ni), mg/l	0.004	0.002	0.02 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.30.	Total Arsenic (as As), mg/l	0.003	0.002	0.01 Max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.31.	Total Chromium (as Cr), mg/l	BDL	0.002	0.05 max./No relaxation	APHA 22nd Edn. 2012:3125B	YES
A.32.	Total suspended solids, mg/l	184.0	-	-, -	IS:3025(P-17)1984	-
A.33.	Vanadium (as V), mg/l	BDL	0.002	-,-	APHA 22nd Edn. 2012:3125B	-
A.34.	**Ammonical Nitrogen (as N)**	**>0.5**	**-**	**0.5 max./No relaxation**	**IS:3025(P-34)1988**	**NO**
A.35.	Total kjeldahl nitrogen (as N)	3.2	-	-, -	IS:3025(P-34)1988	-
A.36.	Chromium (as hexavalent chromium), mg/l	BDL	0.1	-, -	IS:3025(P-52)2003	-

Authorised Signatory:
SANTRAM RAJPUT
Technical Manager

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TESTING OF FOOD | WATER | CHEMICALS | PETROLEUM PRODUCTS | BUILDING MATERIAL | ENVIRONME

TEST CERTIFICATE

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Sample Name: Surface Water

Report Number: 2005538

Report Date: 13/08/2016

Customer Ref: RITES/UE/Chennai Metro/2016/02, Dt. 02/08/2016

S. No.	Test Parameters	Results	M.D.L.	Requirement as per IS:10500-2012 Acceptable Limit/Permissible Limit	Test Method	Conformity
A.37.	Oil & Grease, mg/l	1.0	-	-, -	IS:3025(P-39)1991	-
A.38.	Dissolved oxygen, mg/l	3.7	-	-, -	IS:3025(P-38)1989	-
A.39.	Chemical oxygen demand, mg/l	220.0	-	-, -	IS:3025(P-58)2006	-
A.40.	Biochemical oxygen demand, mg/l	75.0	-	-	IS:3025(P-44)1993	-
A.41.	Total phosphate, mg/l	0.27	0.1	-, -	IS:3025(P-31)1988	-
A.42.	Dissolved phosphate (as P), mg/l	0.27	0.1	-, -	IS:3025(P-31)1988	-
A.43.	Sodium (as Na), mg/l	1,010.0	2.0	-, -	IS:3025(P-45)1993	-
A.44.	Potassium (as K), mg/l	30.0	2.0	-, -	IS:3025(P-45)1993	-
A.45.	Nitrate nitrogen, mg/l	0.25	0.2	-, -	IS:3025(P-34)1988	-
A.46.	Total nitrogen, mg/l	3.2	-	-, -	IS:3025(P-34)1988	-
A.47.	Organic phosphorus, mg/l	BDL	0.00001	-, -	USEPA 8141 A	-
B.	**Microbiological Examination**					
B.1.	**Coliform count, MPN/100ml**	54	-	**Shall not be detectable in any 100ml. sample**	IS:1622-1981	No
B.2.	Faecal coliform, MPN/100ml	<1	-	-, -	IS:1622-1981	-
B.3.	Total coliform organism, cfu/100ml	14	-	-, -	IS:1622-1981	-

Remarks :Protocol-: IS: 10500-2012 for Acceptable limit/Permissible limit.
Note:- According to IS:10500-2012 ,it is recommended that the acceptable limit is to be implemented. Values greater than the acceptable limits render the water is not suitable, but sui may be tolerated in the absence of an alternate source but upto permissible limits.
BDL = Below detection limit, MDL = Method detection limit.

***** End of Report *****

Authorised Signatory:
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TEST REPORT

Accredited by **NABL & NABET**, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No:	PCEL/TR-W-2672	**Report Date:**	09.10.2020
Issued to:	**M/S Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method:	IS 3025 (Part 1) 1987 (RA 2014)		
Sampled by:	Laboratory		
Sample Collected Date:	06.10.2020	**Sample Condition:**	Fit for Analysis
Sample Description:	**Water**	**Sample Reference No:**	PCEL/WW-010-10-20
Qty of Sample Received:	2.5L	**Sample Received On:**	06.10.2020
Sample Mark:	SW-5	**Test Commenced On:**	06.10.2020
Sampling Location:	**Adampakkam Lake**	**Test Completed On:**	09.10.2020

S.No	Parameters	Units	Test Method	Results
1	Colour	-	IS 3025 (Part 4) 1983 (RA 2017)	Light Black
2	Odour	-	IS 3025 (Part 5) 1983 (RA 2017)	Disagreeable
3	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	109.8
4	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2017)	6.93
5	Temperature	°C	IS 3025 (Part 9) 1984 (RA 2017)	30.6
6	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2013)	1164
7	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2017)	680
8	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2017)	313
9	Bio Chemical Oxygen Demand (27°C For 3 days)	mg/l	IS 3025 (Part 44) 1993 (RA 2019)	40.1
10	Chemical Oxygen Demand (COD)	mg/l	IS 3025 (Part 58) 2006 (RA 2017)	160
11	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2014)	BDL(DL 5.0)
12	Aluminium (as Al)	mg/l	IS 3025 (Part 55) 2003 (RA 2019)	0.16
13	Boron (as B)	mg/l	IS 3025 (Part 57) 2005 (RA 2017)	0.88
14	Calcium (as Ca)	mg/l	IS 3025 (Part 40) 1991 (RA 2014)	89

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TEST REPORT

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Report No:		PCE/273-09-2020	Report Date:	07.10.2020
S. No	Parameters	Units	Test Method	Results
15	Chlorides (as Cl-)	mg/l	IS 3025 (Part 32) 1988 (RA 2003)	151
16	Calcium (as Ca)	mg/l	IS 3025 (Part 40) 1991 (RA 2003)	0.13
17	Fluoride (as F)	mg/l	IS 3025 (Part 60) 2008 (RA 2013)	0.4
18	Free Residual Chlorine	mg/l	IS 3025 (Part 26) 1986 (RA 2003)	BDL(DL 0.1)
19	Iron (as Fe)	mg/l	IS 3025 (Part 53) 2003 (RA 2014)	0.36
20	Magnesium (as Mg)	mg/l	IS 3025 (Part 46) 1994 (RA 2003)	89.5
21	N-Nitrate (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2014)	14.6
22	Silica (as SiO_2)	mg/l	IS 3025 (Part 35) 1988 RA 2014)	10.9
23	Manganese (as Mn)	mg/l	IS 3025 (Part 59) 2006 (RA 2017)	0.29
24	Nitrate (as NO_3)	mg/l	IS 3025 (Part 34) 1988 (RA 2003)	0.85
25	Phenolic compound (as C6H5OH)	mg/l	IS 3025 (Part 43) 1992 (RA 2003)	BDL(DL 0.001)
26	Sulphates (as SO_4^{2-})	mg/l	IS 3025 (Part 24) 1986 (RA 2003)	85.3
27	Total Alkalinity (as $CaCO_3$)	mg/l	IS 3025 (Part 23) 1986 (RA 2003)	311
28	Total Hardness (as $CaCO_3$)	mg/l	IS 3025 (Part 21) 2009 (RA 2014)	341
29	Calcium Hardness	mg/l	IS 3025 (Part 40) 1991 (RA 2014)	222
30	Bicarbonates (as HCO_3)	mg/l	IS 3025 (Part 51) 2001 (RA 2017)	185
31	Zinc (as Zn)	mg/l	IS 3025 (Part 49) 1994 (RA 2003)	1.8
32	Cadmium (as Cd)	mg/l	IS 3025 (Part 41) 1992 (RA 2003)	BDL(DL 0.01)
33	Cyanide (as CN)	mg/l	IS 3025 (Part 27) 1986 (RA 2003)	BDL(DL 0.1)
34	Lead (as Pb)	mg/l	IS 3025 (Part 47) 1994 (RA 2003)	BDL(DL 0.01)
35	Nickel (as Ni)	mg/l	IS 3025 (Part 54) 2003 (RA 2014)	BDL(DL 0.01)
36	Total Arsenic (as As)	mg/l	IS 3025 (Part 37) 1988 (RA 1998)	BDL(DL 0.01)
37	Total Chromium (as Cr)	mg/l	IS 3025 (Part 52) 2003 (RA 2014)	BDL(DL 0.01)

Note: BDL - Below Detection Limit, DL - Detection Limit

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Note: 1.The test results are only to the sample submitted for test. 2.Any correction of the test report in full or part shall invalidate the report. 3.Samples will be retained for 15 days from the date of reporting except in case of regulatory samples or specifically instructed by client. 4.Perishable samples will be discarded immediately after reporting. 5.Under no circumstances lab accepts any liability or loss/damage caused by use or misuse of test report after invoicing or issuance of test report

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TEST REPORT

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Report No:	PCEI/TR-W-2075	**Report Date:**	09.10.2020
Issued to:	**M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method:	IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by:	Laboratory		
Sample Collected Date:	06.10.2020	**Sample Condition:**	Fit for Analysis
Sample Description:	**Water**	**Sample Reference No:**	PCEI/WW 033-10-20
Qty of Sample Received:	2.5 L	**Sample Received On:**	06.10.2020
Sample Mark:	SW-5	**Test Commenced On:**	06.10.2020
Sampling Location:	**Adayar River (Near MIOT Hospital)**	**Test Completed On:**	09.10.2020

S.No	Parameters	Units	Test Method	Results
1	Colour	-	IS 3025 (Part 4) 1983 (RA 2017)	Light Brown
2	Odour	-	IS 3025 (Part 5) 1983 (RA 2017)	Agreeable
3	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	43.5
4	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2017)	7.65
5	Temperature	°C	IS 3025 (Part 9) 1984 (RA 2017)	29.5
6	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2013)	1584
7	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2017)	1068
8	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2017)	373
9	Bio chemical Oxygen Demand (27°C for 3 days)	mg/l	IS 3025 (Part 44) 1993 (RA 2014)	16.8
10	Chemical Oxygen Demand (COD)	mg/l	IS 3025 (Part 58) 2006 (RA 2017)	64
11	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2014)	BDL(DL:5.0)
12	Aluminium (as Al)	mg/l	IS 3025 (Part 55) 2003 (RA 2019)	BDL(DL:0.01)
13	Boron (as B)	mg/l	IS 3025 (Part 57) 2005 (RA 2017)	0.02
14	Calcium (as Ca)	mg/l	IS 3025 (Part 40) 1991 (RA 2014)	101

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Report No:		PCEI/TR-N-2673	Report Date:	09.10.2020
S.No	Parameters	Units	Test Method	Results
15	Chlorides (as Cl)	mg/l	IS 3025 (Part 32) 1988 (RA 2003)	290
16	Copper (as Cu)	mg/l	IS 3025 (Part 42) 1992 (RA 2003)	0.28
17	Fluoride (as F)	mg/l	IS 3025 (Part 60) 2008 (RA 2013)	0.80
18	Free Residual Chlorine	mg/l	IS 3025 (Part 26) 1986 (RA 2003)	BDL(DL:0.1)
19	Iron (as Fe)	mg/l	IS 3025 (Part 53) 2003 (RA 2009)	18.3
20	Magnesium (as Mg)	mg/l	IS 3025 (Part 46) 1994 (RA 2003)	35.4
21	Potassium (as K)	mg/l	IS 3025 (Part 45) 1993 (RA 2014)	26.1
22	Silica (as SiO_2)	mg/l	IS 3025 (Part 35) 1988 (RA 2014)	6.42
23	Manganese (as Mn)	mg/l	IS 3025 (Part 59) 2006 (RA 2017)	0.61
24	Nitrate (as NO_3)	mg/l	IS 3025 (Part 34) 1988 (RA 2003)	9.00
25	Phenolic Compound (as C_6H_5OH)	mg/l	IS 3025 (Part 43) 1992 (RA 2003)	BDL(DL:0.001)
26	Sulphates (as SO_4^{2-})	mg/l	IS 3025 (Part 24) 1986 (RA 2003)	119.0
27	Total Alkalinity (as $CaCO_3$)	mg/l	IS 3025 (Part 23) 1986 (RA 2003)	399
28	Total Hardness (as $CaCO_3$)	mg/l	IS 3025 (Part 21) 2009 (RA 2019)	398
29	Calcium Hardness	mg/l	IS 3025 (Part 40) 1991 (RA 2014)	250
30	Bicarbonates (as HCO_3)	mg/l	IS 3025 (Part 51) 2001 (RA 2017)	43
31	Zinc (as Zn)	mg/l	IS 3025 (Part 49) 1994 (RA 2003)	0.51
32	Cadmium (as Cd)	mg/l	IS 3025 (Part 41) 1992 (RA 2003)	BDL(DL:0.01)
33	Cyanide (as CN)	mg/l	IS 3025 (Part 27) 1986 (RA 2003)	BDL(DL:0.1)
34	Lead (as Pb)	mg/l	IS 3025 (Part 47) 1994 (RA 2003)	BDL(DL:0.01)
35	Nickel (as Ni)	mg/l	IS 3025 (Part 54) 2003 (RA 2019)	BDL(DL:0.01)
36	Total Arsenic (as As)	mg/l	IS 3025 (Part 37) 1988 (RA 1999)	BDL(DL:0.01)
37	Total Chromium (as Cr)	mg/l	IS 3025 (Part 52) 2003 (RA 2009)	BDL(DL:0.01)

Note: BDL - Below Detection Limit; DL - Detection Limit

.... **End of Report** ....
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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-W-3795	**Report Date**	: 22.06.2022
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-436-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Adyar River**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.15
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	1125
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	731
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	15.6
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.2

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Report No	: PCEI/TR-W-3795	Report Date	: 22.06.2022

S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	3.64
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.12
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.39
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.43
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	0.03
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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TEST REPORT

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Report No	: PCEI/TR-W-3796	**Report Date**	: 22.06.2022
Issued to	: **M/s Larsen & Toubro Limited Heavy Civil Infrastructure** CMRL - Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-437-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Mugalivakkam**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.19
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	1342
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	872
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	20.5
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.5

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Note: 1.The test results are only to the sample submitted for test. 2.Any Correction of the test report in full or part shall invalidate the report 3.Sample will be retained for 15 days from the date of reporting except in case of regulatory samples or specifically instructed by client. 4.Perishable samples will be discarded immediately after reporting. 5.Under no circumstances lab accepts any liability or loss/damage caused by use or misuse of test report after invoicing or issued of test report

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Report No	: PCEI/TR-W-3796	Report Date	: 22.06.2022

S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	4.29
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.17
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.45
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.46
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	0.029
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

..... End of Report .....
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Report No	: PCEI/TR-W-3797	**Report Date**	: 22.06.2022
Issued to	: **M/s Larsen & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-438-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Steel Yard**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.49
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	1125
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	731
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	29.2
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.6

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Report No	: PCEI/TR-W-3797		Report Date	: 22.06.2022

S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	4.12
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.17
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.41
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.46
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	0.031
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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TEST REPORT

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Report No	: PCEI/TR-W-3798	**Report Date**	: 22.06.2022
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-439-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Batching Plant**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.51
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	1254
4	Total Dissolved Solids @ 180ºC	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	815
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	31.6
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.4

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Note: 1.The test results are only to the sample submitted for test. 2.Any Correction of the test report in full or part shall invalidate the report. 3.Sample will be retained for 15 days from the date of reporting except in case of regulatory samples or specifically instructed by client. 4.Perishable samples will be discarded immediately after reporting. 5.Under no circumstances lab accepts any liability or loss/damage caused by use or misuse of test report after invoicing or issued of test report

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S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	4.09
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.17
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.42
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.49
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	0.022
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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Report No	: POEI/TR-W-3799	**Report Date**	: 22.06.2022
Issued to	: **M/s Larsen & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-440-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Vanuvampet**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.46
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	1215
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	798
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	46.0
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.3

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Note: 1.The test results are only to the sample submitted for test. 2.Any Correction of the test report in full or part shall invalidate the report. 3.Sample will be retained for 15 days from the date of reporting except in case of regulatory samples or specifically instructed by client. 4.Perishable samples will be discarded immediately after reporting. 5.Under no circumstances lab accepts any liability or loss/damage caused by use or misuse of test report after invoicing or issued of test report

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S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	4.16
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.14
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.43
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.49
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	0.024
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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Report No	: PCEI/TR-W-3800	**Report Date**	: 22.06.2022
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-441-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Koyampet**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.48
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	1346
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	875
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	32.5
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.4

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S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	3.85
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.16
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.41
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.51
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	0.023
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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Report No	: PCEI/TR-W-3801	**Report Date**	: 22.06.2022
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-442-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Alandur**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.51
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	1461
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	960
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	54.6
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.6

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Report No	: PCEI/TR-W-3801	Report Date	: 22.06.2022

S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	4.16
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.16
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.51
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- E,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.51
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	0.024
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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Report No	: PCEI/TR-W-3753	**Report Date**	: 22.06.2022
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-394-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **DLF**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	6.78
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	495
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	316
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	4.77
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.3

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Report No	: PCEI/TR-W-3753	Report Date	: 22.06.2022

S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	2.11
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.09
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.18
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.23
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-W-3754	**Report Date**	: 22.06.2022
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-395-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Sathiya Nagar**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.22
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	643
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	414
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	6.33
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	7.20

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Report No	: PCEI/TR-W-3754	Report Date	: 22.06.2022

S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	2.54
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.28
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.31
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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Note: 1.The test results are only to the sample submitted for test. 2.Any Correction of the test report in full or part shall invalidate the report. 3.Sample will be retained for 15 days from the date of reporting except in case of regulatory samples or specifically instructed by client. 4.Perishable samples will be discarded immediately after reporting. 5.Under no circumstances lab accepts any liability or loss/damage caused by use or misuse of test report after invoicing or issued of test report

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Report No	: PCEI/TR-W-3755	**Report Date**	: 22.06.2022
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-396-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Chennai Trade Centre**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.82
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	1466
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	950
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	15.8
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.9

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Report No	: PCEI/TR-W-3755	Report Date	: 22.06.2022

S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	1.76
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.15
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.28
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.46
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	0.36
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coil (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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TEST REPORT

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Report No	: PCEI/TR-W-3756	**Report Date**	: 22.06.2022
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 3025 (Part 1) 1987 (RA 2019)		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/W-397-06-22
Sample Description	: **Ground Water**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Litre	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Casting Yard**		

S.No	Parameters	Units	Test Method	Results
1	Turbidity	NTU	IS 3025 (Part 10) 1984 (RA 2017)	BDL(DL:0.5)
2	pH Value @ 25 °C	-	IS 3025 (Part 11) 1983 (RA 2019)	7.34
3	Electrical Conductivity @ 25°C	µS/cm	IS 3025 (Part 14) 1984 (RA 2019)	1062
4	Total Dissolved Solids @ 180°C	mg/l	IS 3025 (Part 16) 1984 (RA 2019)	685
5	Total Suspended Solids @ 105°C	mg/l	IS 3025 (Part 17) 1984 (RA 2019)	BDL(DL:2.0)
6	Oil & Grease	mg/l	IS 3025 (Part 39) 1991 (RA 2019)	BDL(DL:5.0)
7	Total Phosphorous (as P)	mg/l	IS 3025 (Part 31) 1988 (RA 2019)	BDL(DL:0.1)
8	Total Nitrogen (as N)	mg/l	IS 3025 (Part 34) 1988 (RA 2019)	11.4
9	Volatile Organic Compound (VOC)	ng/l	USEPA Method 5201A	BDL(DL 1.0)
10	Dissolved Oxygen (as DO)	mg/l	IS 3025 (Part 38) 1989 (RA 2019)	6.6

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Report No	: PCEI/TR-W-3756	Report Date	: 22.06.2022

S.No	Parameters	Units	Test Method	Results
11	Manganese (as Mn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.05)
12	Selenium (as Se)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
13	Barium (as Ba)	mg/l	IS 3025 (Part 2) 2004	4.21
14	Silver (as Ag)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
15	Aluminium (as Al)	mg/l	IS 3025 (Part 2) 2004	0.15
16	Boron (as B)	mg/l	IS 3025 (Part 2) 2004	0.48
17	Copper (as Cu)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
18	Zinc (as Zn)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
19	Cadmium (as Cd)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
20	Cyanide (as CN)	mg/l	APHA 23rd Edition,4500 CN- B,E: 2017	BDL(DL:0.02)
21	Lead (as Pb)	mg/l	IS 3025 (Part 2) 2004	0.53
22	Mercury (as Hg)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.001)
23	Nickel (as Ni)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
24	Arsenic (as As)	mg/l	IS 3025 (Part 2) 2004	0.02
25	Total Chromium (as Cr)	mg/l	IS 3025 (Part 2) 2004	BDL(DL:0.01)
26	Escherichia coli (MPN)	Present/Absent	IS 15185 : 2016	Present

Note: BDL - Below Detection Limit; DL - Detection Limit

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7-2. Air

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TEST REPORT

AIR MONITORING

Issued to	**M/S. RITES LTD., RITES BHAVAN** ENVIRONMENTAL DIVISION PLOT No 1, SECTOR 29 GURGAON- 122001 HARYANA.
Date of Reporting	27.07.2016.
Analysis No.(Report No).	A600/16-17/R.N1542.
Nature of Sample	AIR SAMPLE.
Issued to	25.07.2016 – 26.07.2016.
Date of Reporting	ALWARTHIRU NAGAR JUNCTION.

RESULTS

SL. NO	PARAMETER	UNIT	OBSERVATION	PERMISSIBLE LIMIT	PROTOCOL/METHOD
1.	Sulphur Dioxide (SO_2)	$\mu g/m^3$	9.58	80	IS 5182 (Part 2):2001 (RA 2012).
2.	Nitrogen Dioxide (NO_2)	$\mu g/m^3$	13.60	80	IS 5182 (Part 6):2006 (RA 2012).
3.	Particulate matter (PM_{10})	$\mu g/m^3$	84.12	100	IS 5182 (Part23):2006 (RA 2012).
4.	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	41.67	60	SOP A02./Based on Instrumental method.
5.	Carbon Monoxide (CO)	mg/m^3	6.0	4.0	IS 5182 (Part10):1999 (RA 2009).

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I. KARUPPIAH
Chief Executive

ENTREAT

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TEST REPORT

AIR MONITORING

Issued to	M/S. RITES LTD., RITES BHAVAN ENVIRONMENTAL DIVISION PLOT No 1, SECTOR 29 GURGAON- 122001 HARYANA.
Date of Reporting	27.07.2016.
Analysis No.(Report No).	AS99/16-1/R.N1540.
Nature of Sample	AIR SAMPLE.
Date of Monitoring	25.07.2016 – 26.07.2016.
Location of Monitoring	MIOT HOSPITAL (NEAR RAMAVARAM SIGNAL).

RESULTS

SL. NO	PARAMETER	UNIT	OBSERVATION	PERMISSIBLE LIMIT	PROTOCOL/METHOD
1.	Sulphur Dioxide (SO_2)	$\mu g/m^3$	10.80	80	IS 5182 (Part 2):2001 (RA 2012).
2.	Nitrogen Dioxide (NO_2)	$\mu g/m^3$	15.38	80	IS 5182 (Part 6):2006 (RA 2012).
3.	Particulate matter (PM_{10})	$\mu g/m^3$	73.34	100	IS 5182 (Part23):2006 (RA 2012).
4.	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	33.96	60	SOP A02. /Based on Instrumental method.
5.	Carbon Monoxide (CO)	mg/m^3	9.0	4.0	IS 5182 (Part10):1999 (RA 2009).

Verified by:

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I. KARUPPIAH
Chief Executive

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TEST REPORT

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Report No	: PCEI/TR-AAQ-4402	**Report Date**	: 16.12.2019
ULR No	: ULR-TC744619000041SP		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method	: IS 5182 (Part 23) 2006 (RA 2017)		
Sampled by	: Laboratory		
Sample Collected Date	: 11.12.2019	**Sample Reference No**	: PCEI/AAQ-NOV5-12-19
Sample Description	: **Ambient Air**	**Sample Received On**	: 12.12.2019
Qty of Sample Received	: Filter Paper & 10ml	**Test Commenced On**	: 12.12.2019
Sample Condition	: Fit for Analysis	**Test Completed On**	: 16.12.2019
Sampling Location	: **Near Adambakkam MRTS**		

Weather Condition	
Ambient Temperature	: 30°C
Relative Humidity	: 70%
Predominant Wind Direction	: NE-SW
Climate Condition	: Scattered Clouds

S.No	Parameters	Units	Test Method	Results	TNPCB Max. Permissible Limits of NAAQ Standards for Industrial Area (TWA for 24 Hrs)
1	Sulphur dioxide (as SO_2)	$\mu g/m^3$	IS 5182 (Part 2) 2001 (RA 2017)	16.4	80
2	Oxides of Nitrogen (as NO_2)	$\mu g/m^3$	IS 5182 (Part 6) 2006 (RA 2017)	28.3	80
3	Respirable Particulate Matter (PM_{10})	$\mu g/m^3$	IS 5182 (Part 23) 2006 (RA 2017)	61.6	100
4	Respirable Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	NAAQMS/36/2012-13 (Volume 1)	34.9	60
5	Carbon Monoxide (as CO)	mg/m^3	IS 5182 (Part 10) 1999 (RA 2014)	BDL(DL:1.2)	4*

Note: i) NAAQS - National Ambient Air Quality Standards issued by CPCB (Central Pollution Control Board) in Nov 2009
ii) TWA - Time Weighted Average iii) *- TWA for 1 Hour iv) ** - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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Report No	: PCEI/TR/AAQ-4403	**Report Date**	: 16.12.2019
ULR No	: ULR-TC744619000341GP		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method	: IS 5182 (Part 23) 2006 (RA 2017)		
Sampled by	: Laboratory		
Sample Collected Date	: 11.12.2019	**Sample Reference No**	: PCEI/AAQ-N316-12-19
Sample Description	: **Ambient Air**	**Sample Received On**	: 12.12.2019
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 12.12.2019
Sample Condition	: Fit for Analysis	**Test Completed On**	: 16.12.2019
Sampling Location	: **Madipakkam Koot Road Junction**		

Weather Condition	
Ambient Temperature	: 30°C
Relative Humidity	: 75%
Predominent Wind Direction	: NE-SW
Climatic Condition	: Scattered Clouds

S.No	Parameters	Units	Test Method	Results	TNPCB Max. Permissible Limits of NAAQ Standards for Industrial Area (TWA for 24 Hrs)
1	Sulphur Dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	14.3	80
2	Oxides of Nitrogen (as NO_x)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	29.6	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	63.2	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	NAAQMS/36/2012-13 (Volume 1)	31.9	60
5	Carbon Monoxide (as CO)	mg/m³	IS 5182 (Part 10) 1999 (RA 2014)	BDL(DL:1.2)	4*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in Nov 2009
ii) TWA - Time Weighted Average iii) * - TWA for 1 Hour iv) ** - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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Designation: Technical Manager

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TEST REPORT

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Report No	: PCEI/TR-AAQ-4404	**Report Date**	: 16.12.2019.
ULR No	: ULR-TC274615I600039127F		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method	: IS 5182 (Part 23) 2006 (RA 2017)		
Sampled by	: Laboratory		
Sample Collected Date	: 11.12.2019	**Sample Reference No**	: PCEI/AAQ-N317-12-19
Sample Description	: **Ambient Air**	**Sample Received On**	: 12.12.2019
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 12.12.2019
Sample Condition	: Fit for Analysis	**Test Completed On**	: 16.12.2019
Sampling Location	: **Vellakal Bus Stop**		

Weather Condition	
Ambient Temperature	: 31°C
Relative Humidity	: 66%
Predominant Wind Direction	: NE-SW
Climate Condition	: Scattered Clouds

S.No	Parameters	Units	Test Method	Results	TNPCB Max. Permissible Limits of NAAQ Standards for Industrial Area (TWA for 24 Hrs)
1	Sulphur dioxide (as SO_2)	$\mu g/m^3$	IS 5182 (Part 2) 2001 (RA 2017)	18.9	80
2	Oxides of Nitrogen (as NO_x)	$\mu g/m^3$	IS 5182 (Part 6) 2006 (RA 2017)	25.7	80
3	Respirable Particulate Matter (PM_{10})	$\mu g/m^3$	IS 5182 (Part 23) 2006 (RA 2017)	61.1	100
4	Respirable Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	NAAQMS/36/2012-13 (Volume 1)	35.3	60
5	Carbon Monoxide (as CO)	mg/m^3	IS 5182 (Part 10) 1999 (RA 2014)	BDL(DL:1.2)	4*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in Nov 2009
ii) TWA - Time Weighted Average iii) * - TWA for 1 Hour iv) ** - TWA for Annual
BDL - Below Detection Limit , DL - Detection Limit

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Author and Signatory
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TEST REPORT

AIR MONITORING

Issued to	**M/S. RITES LTD., RITES BHAVAN ENVIRONMENTAL DIVISION** PLOT No 1, SECTOR 29 GURGAON- 122001 HARYANA.
Date of Reporting	05.08.2016.
Analysis No.(Report No).	A620/16-17/R.N1582
Nature of Sample	AIR SAMPLE.
Date of Monitoring	03.08.2016-04.08.2016.
Location of Monitoring	MEDAVAKKAM JUNCTION (Opp.to canara Bank)

RESULTS

SL. NO	PARAMETER	UNIT	OBSERVATION	PERMISSIBLE LIMIT	PROTOCOL/METHOD
1.	Sulphur Dioxide (SO_2)	$\mu g/m^3$	8.82	80	IS 5182 (Part 2):2001 (RA 2012).
2.	Nitrogen Dioxide (NO_2)	$\mu g/m^3$	9.35	80	IS 5182 (Part 6):2006 (RA 2012).
3.	Particulate matter (PM_{10})	$\mu g/m^3$	69.97	100	IS 5182 (Part23):2006 (RA 2012).
4.	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	25.14	60	SOP MG: /Based on Instrumental method.
5.	Carbon Monoxide (CO)	mg/m^3	0.0	4.0	IS 5182 (Part10):1999 (RA 2009).

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Authorised Signatory
L. KARUPPIAH
Chief Executive

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TEST REPORT

AIR MONITORING

Issued to	**M/S. RITES LTD., RITES BHAVAN ENVIRONMENTAL DIVISION** PLOT No 1, SECTOR 29 GURGAON 122001 HARYANA.
Date of Reporting	04.08.2016.
Analysis No.(Report No).	A618/16-17/R.N1578
Nature of Sample	AIR SAMPLE
Date of Monitoring	02.08.2016 - 03.08.2016
Location of Monitoring	GLOBAL HOSPITAL (Indira priyadarshini Nagar)

RESULTS

SL. NO	PARAMETER	UNIT	OBSERVATION	PERMISSIBLE LIMIT	PROTOCOL/METHOD
1.	Sulphur Dioxide (SO_2)	$\mu g/m^3$	6.23	80	IS 5182 (Part 2):2001 (RA 2012).
2.	Nitrogen Dioxide (NO_2)	$\mu g/m^3$	9.48	80	IS 5182 (Part 6):2006 (RA 2012).
3.	Particulate matter (PM_{10})	$\mu g/m^3$	62.37	100	IS 5182 (Part23):2006 (RA 2012).
4.	Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	29.16	60	SOP A02 /Based on Instrumental method.
5.	Carbon Monoxide (CO)	mg/m^3	4.0	4.0	IS 5182 (Part10):1999 (RA 2009).

Verified by:

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Chief Executive

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-AAQ-3748	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larsen & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-389-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Casting yard**		

Weather Condition	
Ambient Temperature	: 31°C
Relative Humidity	: 64%
Climate Condition	: broken clouds
Predominent Wind Direction	: NS

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	$\mu g/m^3$	IS 5182 (Part 2) 2001 (RA 2017)	13.8	80
2	Oxides of Nitrogen (as NO_2)	$\mu g/m^3$	IS 5182 (Part 6) 2006 (RA 2017)	22.3	80
3	Respirable Particulate Matter (PM_{10})	$\mu g/m^3$	IS 5182 (Part 23) 2006 (RA 2017)	80.5	100
4	Respirable Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	IS 5182 (Part 24) 2019	29.4	60
5	Ozone (as O_3)	$\mu g/m^3$	IS 5182 (Part 9) 1974 (RA 2019)	13.5	180**
6	Lead (as Pb)	$\mu g/m^3$	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m^3	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	$\mu g/m^3$	IS 5182 (Part 25) 2018	5.56	400**
9	Benzene (C_6H_6)	$\mu g/m^3$	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m^3	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m^3	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m^3	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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Report No	: PCEI/TR-AAQ-3768	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-409-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Adyar River**		

Weather Condition	
Ambient Temperature	: 31°C
Relative Humidity	: 59%
Climate Condition	: Partly sunny
Predominent Wind Direction	: NE

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	12.3	80
2	Oxides of Nitrogen (as NO_2)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	24.6	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	59.8	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	IS 5182 (Part 24) 2019	30.4	60
5	Ozone (as O_3)	µg/m³	IS 5182 (Part 9) 1974 (RA 2019)	16.9	180**
6	Lead (as Pb)	µg/m³	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m³	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	µg/m³	IS 5182 (Part 25) 2018	5.25	400**
9	Benzene (C_6H_6)	µg/m³	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m³	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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TEST REPORT

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Report No	: PCEI/TR-AAQ-3769	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-410-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Mugalivakkam**		

Weather Condition	
Ambient Temperature	: 31°C
Relative Humidity	: 61%
Climate Condition	: Partly sunny
Predominent Wind Direction	: NS

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	$\mu g/m^3$	IS 5182 (Part 2) 2001 (RA 2017)	13.8	80
2	Oxides of Nitrogen (as NO_2)	$\mu g/m^3$	IS 5182 (Part 6) 2006 (RA 2017)	22.6	80
3	Respirable Particulate Matter (PM_{10})	$\mu g/m^3$	IS 5182 (Part 23) 2006 (RA 2017)	60.5	100
4	Respirable Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	IS 5182 (Part 24) 2019	31.2	60
5	Ozone (as O_3)	$\mu g/m^3$	IS 5182 (Part 9) 1974 (RA 2019)	12.6	180**
6	Lead (as Pb)	$\mu g/m^3$	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m^3	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	$\mu g/m^3$	IS 5182 (Part 25) 2018	5.56	400**
9	Benzene (C_6H_6)	$\mu g/m^3$	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m^3	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m^3	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m^3	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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Report No	: PCEI/TR-AAQ-3770	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larsen & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - EC\02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-411-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Steel Yard**		

Weather Condition	
Ambient Temperature	: 31°C
Relative Humidity	: 64%
Climate Condition	: Scattered Clouds
Predominent Wind Direction	: NNE

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	12.3	80
2	Oxides of Nitrogen (as NO_2)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	29.5	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	61.2	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	IS 5182 (Part 24) 2019	30.5	60
5	Ozone (as O_3)	µg/m³	IS 5182 (Part 9) 1974 (RA 2019)	12.5	180**
6	Lead (as Pb)	µg/m³	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m³	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	µg/m³	IS 5182 (Part 25) 2018	5.45	400**
9	Benzene (C_6H_6)	µg/m³	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m³	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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TEST REPORT

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Report No	: PCEI/TR-AAQ-3771	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CNRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-412-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Batching Plant**		

Weather Condition	
Ambient Temperature	: 31°C
Relative Humidity	: 63%
Climate Condition	: Partly sunny
Predominent Wind Direction	: SW

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	12.6	80
2	Oxides of Nitrogen (as NO_2)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	25.1	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	62.2	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	IS 5182 (Part 24) 2019	31.2	60
5	Ozone (as O_3)	µg/m³	IS 5182 (Part 9) 1974 (RA 2019)	12.9	180**
6	Lead (as Pb)	µg/m³	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m³	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	µg/m³	IS 5182 (Part 25) 2018	5.62	400**
9	Benzene (C_6H_6)	µg/m³	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m³	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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Report No	: PCEI/TR-AAQ-3772	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CNRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-413-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Vanuvampet**		

Weather Condition	
Ambient Temperature	: 31°C
Relative Humidity	: 63%
Climate Condition	: Scattered Clouds
Predominent Wind Direction	: NNW

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	11.2	80
2	Oxides of Nitrogen (as NO_2)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	24.8	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	61.8	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	IS 5182 (Part 24) 2019	31.5	60
5	Ozone (as O_3)	µg/m³	IS 5182 (Part 9) 1974 (RA 2019)	10.9	180**
6	Lead (as Pb)	µg/m³	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m³	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	µg/m³	IS 5182 (Part 25) 2018	5.19	400**
9	Benzene (C_6H_6)	µg/m³	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m³	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average ii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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TEST REPORT

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Report No	: PCEI/TR-AAQ-1773	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-414-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Koyampet**		

Weather Condition	
Ambient Temperature	: 31°C
Relative Humidity	: 64%
Climate Condition	: Scattered Clouds
Predominent Wind Direction	: NE

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	12.0	80
2	Oxides of Nitrogen (as NO_2)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	25.1	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	64.5	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	IS 5182 (Part 24) 2019	31.2	60
5	Ozone (as O_3)	µg/m³	IS 5182 (Part 9) 1974 (RA 2019)	10.9	180**
6	Lead (as Pb)	µg/m³	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m³	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	µg/m³	IS 5182 (Part 25) 2018	5.84	400**
9	Benzene (C_6H_6)	µg/m³	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m³	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

..... End of Report .....
Page 1 of 1

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Note: 1.The test results are only to the sample submitted for test. 2.Any Correction of the test report in full or part shall invalidate the report 3.Sample will be retained for 15 days from the date of reporting except in case of regulatory samples or specifically instructed by client. 4.Perishable samples will be discarded immediately after reporting. 5.Under no circumstances lab accepts any liability or loss/damage caused by use or misuse of test report after invoicing or issued of test report

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TEST REPORT

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Report No	: PCEI/TR-AAQ-3767	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-408-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Alandur**		

Weather Condition	
Ambient Temperature	: 31°C
Relative Humidity	: 63%
Climate Condition	: Scattered Clouds
Predominent Wind Direction	: NS

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	13.1	80
2	Oxides of Nitrogen (as NO_2)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	24.9	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	64.8	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	IS 5182 (Part 24) 2019	32.4	60
5	Ozone (as O_3)	µg/m³	IS 5182 (Part 9) 1974 (RA 2019)	12.7	180**
6	Lead (as Pb)	µg/m³	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m³	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	µg/m³	IS 5182 (Part 25) 2018	5.49	400**
9	Benzene (C_6H_6)	µg/m³	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m³	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

..... End of Report .....
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TEST REPORT

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SAMPLE DRAWN BY LABORATORY

TC 8057

Issued to:
M/s. KEC International,
CMRC,Phase - 2, Sholinganallur.

Report Number	: BV/CHEN/22/05/4072-001		Report Date	: 12.05.2022
Internal Sample Number	: 899899		Page	: 1 of 1
Sample Details				
Product Name	: Ambient Air Quality		Received on	: 04.05.2022
Sample description	: Ambient Air Monitoring		**Analysis :**	
Location	: Near TP-3,Kovilambakkam		Commenced on	: 05.05.2022
Sample drawn by	: Lab Rep: Mr. N.P.Ilango		Completed on	: 11.05.2022
Date and duration of sampling	: From : 10.10AM on 02.05.2022			
	To : 10.10AM on 03.05.2022			
Sampling Protocol	: BVILCH/ENA/SOP-021			

Sl.No.	Pollutants	Units	Results	Sampling and Analysis Method	National ambient air quality standards,CPCB Notification Nov. 2009	
					Time Weighted Average	Industrial, Residential, Rural and Other area
1.	Particulate Matter (size less than 10 µm) or PM_{10}	µg/m³	73.8	IS 5182 (Part 23) : 2006	24 Hours	100
2.	Particulate Matter (size less than 2.5 µm) or $PM_{2.5}$	µg/m³	30.4	IS 5182 (Part 24): 2019	24 Hours	60
3.	Sulphur-di- oxide (SO_2)	µg/m³	22.0	IS 5182 (Part 2):2001	24 Hours	80
4.	Nitrogen-di- oxide (NO_2)	µg/m³	34.2	IS 5182 (Part 6) : 2006	24 Hours	80
5.	Carbon Monoxide (CO)	mg/m³	BLQ(LOQ:1.0)	IS 5182 (Part 10) : 1999	24 Hours	80

...............End..............

Report Prepared By: S.Asaithambi

Authorised Signatory

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TEST REPORT

SAMPLE DRAWN BY LABORATORY

TC 8057

Issued to:
M/s. KEC International,
CMRC,Phase - 2, Sholinganallur.

Report Number	: BV/CHEN/22/05/4072-002		Report Date	:	12.05.2022
Internal Sample Number	: 899900		Page	:	1 of 1
Sample Details					
Product Name	: Ambient Air Quality		Received on	:	04.05.2022
Sample description	: Ambient Air Monitoring		**Analysis :**		
Location	: Near Batching Plant		Commenced on	:	05.05.2022
Sample drawn by	: Lab Rep: Mr. N.P.Ilango		Completed on	:	11.05.2022
Date and duration of sampling	: From : 09.40 AM on 02.05.2022 To : 09.40 AM on 03.05.2022				
Sampling Protocol	: BVILCH/ENA/SOP-021				

Sl.No.	Pollutants	Units	Results	Sampling and Analysis Method	National ambient air quality standards,CPCB Notification Nov. 2009	
					Time Weighted Average	Industrial, Residential, Rural and Other area
1.	Particulate Matter (size less than 10 µm) or PM_{10}	µg/m³	69.2	IS 5182 (Part 23) : 2006	24 Hours	100
2.	Particulate Matter (size less than 2.5 µm) or $PM_{2.5}$	µg/m³	26.7	IS 5182 (Part 24): 2019	24 Hours	60
3.	Sulphur-di- oxide (SO_2)	µg/m³	16.5	IS 5182 (Part 2):2001	24 Hours	80
4.	Nitrogen-di- oxide (NO_2)	µg/m³	27.8	IS 5182 (Part 6) : 2006	24 Hours	80
5.	Carbon Monoxide (CO)	mg/m³	BLQ(LOQ:1.0)	IS 5182 (Part 10) : 1999	24 Hours	80

.....End.....

Report Prepared By: S.Kavitharani

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TEST REPORT

SAMPLE DRAWN BY LABORATORY

TC 8057

Issued to:
M/s. KEC International,
CMRC,Phase - 2, Sholinganallur.

Report Number	: BV/CHEN/22/05/4072-003		Report Date	:	12.05.2022
Internal Sample Number	: 899901		Page	:	1 of 1
Sample Details					
Product Name	: Ambient Air Quality		Received on	:	04.05.2022
Sample description	: Ambient Air Monitoring		**Analysis :**		
Location	: Near TP-6 CMRL Main Office		Commenced on	:	05.05.2022
Sample drawn by	: Lab Rep: Mr. N.P.Ilango		Completed on	:	11.05.2022
Date and duration of sampling	: From : 10.00AM on 02.05.2022 To : 10.00AMon 03.05.2022				
Sampling Protocol	: BVILCH/ENA/SOP-021				

Sl.No.	Pollutants	Units	Results	Sampling and Analysis Method	National ambient air quality standards,CPCB Notification Nov. 2009	
					Time Weighted Average	Industrial, Residential, Rural and Other area
1.	Particulate Matter (size less than 10 µm) or PM_{10}	µg/m³	70.5	IS 5182 (Part 23) : 2006	24 Hours	100
2.	Particulate Matter (size less than 2.5 µm) or $PM_{2.5}$	µg/m³	28.3	IS 5182 (Part 24): 2019	24 Hours	60
3.	Sulphur-di- oxide (SO_2)	µg/m³	19.3	IS 5182 (Part 2):2001	24 Hours	80
4.	Nitrogen-di- oxide (NO_2)	µg/m³	32.8	IS 5182 (Part 6) : 2006	24 Hours	80
5.	Carbon Monoxide (CO)	mg/m³	BLQ(LOQ:1.0)	IS 5182 (Part 10) : 1999	24 Hours	80

.....End.....

Report Prepared By: S.Kuttilanda

Authorised Signatory

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TEST REPORT

SAMPLE DRAWN BY LABORATORY

TC-8057

Issued to:
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Report Number	: BV/CHEN/22/05/4072-004		Report Date	:	12.05.2022
Internal Sample Number	: 899902		Page	:	1 of 1
Sample Details					
Product Name	: Ambient Air Quality		Received on	:	04.05.2022
Sample description	: Ambient Air Monitoring		**Analysis :**		
Location	: Near TP-8 Elcot Sholinganallur		Commenced on	:	05.05.2022
Sample drawn by	: Lab Rep: Mr. N.P.Ilango		Completed on	:	11.05.2022
Date and duration of sampling	: From : 10.20AM on 02.05.2022 To : 10.20AMon 03.05.2022				
Sampling Protocol	: BVILCH/ENA/SOP-021				

Sl.No.	Pollutants	Units	Results	Sampling and Analysis Method	National ambient air quality standards,CPCB Notification Nov. 2009	
					Time Weighted Average	Industrial, Residential, Rural and Other area
1.	Particulate Matter (size less than 10 µm) or PM_{10}	µg/m³	81.6	IS 5182 (Part 23) : 2006	24 Hours	100
2.	Particulate Matter (size less than 2.5 µm) or $PM_{2.5}$	µg/m³	34.1	IS 5182 (Part 24): 2019	24 Hours	60
3.	Sulphur-di- oxide (SO_2)	µg/m³	13.8	IS 5182 (Part 2):2001	24 Hours	80
4.	Nitrogen-di- oxide (NO_2)	µg/m³	30.0	IS 5182 (Part 6) : 2006	24 Hours	80
5.	Carbon Monoxide (CO)	mg/m³	BLQ(LOQ:1.0)	IS 5182 (Part 10) : 1999	24 Hours	80

.....End.....

Report Prepared By: S.Aadhavan

Authorised Signatory

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SAMPLE DRAWN BY LABORATORY

TC 8057

Issued to:
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Report Number	:	BV/CHEN/22/05/4072-005	Report Date	:	12.05.2022
Internal Sample Number	:	8999903	Page	:	1 of 1
Sample Details					
Product Name	:	Ambient Air Quality	Received on	:	04.05.2022
Sample description	:	Ambient Air Monitoring	**Analysis :**		
Location	:	Near Casting Yard Office Area - Kolabakkam	Commenced on	:	05.05.2022
Sample drawn by	:	Lab Rep: Mr. N.P.Ilango	Completed on	:	11.05.2022
Date and duration of sampling	:	From : 09.00 AM on 02.05.2022			
		To : 09.00 AM on 03.05.2022			
Sampling Protocol	:	BVLCH/ENA/SOP-021			

Sl.No.	Pollutants	Units	Results	Sampling and Analysis Method	National ambient air quality standards,CPCB Notification Nov. 2009	
					Time Weighted Average	Industrial, Residential, Rural and Other area
1.	Particulate Matter (size less than 10 µm) or PM_{10}	µg/m³	74.7	IS 5182 (Part 23) : 2006	24 Hours	100
2.	Particulate Matter (size less than 2.5 µm) or $PM_{2.5}$	µg/m³	32.5	IS 5182 (Part 24): 2019	24 Hours	60
3.	Sulphur-di- oxide (SO_2)	µg/m³	21.1	IS 5182 (Part 2):2001	24 Hours	80
4.	Nitrogen-di- oxide (NO_2)	µg/m³	32.1	IS 5182 (Part 6) : 2006	24 Hours	80
5.	Carbon Monoxide (CO)	mg/m³	BLQ(LOQ:1.0)	IS 5182 (Part 10) : 1999	24 Hours	80

..................End..................
Report Prepared By: S.Anjhanna

Authorised Signatory

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-AAQ-3745	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-386-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **DLF**		

Weather Condition	
Ambient Temperature	: 34°C
Relative Humidity	: 55%
Climate Condition	: Scattered Clouds
Predominent Wind Direction	: W

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	14.1	80
2	Oxides of Nitrogen (as NO_2)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	21.9	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	61.6	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	IS 5182 (Part 24) 2019	30.1	60
5	Ozone (as O_3)	µg/m³	IS 5182 (Part 9) 1974 (RA 2019)	13.8	180**
6	Lead (as Pb)	µg/m³	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m³	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	µg/m³	IS 5182 (Part 25) 2018	5.48	400**
9	Benzene (C_6H_6)	µg/m³	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m³	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-AAQ-3746	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-387-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Sathiya Nagar**		

Weather Condition	
Ambient Temperature	: 36°C
Relative Humidity	: 52%
Climate Condition	: Sunny
Predominent Wind Direction	: WS

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	12.6	80
2	Oxides of Nitrogen (as NO_2)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	19.4	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	60.8	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	IS 5182 (Part 24) 2019	28.5	60
5	Ozone (as O_3)	µg/m³	IS 5182 (Part 9) 1974 (RA 2019)	11.2	180**
6	Lead (as Pb)	µg/m³	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m³	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	µg/m³	IS 5182 (Part 25) 2018	4.85	400**
9	Benzene (C_6H_6)	µg/m³	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m³	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-AAQ-3747	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-388-06-22
Sample Description	: **Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Chennai Trade Centre**		

Weather Condition	
Ambient Temperature	: 36°C
Relative Humidity	: 52%
Climate Condition	: Sunny
Predominent Wind Direction	: E

S.No	Parameters	Units		Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	µg/m³	IS 5182 (Part 2) 2001 (RA 2017)	14.6	80
2	Oxides of Nitrogen (as NO_2)	µg/m³	IS 5182 (Part 6) 2006 (RA 2017)	24.0	80
3	Respirable Particulate Matter (PM_{10})	µg/m³	IS 5182 (Part 23) 2006 (RA 2017)	62.8	100
4	Respirable Particulate Matter ($PM_{2.5}$)	µg/m³	IS 5182 (Part 24) 2019	33.1	60
5	Ozone (as O_3)	µg/m³	IS 5182 (Part 9) 1974 (RA 2019)	12.0	180**
6	Lead (as Pb)	µg/m³	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m³	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	µg/m³	IS 5182 (Part 25) 2018	5.82	400**
9	Benzene (C_6H_6)	µg/m³	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m³	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m³	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Note: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-AAQ-3748	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	**: M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 5182 (Part 23) 2006		
Sampled by	: Laboratory		
Sample Collected Date	: 14.06.2022	**Sample Reference No**	: PCEI/AAQ-389-06-22
Sample Description	**: Ambient Air**	**Sample Received On**	: 15.06.2022
Qty of Sample Received	: Filter Paper & 30ml	**Test Commenced On**	: 15.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	**: Casting yard**		

Weather Condition	
Ambient Temperature	: 35°C
Relative Humidity	: 55%
Climate Condition	: Sunny
Predominent Wind Direction	: NS

S.No	Parameters	Units	Test Method	Results	NAAQ Standards for Industrial, Residential, Rural and Other Area
1	Sulphur dioxide (as SO_2)	$\mu g/m^3$	IS 5182 (Part 2) 2001 (RA 2017)	13.8	80
2	Oxides of Nitrogen (as NO_2)	$\mu g/m^3$	IS 5182 (Part 6) 2006 (RA 2017)	22.3	80
3	Respirable Particulate Matter (PM_{10})	$\mu g/m^3$	IS 5182 (Part 23) 2006 (RA 2017)	60.5	100
4	Respirable Particulate Matter ($PM_{2.5}$)	$\mu g/m^3$	IS 5182 (Part 24) 2019	29.4	60
5	Ozone (as O_3)	$\mu g/m^3$	IS 5182 (Part 9) 1974 (RA 2019)	13.5	180**
6	Lead (as Pb)	$\mu g/m^3$	IS 5182 (Part 22) 2004 (RA 2019)	BDL(DL:0.05)	1
7	Carbon Monoxide (as CO)	mg/m^3	PCEI/SOP/AAQ/003	BDL(DL:1.14)	4**
8	Ammonia (as NH_3)	$\mu g/m^3$	IS 5182 (Part 25) 2018	5.56	400**
9	Benzene (C_6H_6)	$\mu g/m^3$	IS 5182 (Part 11) 2006 (RA 2017)	BDL(DL:1.0)	5*
10	Benzo (a) Pyrene (BaP)	ng/m^3	IS 5182 (Part 12) 2004 (RA 2019)	BDL(DL:1.0)	1*
11	Arsenic (as As)	ng/m^3	PCEI/SOP/AAQ/002	BDL(DL:2.0)	6*
12	Nickel (as Ni)	ng/m^3	PCEI/SOP/AAQ/002	BDL(DL:10)	20*

Notes: i) NAAQS - National Ambient Air Quality Standards Issued by CPCB (Central Pollution Control Board) in 2009
ii) TWA - Time Weighted Average iii) **- TWA for 1 Hour iv) * - TWA for Annual
BDL - Below Detection Limit ; DL - Detection Limit

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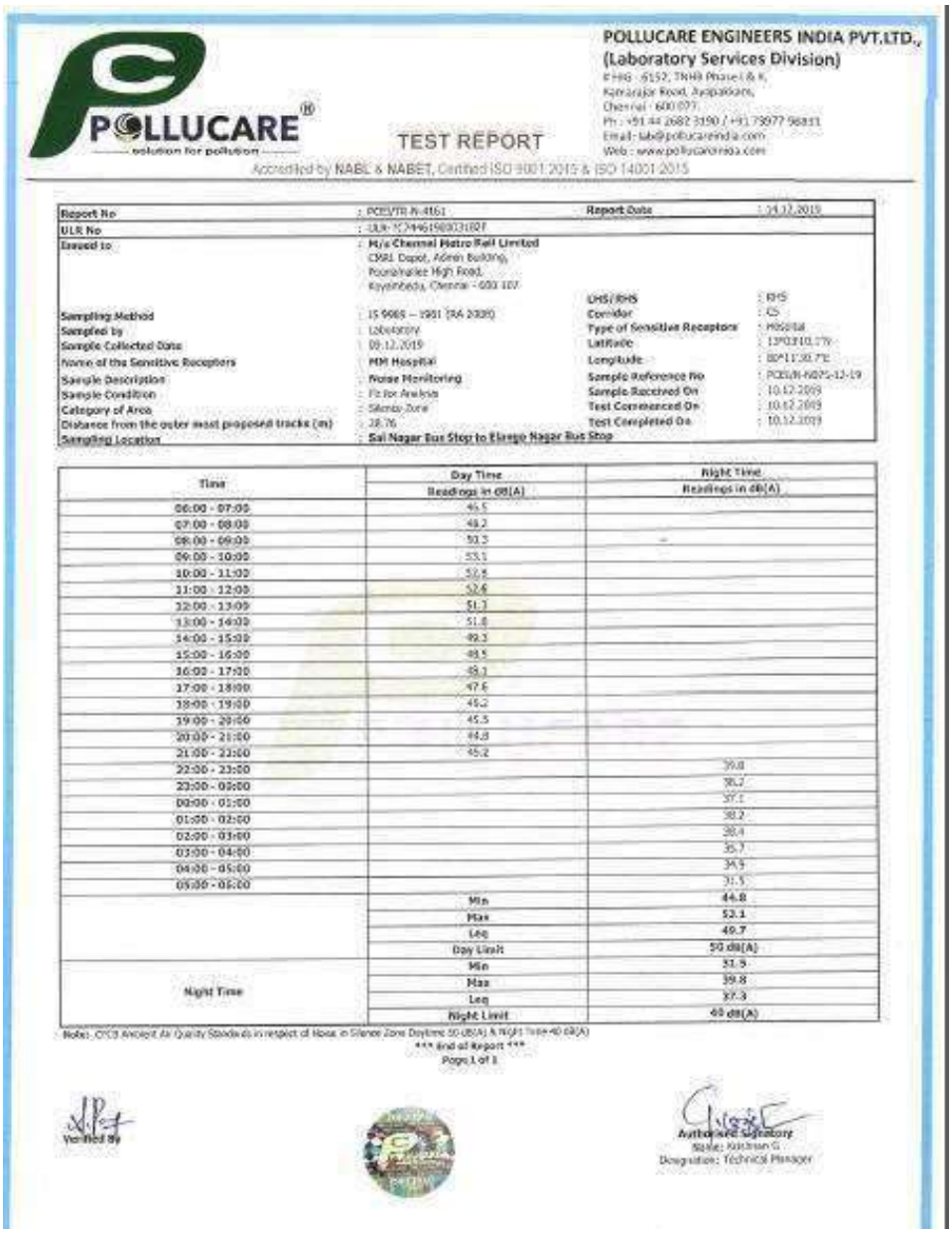
7-3. Noise



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Report No	: PCELTR/N-4161	Report Date	: 14.12.2019
ULR No	: ULR-TC744619000319F		
Issued to	: M/s Chennai Metro Rail Limited CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
		LHS / RHS	: RHS
Sampling Method	: IS 9989 – 1981 (RA 2009)	Corridor	: CS
Sampled by	: Laboratory	Type of Sensitive Receptors	: Hospital
Sample Collected Date	: 09.12.2019	Latitude	: 13°03'10.17"
Name of the Sensitive Receptors	: MM Hospital	Longitude	: 80°11'30.7"
Sample Description	: Noise Monitoring	Sample Reference No	: PCELN-N0PS-12-19
Sample Condition	: Fit for Analysis	Sample Received On	: 10.12.2019
Category of Area	: Silence Zone	Test Commenced On	: 10.12.2019
Distance from the outer most proposed tracks (m)	: 28.76	Test Completed On	: 10.12.2019
Sampling Location	: Sai Nagar Bus Stop to Elango Nagar Bus Stop		

Time	Day Time Readings in dB(A)	Night Time Readings in dB(A)
06:00 - 07:00	46.5	
07:00 - 08:00	48.2	
08:00 - 09:00	50.3	
09:00 - 10:00	53.1	
10:00 - 11:00	52.5	
11:00 - 12:00	52.6	
12:00 - 13:00	51.3	
13:00 - 14:00	51.8	
14:00 - 15:00	49.3	
15:00 - 16:00	48.5	
16:00 - 17:00	48.1	
17:00 - 18:00	47.6	
18:00 - 19:00	46.2	
19:00 - 20:00	45.5	
20:00 - 21:00	44.8	
21:00 - 22:00	45.2	
22:00 - 23:00		39.8
23:00 - 00:00		38.2
00:00 - 01:00		37.1
01:00 - 02:00		38.2
02:00 - 03:00		38.4
03:00 - 04:00		35.7
04:00 - 05:00		34.9
05:00 - 06:00		31.5
Day Time	Min	44.8
	Max	53.1
	Leq	49.7
	Day Limit	50 dB(A)
Night Time	Min	31.5
	Max	39.8
	Leq	37.3
	Night Limit	40 dB(A)

Note: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone Daytime 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Verified By

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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TEST REPORT

NOISE MONITORING

Issued to	**M/S. RITES LTD., RITES BHAVAN** ENVIRONMENTAL DIVISION PLOT No 1, SECTOR 29 GURGAON- 122001 HARYANA.
Report No & Date.	1541/16-17 dt 27.07.2016.
Period of Monitoring	25.07.2016 – 26.07.2016.
Location of Monitoring	ALWARTHIRU NAGAR JUNCTION.

RESULTS

S. No.	Monitoring Duration	Hourly Leq, dB(A)	S. No.	Monitoring Duration	Hourly Leq, dB(A)
1.	06:00 to 07:00	72.97	13.	18:00 to 19:00	79.88
2.	07:00 to 08:00	74.77	14.	19:00 to 20:00	77.12
3.	08:00 to 09:00	75.42	15.	20:00 to 21:00	74.87
4.	09:00 to 10:00	78.47	16.	21:00 to 22:00	69.26
5.	10:00 to 11:00	78.67	17.	22:00 to 23:00	61.26
6.	11:00 to 12:00	79.25	18.	23:00 to 24:00	63.17
7.	12:00 to 13:00	79.52	19.	24:00 to 01:00	64.96
8.	13:00 to 14:00	80.11	20.	01:00 to 02:00	62.65
9.	14:00 to 15:00	79.49	21.	02:00 to 03:00	69.03
10.	15:00 to 16:00	80.90	22.	03:00 to 04:00	71.04
11.	16:00 to 17:00	81.60	23.	04:00 to 05:00	71.16
12.	17:00 to 18:00	80.20	24.	05:00 to 06:00	69.58

OVERALL RESULT

L_{eq}	L_{10}	L_{50}	L_{90}	L_{max}	L_{min}	L_{day}	L_{night}	L_{dn}
81.19	80.55	76.27	63.35	81.60	61.26	77.66	66.61	72.13

PERMISSIBLE LIMIT: AMBIENT NOISE STANDARDS as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000

Area	Category of Area	Limits in dB(A) Leq	
		Day Time	Night Time
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence Zone	50	40

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015 & ISO 14001:2015

Report No	: PCEI/TR/N-4165	**Report Date**	: 14.12.2019
ULR No	: ULR-TC446190003186F		
Issued to	: M/s Chennai Metro Rail Limited CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107.		
		LHS/RHS	: LHS
Sampling Method	: IS 9989 – 1981 (RA 2008)	**Corridor**	: C5
Sampled by	: Laboratory	**Type of Sensitive Receptors**	: Hospital
Sample Collected Date	: 11.12.2019	**Latitude**	: 13°01'59.2"N
Name of the Sensitive Receptors	: DMI St. Joseph Hospital	**Longitude**	: 80°09'40.0"E
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-4079-12-19
Sample Condition	: Fit for Analysis	**Sample Received On**	: 12.12.2019
Category of Area	: Silence Zone	**Test Commenced On**	: 12.12.2019
Distance from the outer most proposed tracks (m)	: 52.93	**Test Completed On**	: 12.12.2019
Sampling Location	: Porur to Mugalivakkam		

Time	Day Time Readings in dB(A)	Night Time Readings in dB(A)
06:00 - 07:00	47.2	
07:00 - 08:00	48.2	
08:00 - 09:00	49.3	
09:00 - 10:00	50.8	
10:00 - 11:00	50.9	
11:00 - 12:00	51.3	
12:00 - 13:00	50.0	
13:00 - 14:00	47.8	
14:00 - 15:00	48.1	
15:00 - 16:00	49.2	
16:00 - 17:00	48.2	
17:00 - 18:00	47.6	
18:00 - 19:00	47.0	
19:00 - 20:00	46.8	
20:00 - 21:00	45.6	
21:00 - 22:00	45.0	
22:00 - 23:00		41.9
23:00 - 00:00		39.5
00:00 - 01:00		34.7
01:00 - 02:00		38.2
02:00 - 03:00		37.8
03:00 - 04:00		36.5
04:00 - 05:00		35.2
05:00 - 06:00		39.1
	Min	45.0
	Max	51.3
	Leq	48.7
	Day Limit	50 dB(A)
Night Time	Min	34.7
	Max	41.9
	Leq	38.2
	Night Limit	40 dB(A)

Notes: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone (Daytime 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Verified By

Authorised Signatory
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Designation: Technical Manager

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Report No	: PCEI/TR-N-4164	Report Date	: 14.12.2019
ULR No	: ULR-TC744619000031857		
Issued to	: M/s Chennai Metro Rail Limited CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107.		
		LHS/RHS	: U/S
Sampling Method	: IS 9989 – 1981 (RA 2008)	Corridor	: CS
Sampled by	: Laboratory	Type of Sensitive Receptors	: School
Sample Collected Date	: 11.12.2019	Latitude	: 13°03'01.0"N
Name of the Sensitive Receptors	: Government Boys School	Longitude	: 80°09'36.0"E
Sample Description	: Noise Monitoring	Sample Reference No	: PCEI/N-N078-12-19
Sample Condition	: Fit for Analysis	Sample Received On	: 12.12.2019
Category of Area	: Silence Zone	Test Commenced On	: 12.12.2019
Distance from the outer most proposed tracks (m)	: 46.03	Test Completed On	: 12.12.2019
Sampling Location	: Porur to Mugalivakkam		

Time	Day Time Readings in dB(A)	Night Time Readings in dB(A)
06:00 - 07:00	48.2	
07:00 - 08:00	49.5	
08:00 - 09:00	56.1	
09:00 - 10:00	59.8	
10:00 - 11:00	56.5	
11:00 - 12:00	53.2	
12:00 - 13:00	54.8	
13:00 - 14:00	60.9	
14:00 - 15:00	58.1	
15:00 - 16:00	53.4	
16:00 - 17:00	52.7	
17:00 - 18:00	50.9	
18:00 - 19:00	48.3	
19:00 - 20:00	47.3	
20:00 - 21:00	48.0	
21:00 - 22:00	45.2	
22:00 - 23:00		39.8
23:00 - 00:00		37.6
00:00 - 01:00		37.1
01:00 - 02:00		36.5
02:00 - 03:00		34.5
03:00 - 04:00		33.7
04:00 - 05:00		33.1
05:00 - 06:00		34.6
	Min	45.2
	Max	60.9
	Leq	54.9
	Day Limit	50 dB(A)
Night Time	Min	33.1
	Max	39.8
	Leq	36.4
	Night Limit	40 dB(A)

Note: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone Daytime 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Verified By

Authorised Signatory
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Designation: Technical Manager

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TEST REPORT

NOISE MONITORING

Issued to	M/S. RITES LTD., RITES BHAVAN ENVIRONMENTAL DIVISION PLOT No 1, SECTOR 29 GURGAON- 122001 HARYANA.
Report No & Date.	1539/16-17 dt 27.07.2016.
Period of Monitoring	25.07.2016 – 26.07.2016.
Location of Monitoring	MIOT HOSPITAL (NEAR RAMAVARAM SIGNAL)

RESULTS

S. No.	Monitoring Duration	Hourly Leq, dB(A)	S. No.	Monitoring Duration	Hourly Leq, dB(A)
1.	06:00 to 07:00	72.39	13.	18:00 to 19:00	75.84
2.	07:00 to 08:00	80.03	14.	19:00 to 20:00	77.59
3.	08:00 to 09:00	79.91	15.	20:00 to 21:00	78.16
4.	09:00 to 10:00	78.00	16.	21:00 to 22:00	75.10
5.	10:00 to 11:00	77.36	17.	22:00 to 23:00	77.45
6.	11:00 to 12:00	77.17	18.	23:00 to 24:00	75.73
7.	12:00 to 13:00	76.36	19.	24:00 to 01:00	72.99
8.	13:00 to 14:00	75.50	20.	01:00 to 02:00	73.80
9.	14:00 to 15:00	75.43	21.	02:00 to 03:00	75.23
10.	15:00 to 16:00	74.46	22.	03:00 to 04:00	70.22
11.	16:00 to 17:00	73.66	23.	04:00 to 05:00	70.35
12.	17:00 to 18:00	75.29	24.	05:00 to 06:00	70.00

OVERALL RESULT

Leq	L_{10}	L_{50}	L_{90}	L_{max}	L_{min}	L_{day}	L_{night}	L_{dn}
76.78	79.04	75.47	70.16	79.91	70.00	76.39	73.22	74.80

PERMISSIBLE LIMIT: AMBIENT NOISE STANDARDS as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000

Area	Category of Area	Limits in dB(A) Leq	
		Day Time	Night Time
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence Zone	50	40

Verified by:

Authorised Signatory

KARUPPIAH
Chief Executive

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Report No	: PCEI/TR-N-4162	**Report Date**	: 14.12.2019
ULR No	: ULR-TC744619000031 03F		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
		LHS/RHS	: RHS
Sampling Method	: IS 9989 - 1981 (RA 2008)	**Corridor**	: C5
Sampled by	: Laboratory	**Type of Sensitive Receptors**	: College
Sample Collected Date	: 10.12.2019	**Latitude**	: 13°00'48.9"N
Name of the Sensitive Receptors	: **St. Joseph College**	**Longitude**	: 80°11'37.2"E
Sample Description	: **Noise Monitoring**	**Sample Reference No**	: PCEI/N-0676-12-19
Sample Condition	: Fit for Analysis	**Sample Received On**	: 11.12.2019
Category of Area	: Silence Zone	**Test Commenced On**	: 11.12.2019
Distance from the outer most proposed tracks (m)	: 39.00	**Test Completed On**	: 11.12.2019
Sampling Location	: **CTC to St. Wesley Church**		

Time	Day Time Readings in dB(A)	Night Time Readings in dB(A)
06:00 - 07:00	45.8	
07:00 - 08:00	49.2	
08:00 - 09:00	55.1	
09:00 - 10:00	58.4	
10:00 - 11:00	59.0	
11:00 - 12:00	52.3	
12:00 - 13:00	50.0	
13:00 - 14:00	57.6	
14:00 - 15:00	53.5	
15:00 - 16:00	59.0	
16:00 - 17:00	57.8	
17:00 - 18:00	59.1	
18:00 - 19:00	47.0	
19:00 - 20:00	46.8	
20:00 - 21:00	45.3	
21:00 - 22:00	44.3	
22:00 - 23:00		38.3
23:00 - 00:00		37.2
00:00 - 01:00		37.5
01:00 - 02:00		36.5
02:00 - 03:00		35.1
03:00 - 04:00		34.4
04:00 - 05:00		33.5
05:00 - 06:00		35.2
	Min	44.3
	Max	59.8
	Leq	54.8
	Day Limit	50 dB(A)
Night Time	Min	33.5
	Max	38.3
	Leq	36.2
	Night Limit	40 dB(A)

Note: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone Daytime 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Verified By

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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TEST REPORT

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Report No	: PCEI/TR-N-4168	Report Date	: 14.12.2019
ULR No	: ULR-TC744615000319IF		
Issued to	: M/s Chennai Metro Rail Limited CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method	: IS 9989 – 1981 (RA 2008)	LHS/RHS	: LHS
Sampled by	: Laboratory	Corridor	: CS
Sample Collected Date	: 12.12.2019	Type of Sensitive Receptors	: School
Name of the Sensitive Receptors	: Contonment Board High School	Latitude	: 13°00'46.5"N
Sample Description	: Noise Monitoring	Longitude	: 80°11'43.3"E
Sample Condition	: Fit for Analysis	Sample Reference No	: PCEI/N-4068-12-19
Category of Area	: Silence Zone	Sample Received On	: 13.12.2019
Distance from the outer most proposed tracks (m)	: 77.93	Test Commenced On	: 13.12.2019
Sampling Location	: CTC to St. Wesley Church	Test Completed On	: 13.12.2019

Time	Day Time Readings in dB(A)	Night Time Readings in dB(A)
06:00 - 07:00	40.8	
07:00 - 08:00	41.6	
08:00 - 09:00	42.8	
09:00 - 10:00	44.1	
10:00 - 11:00	45.8	
11:00 - 12:00	47.3	
12:00 - 13:00	49.8	
13:00 - 14:00	46.2	
14:00 - 15:00	47.5	
15:00 - 16:00	43.2	
16:00 - 17:00	43.5	
17:00 - 18:00	40.6	
18:00 - 19:00	44.0	
19:00 - 20:00	43.2	
20:00 - 21:00	42.1	
21:00 - 22:00	40.6	
22:00 - 23:00		34.9
23:00 - 00:00		34.5
00:00 - 01:00		34.8
01:00 - 02:00		36.2
02:00 - 03:00		33.7
03:00 - 04:00		33.1
04:00 - 05:00		34.4
05:00 - 06:00		35.8
	Min	40.6
	Max	49.8
	Leq	45.2
	Day Limit	50 dB(A)
Night Time	Min	33.1
	Max	36.2
	Leq	34.8
	Night Limit	40 dB(A)

Note: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone Daytime 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Verified By

Authorised Signatory
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Designation: Technical Manager

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TEST REPORT

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Report No	: PCEI/TR-N-4167	Report Date	: 14.12.2019
ULR No	: ULR-TC7446/19000034##F		
Issued to	: M/s Chennai Metro Rail Limited CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107	LHS/RHS	: LHS
Sampling Method	: IS 9989 – 1981 (RA 2008)	Corridor	: C5
Sampled by	: Laboratory	Type of Sensitive Receptors	: School
Sample Collected Date	: 12.12.2019	Latitude	: 13°00'12.5"N
Name of the Sensitive Receptors	: National Matric. Hr. Sec. School	Longitude	: 80°12'14.7"E
Sample Description	: Noise Monitoring	Sample Reference No	: PCEI/N-N081-12-19
Sample Condition	: Fit for Analysis	Sample Received On	: 13.12.2019
Category of Area	: Silence Zone	Test Commenced On	: 13.12.2019
Distance from the outer most proposed tracks (m)	: 56.00	Test Completed On	: 13.12.2019
Sampling Location	: St. Wesley Church to Alandur		

Time	Day Time Readings in dB(A)	Night Time Readings in dB(A)
06:00 - 07:00	48.2	
07:00 - 08:00	46.2	
08:00 - 09:00	47.6	
09:00 - 10:00	49.5	
10:00 - 11:00	51.6	
11:00 - 12:00	53.6	
12:00 - 13:00	54.8	
13:00 - 14:00	53.8	
14:00 - 15:00	55.0	
15:00 - 16:00	53.1	
16:00 - 17:00	52.9	
17:00 - 18:00	50.6	
18:00 - 19:00	49.6	
19:00 - 20:00	47.2	
20:00 - 21:00	46.9	
21:00 - 22:00	45.3	
22:00 - 23:00		41.6
23:00 - 00:00		40.6
00:00 - 01:00		39.7
01:00 - 02:00		38.4
02:00 - 03:00		39.4
03:00 - 04:00		38.6
04:00 - 05:00		35.1
05:00 - 06:00		33.9
	Min	45.3
	Max	55.0
	Leq	51.4
	Day Limit	50 dB(A)
Night Time	Min	33.9
	Max	41.6
	Leq	38.7
	Night Limit	40 dB(A)

Note: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone Daytime 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Page 1 of 1

Verified By

Authorised Signatory
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TEST REPORT

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Report No	: PCE/STR-N-4158	Report Date	: 14.12.2019
ULR No	: ULR-TC74481500013179F		
Issued to	: M/s Chennai Metro Rail Limited (M&I, Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107.		
Sampling Method	: IS:9989 – 1981 (RA 2008)	LHS/RHS	: U/S
Sampled by	: Laboratory	Corridor	: CS
Sample Collected Date	: 07.12.2019	Type of Sensitive Receptors	: Hospital
Name of the Sensitive Receptors	: Kalpana Hospital	Latitude	: 13°04'57.4"N
Sample Description	: Noise Monitoring	Longitude	: 80°13'46.3"E
Sample Condition	: Fit for Analysis	Sample Reference No	: PCE/EN-N072-12-19
Category of Area	: Silence Zone	Sample Received On	: 08.12.2019
Distance from the outer most proposed tracks (m)	: 1.00	Test Commenced On	: 08.12.2019
Sampling Location	: Arumbakkam MRTS to Mahalakshmi Main Road	Test Completed On	: 08.12.2019

Time		Day Time Readings in dB(A)	Night Time Readings in dB(A)
06:00 - 07:00		53.6	
07:00 - 08:00		54.5	
08:00 - 09:00		56.3	
09:00 - 10:00		57.4	
10:00 - 11:00		57.3	
11:00 - 12:00		52.1	
12:00 - 13:00		56.8	
13:00 - 14:00		55.7	
14:00 - 15:00		55.1	
15:00 - 16:00		52.9	
16:00 - 17:00		51.5	
17:00 - 18:00		50.8	
18:00 - 19:00		51.3	
19:00 - 20:00		55.7	
20:00 - 21:00		56.1	
21:00 - 22:00		53.4	
22:00 - 23:00			37.8
23:00 - 00:00			36.6
00:00 - 01:00			35.2
01:00 - 02:00			34.2
02:00 - 03:00			33.8
03:00 - 04:00			33.1
04:00 - 05:00			32.1
05:00 - 06:00			33.9
Day Time	Min		50.8
	Max		57.4
	Leq		54.8
	Day Limit		50 dB(A)
Night Time	Min		32.1
	Max		37.8
	Leq		35.0
	Night Limit		40 d B(A)

Note: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone Daytime 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Verified By

Authorised Signatory
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Report No	: PCEI/TR-N-4190	**Report Date**	: 14.12.2019
ULR No	: ULR-TC744619000031 81F		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107.		
		LHS/RHS	: RHS
Sampling Method	: IS 9989 – 1981 (RA 2008)	**Corridor**	: C5
Sampled by	: Laboratory	**Type of Sensitive Receptors**	: Temple
Sample Collected Date	: 09.12.2019	**Latitude**	: 12° 55' 52.2768" N
Name of the Sensitive Receptors	: **Sri Varasidhi Vinayagar Koil**	**Longitude**	: 80°10'54.2" E
Sample Description	: **Noise Monitoring**	**Sample Reference No**	: PCEI/N-NE04-12-16
Sample Condition	: Fit for Analysis	**Sample Received On**	: 10.12.2019
Category of Area	: Silence Zone	**Test Commenced On**	: 10.12.2019
Distance from the outer most proposed tracks (m)	: 23.01	**Test Completed On**	: 10.12.2019
Sampling Location	: **Madipakkam Koot Road Bus Stop to Venkateswara Nagar**		

Time	Day Time Readings in dB(A)	Night Time Readings in dB(A)
06:00 - 07:00	46.8	
07:00 - 08:00	47.3	
08:00 - 09:00	49.5	
09:00 - 10:00	48.2	
10:00 - 11:00	47.9	
11:00 - 12:00	42.6	
12:00 - 13:00	43.4	
13:00 - 14:00	45.9	
14:00 - 15:00	45.7	
15:00 - 16:00	49.4	
16:00 - 17:00	48.6	
17:00 - 18:00	49.4	
18:00 - 19:00	48.3	
19:00 - 20:00	47.0	
20:00 - 21:00	45.5	
21:00 - 22:00	45.3	
22:00 - 23:00		38.4
23:00 - 00:00		35.9
00:00 - 01:00		34.3
01:00 - 02:00		33.6
02:00 - 03:00		35.8
03:00 - 04:00		32.3
04:00 - 05:00		31.7
05:00 - 06:00		34.9
	Min	42.6
	Max	49.5
	Leq	47.4
	Day Limit	50 dB(A)
Night Time	Min	31.6
	Max	38.4
	Leq	35.0
	Night Limit	40 dB(A)

Note: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone Daytime 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Verified By

Authorised Signatory
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Designation: Technical Manager

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Report No	: PCE/TR/N-4159	**Report Date**	: 14.12.2019
ULR No	: ULR-TC449619000318OF		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
		LHS/RHS	: LHS
Sampling Method	: IS 9989 – 1981 (RA 2001)	**Corridor**	: CS
Sampled by	: Laboratory	**Type of Sensitive Receptors**	: Hospital
Sample Collected Date	: 07.12.2019	**Latitude**	: 13°5'50.17"N
Name of the Sensitive Receptors	: **Anjakka Hospital**	**Longitude**	: 80°11'16.5"E
Sample Description	: **Noise Monitoring**	**Sample Reference No**	: PCE/N-M073-12-19
Sample Condition	: Fit for Analysis	**Sample Received On**	: 08.12.2019
Category of Area	: Silence Zone	**Test Commenced On**	: 08.12.2019
Distance from the outer most proposed tracks (m)	: 11.00	**Test Completed On**	: 08.12.2019
Sampling Location	: **Madipakkam Kock Road Bus Stop to Venkateswara Nagar**		

Time	Day Time	Night Time
	Readings in dB(A)	Readings in dB(A)
06:00 - 07:00	43.8	
07:00 - 08:00	41.7	
08:00 - 09:00	41.3	
09:00 - 10:00	43.1	
10:00 - 11:00	43.4	
11:00 - 12:00	44.2	
12:00 - 13:00	45.6	
13:00 - 14:00	45.8	
14:00 - 15:00	45.4	
15:00 - 16:00	44.1	
16:00 - 17:00	43.5	
17:00 - 18:00	43.2	
18:00 - 19:00	40.8	
19:00 - 20:00	39.2	
20:00 - 21:00	39.5	
21:00 - 22:00	38.3	
22:00 - 23:00		38.3
23:00 - 00:00		36.5
00:00 - 01:00		36.5
01:00 - 02:00		33.7
02:00 - 03:00		33.1
03:00 - 04:00		34.6
04:00 - 05:00		34.2
05:00 - 06:00		34.1
Day Time	Min	38.3
	Max	45.8
	Leq	42.8
	Day Limit	50 dB(A)
Night Time	Min	33.1
	Max	38.3
	Leq	35.3
	Night Limit	40 dB(A)

Notes: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone (Industrial 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Verified By

Authorised Signatory
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Designation: Technical Manager

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Report No	: PCEI/TR/R-4183	**Report Date**	: 14.12.2019
ULR No	: ULR-TC549619000318AF		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
		LHS/RHS	: LHS
Sampling Method	: IS 9989 - 1981 (RA 2008)	**Corridor**	: CS
Sampled by	: Laboratory	**Type of Sensitive Receptors**	: School
Sample Collected Date	: 10.12.2019	**Latitude**	: 13°03'06.1"N
Name of the Sensitive Receptors	: **Ravindra Bharti Global School**	**Longitude**	: 80°11'08.5"E
Sample Description	: **Noise Monitoring**	**Sample Reference No**	: PCEI/N-R077-12-19
Sample Condition	: Fit for Analysis	**Sample Received On**	: 11.12.2019
Category of Area	: Silence Zone	**Test Commenced On**	: 11.12.2019
Distance from the outer most proposed tracks (m)	: 42.64	**Test Completed On**	: 11.12.2019
Sampling Location	: **Venkateswara Nagar - Echankadu Bus Stop**		

Time	Day Time	Night Time
	Readings in dB(A)	Readings in dB(A)
06:00 - 07:00	40.3	
07:00 - 08:00	43.6	
08:00 - 09:00	49.8	
09:00 - 10:00	54.1	
10:00 - 11:00	58.6	
11:00 - 12:00	49.3	
12:00 - 13:00	51.9	
13:00 - 14:00	53.7	
14:00 - 15:00	56.5	
15:00 - 16:00	51.9	
16:00 - 17:00	58.7	
17:00 - 18:00	66.3	
18:00 - 19:00	53.1	
19:00 - 20:00	50.8	
20:00 - 21:00	49.6	
21:00 - 22:00	44.3	
22:00 - 23:00		37.8
23:00 - 00:00		35.2
00:00 - 01:00		34.2
01:00 - 02:00		33.8
02:00 - 03:00		33.1
03:00 - 04:00		32.1
04:00 - 05:00		33.4
05:00 - 06:00		34.6
	Min	40.3
	Max	66.3
	Leq	54.1
	Day Limit	50 dB(A)
Night Time	Min	32.1
	Max	37.8
	Leq	34.6
	Night Limit	40 dB(A)

Note: CPCB Ambient Air Quality Standards in respect of Noise in Silence Zone Daytime 50 dB(A) & Night Time 40 dB(A)

*** End of Report ***

Verified By

Authorised Signatory
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Designation: Technical Manager

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TEST REPORT

NOISE MONITORING

Issued to	**M/S. RITES LTD., RITES BHAVAN** ENVIRONMENTAL DIVISION PLOT No 1, SECTOR 29 GURGAON 122001 HARYANA.
Report No & Date.	1581/16-17 dt 05.08.2016.
Period of Monitoring	03.08.2016-04.08.2016.
Location of Monitoring	MEDAVAKKAM JUNCTION (Opp to canara Bank)

RESULTS

S. No.	Monitoring Duration	Hourly Leq, dB(A)	S. No.	Monitoring Duration	Hourly Leq, dB(A)
1.	06:00 to 07:00	72.05	13.	18:00 to 19:00	68.49
2.	07:00 to 08:00	71.10	14.	19:00 to 20:00	68.75
3.	08:00 to 09:00	70.41	15.	20:00 to 21:00	65.66
4.	09:00 to 10:00	72.34	16.	21:00 to 22:00	62.60
5.	10:00 to 11:00	70.48	17.	22:00 to 23:00	58.70
6.	11:00 to 12:00	72.37	18.	23:00 to 24:00	57.31
7.	12:00 to 13:00	73.79	19.	24:00 to 01:00	56.49
8.	13:00 to 14:00	66.70	20.	01:00 to 02:00	58.70
9.	14:00 to 15:00	62.29	21.	02:00 to 03:00	65.15
10.	15:00 to 16:00	72.81	22.	03:00 to 04:00	59.20
11.	16:00 to 17:00	69.69	23.	04:00 to 05:00	64.64
12.	17:00 to 18:00	70.32	24.	05:00 to 06:00	67.08

OVERALL RESULT

L_{eq}	L_{10}	L_{50}	L_{90}	L_{max}	L_{min}	L_{day}	L_{night}	L_{DN}
71.00	72.59	67.78	58.70	73.79	56.49	69.37	60.91	65.14

PERMISSIBLE LIMIT: AMBIENT NOISE STANDARDS as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000

Area	Category of Area	Limits in dB(A) Leq	
		Day Time	Night Time
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence Zone	50	40

Verified by:

Authorised Signatory

"SAVE ENVIRONMENT"

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TEST REPORT

NOISE MONITORING

Issued to	M/S. RITES LTD., RITES BHAVAN ENVIRONMENTAL DIVISION PLOT No 1, SECTOR 29 GURGAON- 122001 HARYANA.
Report No-& Date.	1577/16-17 dt 04.08.2016.
Period of Monitoring	02.08.2016 - 03.08.2016
Location of Monitoring	GLOBAL HOSPITAL (Indira priyadarshini Nagar)

RESULTS

S. No.	Monitoring Duration	Hourly Leq, dB(A)	S. No.	Monitoring Duration	Hourly Leq, dB(A)
1.	06:00 to 07:00	69.70	13.	18:00 to 19:00	61.80
2.	07:00 to 08:00	73.48	14.	19:00 to 20:00	61.23
3.	08:00 to 09:00	71.88	15.	20:00 to 21:00	60.28
4.	09:00 to 10:00	68.05	16.	21:00 to 22:00	61.32
5.	10:00 to 11:00	62.57	17.	22:00 to 23:00	64.05
6.	11:00 to 12:00	69.99	18.	23:00 to 24:00	59.51
7.	12:00 to 13:00	68.55	19.	24:00 to 01:00	57.25
8.	13:00 to 14:00	64.28	20.	01:00 to 02:00	57.39
9.	14:00 to 15:00	80.68	21.	02:00 to 03:00	62.17
10.	15:00 to 16:00	63.13	22.	03:00 to 04:00	66.12
11.	16:00 to 17:00	59.29	23.	04:00 to 05:00	69.60
12.	17:00 to 18:00	61.85	24.	05:00 to 06:00	69.06

OVERALL RESULT

Leq	L_{10}	L_{50}	L_{90}	L_{max}	L_{min}	L_{day}	L_{night}	L_{DN}
66.55	72.68	63.59	59.35	80.68	57.25	66.13	63.14	64.64

PERMISSIBLE LIMIT: AMBIENT NOISE STANDARDS as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000

Area	Category of Area	Limits in dB(A) Leq	
		Day Time	Night Time
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence Zone	50	40

Verified by:

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T. KARUPPIAH

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3788	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-429-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 15.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 15.06.2022
Sampling Date	: 14.06.2022 to 15.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Adyar River**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Lutron/SL-4023SD	PCEI/EQ/78	15.10.2021	14.10.2022

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	06:00 - 07:00	62.5	-
14.06.2022	07:00 - 08:00	58.7	-
14.06.2022	08:00 - 09:00	54.6	-
14.06.2022	09:00 - 10:00	60.8	-
14.06.2022	10:00 - 11:00	67.8	-
14.06.2022	11:00 - 12:00	51.9	-
14.06.2022	12:00 - 13:00	54.9	-
14.06.2022	13:00 - 14:00	60.7	-
14.06.2022	14:00 - 15:00	61.7	-
14.06.2022	15:00 - 16:00	62.5	-
14.06.2022	16:00 - 17:00	64.0	-
14.06.2022	17:00 - 18:00	57.5	-
14.06.2022	18:00 - 19:00	61.8	-
14.06.2022	19:00 - 20:00	61.0	-
14.06.2022	20:00 - 21:00	54.2	-
14.06.2022	21:00 - 22:00	64.0	-

M. Hemanth
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Report No	: POEI/TR-N-3788		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	22:00 - 23:00	-	51.6
14.06.2022	23:00 - 00:00	-	50.9
15.06.2022	00:00 - 01:00	-	49.8
15.06.2022	01:00 - 02:00	-	47.5
15.06.2022	02:00 - 03:00	-	50.9
15.06.2022	03:00 - 04:00	-	51.9
15.06.2022	04:00 - 05:00	-	50.8
15.06.2022	05:00 - 06:00	-	49.8
Day Time		Leq (Day)	61.7
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	50.6
		Night Time Limit	55 dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.
In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

*** End of Report ***

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3789	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL - Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-430-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 15.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 15.06.2022
Sampling Date	: 14.06.2022 to 15.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Mugalivakkam**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Lutron/SL-4023SD	PCEI/EQ/54	15.10.2021	14.10.2022

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	06:00 - 07:00	50.9	-
14.06.2022	07:00 - 08:00	51.7	-
14.06.2022	08:00 - 09:00	64.8	-
14.06.2022	09:00 - 10:00	62.7	-
14.06.2022	10:00 - 11:00	61.9	-
14.06.2022	11:00 - 12:00	59.8	-
14.06.2022	12:00 - 13:00	60.6	-
14.06.2022	13:00 - 14:00	61.4	-
14.06.2022	14:00 - 15:00	57.9	-
14.06.2022	15:00 - 16:00	62.9	-
14.06.2022	16:00 - 17:00	64.0	-
14.06.2022	17:00 - 18:00	59.9	-
14.06.2022	18:00 - 19:00	61.2	-
14.06.2022	19:00 - 20:00	52.4	-
14.06.2022	20:00 - 21:00	49.8	-
14.06.2022	21:00 - 22:00	61.8	-

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Report No	: PCEI/TR-N-3789		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	22:00 - 23:00	-	51.6
14.06.2022	23:00 - 00:00	-	46.8
15.06.2022	00:00 - 01:00	-	51.9
15.06.2022	01:00 - 02:00	-	49.5
15.06.2022	02:00 - 03:00	-	46.8
15.06.2022	03:00 - 04:00	-	54.0
15.06.2022	04:00 - 05:00	-	51.9
15.06.2022	05:00 - 06:00	-	55.0
Day Time		Leq (Day)	60.8
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	51.8
		Night Time Limit	55 dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.
In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area [THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

*** End of Report ***

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TEST REPORT

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Report No	: PCEI/TR-N-3790	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-431-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 15.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 15.06.2022
Sampling Date	: 14.06.2022 to 15.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Steel Yard**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Hamsun/HD82202	PCEI/EQ/58	07.02.2022	06.02.2023

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	06:00 - 07:00	61.9	-
14.06.2022	07:00 - 08:00	59.4	-
14.06.2022	08:00 - 09:00	57.2	-
14.06.2022	09:00 - 10:00	68.9	-
14.06.2022	10:00 - 11:00	61.5	-
14.06.2022	11:00 - 12:00	65.0	-
14.06.2022	12:00 - 13:00	57.2	-
14.06.2022	13:00 - 14:00	56.2	-
14.06.2022	14:00 - 15:00	49.8	-
14.06.2022	15:00 - 16:00	58.2	-
14.06.2022	16:00 - 17:00	59.7	-
14.06.2022	17:00 - 18:00	54.6	-
14.06.2022	18:00 - 19:00	64.3	-
14.06.2022	19:00 - 20:00	61.5	-
14.06.2022	20:00 - 21:00	49.2	-
14.06.2022	21:00 - 22:00	57.2	-

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Report No	: PCEI/TR-N-3790		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	22:00 - 23:00	-	51.9
14.06.2022	23:00 - 00:00	-	52.4
15.06.2022	00:00 - 01:00	-	49.8
15.06.2022	01:00 - 02:00	-	47.2
15.06.2022	02:00 - 03:00	-	46.8
15.06.2022	03:00 - 04:00	-	48.5
15.06.2022	04:00 - 05:00	-	51.6
15.06.2022	05:00 - 06:00	-	53.8
Day Time		Leq (Day)	61.6
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	50.9
		Night Time Limit	55 dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.
In the following Noise results. The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

***** End of Report *****

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3791	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-432-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 15.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 15.06.2022
Sampling Date	: 14.06.2022 to 15.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Batching Plant**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Hemsun/HDB22011	PCEI/EQ/99	07.02.2022	06.02.2023

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	06:00 - 07:00	61.9	-
14.06.2022	07:00 - 08:00	63.4	-
14.06.2022	08:00 - 09:00	58.7	-
14.06.2022	09:00 - 10:00	61.7	-
14.06.2022	10:00 - 11:00	63.8	-
14.06.2022	11:00 - 12:00	64.8	-
14.06.2022	12:00 - 13:00	49.5	-
14.06.2022	13:00 - 14:00	57.6	-
14.06.2022	14:00 - 15:00	50.8	-
14.06.2022	15:00 - 16:00	55.0	-
14.06.2022	16:00 - 17:00	61.8	-
14.06.2022	17:00 - 18:00	57.6	-
14.06.2022	18:00 - 19:00	62.7	-
14.06.2022	19:00 - 20:00	63.7	-
14.06.2022	20:00 - 21:00	62.2	-
14.06.2022	21:00 - 22:00	57.8	-

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Report No	: PCEI/TR-N-3791		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	22:00 - 23:00	-	51.6
14.06.2022	23:00 - 00:00	-	53.7
15.06.2022	00:00 - 01:00	-	50.7
15.06.2022	01:00 - 02:00	-	48.9
15.06.2022	02:00 - 03:00	-	57.8
15.06.2022	03:00 - 04:00	-	55.0
15.06.2022	04:00 - 05:00	-	46.8
15.06.2022	05:00 - 06:00	-	45.2
Day Time		Leq (Day)	61.2
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	52.9
		Night Time Limit	55 dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.
In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

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TEST REPORT

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Report No	: PCEI/TR-N-3792	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-433-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 16.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 16.06.2022
Sampling Date	: 15.06.2022 to 16.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Vanuvampet**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Lutron/SL-4023SD	PCEI/EQ/05	07.02.2022	06.02.2023

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
15.06.2022	06:00 - 07:00	59.8	-
15.06.2022	07:00 - 08:00	61.4	-
15.06.2022	08:00 - 09:00	62.0	-
15.06.2022	09:00 - 10:00	58.7	-
15.06.2022	10:00 - 11:00	59.8	-
15.06.2022	11:00 - 12:00	61.4	-
15.06.2022	12:00 - 13:00	62.7	-
15.06.2022	13:00 - 14:00	63.8	-
15.06.2022	14:00 - 15:00	49.7	-
15.06.2022	15:00 - 16:00	55.8	-
15.06.2022	16:00 - 17:00	59.8	-
15.06.2022	17:00 - 18:00	54.6	-
15.06.2022	18:00 - 19:00	63.8	-
15.06.2022	19:00 - 20:00	64.8	-
15.06.2022	20:00 - 21:00	61.1	-
15.06.2022	21:00 - 22:00	54.8	-

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Report No	: PCEI/TR-N-3792		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
15.06.2022	22:00 - 23:00	-	54.0
15.06.2022	23:00 - 00:00	-	51.2
16.06.2022	00:00 - 01:00	-	49.5
16.06.2022	01:00 - 02:00	-	47.5
16.06.2022	02:00 - 03:00	-	50.2
16.06.2022	03:00 - 04:00	-	53.4
16.06.2022	04:00 - 05:00	-	49.0
16.06.2022	05:00 - 06:00	-	50.4
Day Time		Leq (Day)	61.0
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	51.1
		Night Time Limit	55 dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.
In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

*** End of Report ***

Verified By

Authorised Signatory

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3793	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar.		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-434-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 16.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 16.06.2022
Sampling Date	: 15.06.2022 to 16.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Koyampet**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Hemsun/HD82202	PCEI/EQ/79	07.02.2022	06.02.2023

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
15.06.2022	06:00 - 07:00	64.8	-
15.06.2022	07:00 - 08:00	54.9	-
15.06.2022	08:00 - 09:00	57.0	-
15.06.2022	09:00 - 10:00	62.5	-
15.06.2022	10:00 - 11:00	60.3	-
15.06.2022	11:00 - 12:00	64.8	-
15.06.2022	12:00 - 13:00	59.7	-
15.06.2022	13:00 - 14:00	58.7	-
15.06.2022	14:00 - 15:00	51.4	-
15.06.2022	15:00 - 16:00	59.0	-
15.06.2022	16:00 - 17:00	57.8	-
15.06.2022	17:00 - 18:00	57.6	-
15.06.2022	18:00 - 19:00	57.8	-
15.06.2022	19:00 - 20:00	56.4	-
15.06.2022	20:00 - 21:00	51.8	-
15.06.2022	21:00 - 22:00	55.6	-

M. Hariharan
Verified By

Authorised Signatory

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3793		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
15.06.2022	22:00 - 23:00	-	50.6
15.06.2022	23:00 - 00:00	-	46.2
16.06.2022	00:00 - 01:00	-	45.0
16.06.2022	01:00 - 02:00	-	53.4
16.06.2022	02:00 - 03:00	-	51.9
16.06.2022	03:00 - 04:00	-	50.7
16.06.2022	04:00 - 05:00	-	54.6
16.06.2022	05:00 - 06:00	-	53.6
Day Time		Leq (Day)	59.8
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	51.4
		Night Time Limit	55 dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.
In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

***** End of Report *****

M. Hemanth
Verified By

Authorised Signatory

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3794	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-435-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 16.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 16.06.2022
Sampling Date	: 15.06.2022 to 16.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Alandur**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Lutron/SL-4023SD	PCEI/EQ/45	07.02.2022	06.02.2023

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
15.06.2022	06:00 - 07:00	54.2	-
15.06.2022	07:00 - 08:00	57.8	-
15.06.2022	08:00 - 09:00	61.8	-
15.06.2022	09:00 - 10:00	65.9	-
15.06.2022	10:00 - 11:00	64.5	-
15.06.2022	11:00 - 12:00	62.4	-
15.06.2022	12:00 - 13:00	60.7	-
15.06.2022	13:00 - 14:00	65.4	-
15.06.2022	14:00 - 15:00	61.3	-
15.06.2022	15:00 - 16:00	60.2	-
15.06.2022	16:00 - 17:00	58.6	-
15.06.2022	17:00 - 18:00	59.7	-
15.06.2022	18:00 - 19:00	55.6	-
15.06.2022	19:00 - 20:00	64.0	-
15.06.2022	20:00 - 21:00	62.4	-
15.06.2022	21:00 - 22:00	61.1	-

Verified By

Authorised Signatory

Note: 1.The test results are only to the sample submitted for test. 2.Any Correction of the test report in full or part shall invalidate the report 3.Sample will be retained for 15 days from the date of reporting except in case of regulatory samples or specifically instructed by client. 4.Perishable samples will be discarded immediately after reporting. 5.Under no circumstances lab accepts any liability or loss/damage caused by use or misuse of test report after invoicing or issued of test report

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3794		Report Date	: 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time	
		Readings dB(A)	Readings dB(A)	
15.06.2022	22:00 - 23:00	-	50.6	
15.06.2022	23:00 - 00:00	-	42.8	
16.06.2022	00:00 - 01:00	-	53.4	
16.06.2022	01:00 - 02:00	-	51.5	
16.06.2022	02:00 - 03:00	-	52.8	
16.06.2022	03:00 - 04:00	-	50.9	
16.06.2022	04:00 - 05:00	-	46.2	
16.06.2022	05:00 - 06:00	-	49.9	
Day Time		Leq (Day)	62.0	
		Day Time Limit	65 dB(A)	
Night Time		Leq (Night)	50.7	
		Night Time Limit	55 dB(A)	

Notes

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.
In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

***** End of Report *****

Verified By

Authorised Signatory

TEST REPORT

SAMPLE DRAWN BY LABORATORY

TC 8057

Issued to:
M/s. KEC International,
CMRC,Phase - 2, Sholinganallur.

Report Number	:	BV/CHEN/22/05/4072-007	Report Date	:	12.05.2022
Internal Sample Number	:	899905	Page	:	1 of 1
Sample Details:					
Product Name	:	Ambient Noise Level	Received on	:	04.05.2022
Sample description	:	Noise Level Measurement	**Analysis :**		
Location	:	Near TP - 3, Kovilambakkam	Commenced on	:	10.05.2022
Sample drawn by	:	Lab Rep: Mr. N.P Ilango	Completed on	:	11.05.2022
Sampling Date	:	02&03.05.2022			
Sampling Protocol	:	IS 9989 : 1981			

TIME	RESULTS LAVG dB(A)
10.00 AM	71.6
11.00 AM	73.3
12.00 PM	74.9
01.00 PM	71.0
02.00 PM	74.0
03.00 PM	69.8
04.00 PM	70.1
05.00 PM	66.6
06.00 PM	68.3
07.00 PM	69.8
08.00 PM	71.1
09.00 PM	74.0
10.00 PM	70.9
11.00 PM	63.5
12.00 AM	69.8
01.00 AM	66.3
02.00 AM	67.5
03.00 AM	68.8
04.00 AM	67.1
05.00 AM	65.2
06.00 AM	69.3
07.00 AM	72.5
08.00 AM	74.8
09.00 AM	73.0
10.00 AM	74.5

** The Gazette of India : Extraordinary [Part II – Sec.3 (ii)] under Ministry of Environment & Forests Notification with respect to Noise as per The Noise Pollution (Regulation and Control) (Amendment) Rules, 2010. 6.00 AM to 10.00 PM – 75 dBA (Max) 10.00PM to 06.00 AM – 70 dBA (Max)

.....End.....

Report Prepared By : S.Aadhavan

Authorised Signatory

M.RAMESH
MANAGER

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Phase III, Ekkattuthangal, Guindy, Chennai-600 032.
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SI No. : 09590/ 2022-23

TEST REPORT

SAMPLE DRAWN BY LABORATORY

TC 8057

Issued to:
M/s. KEC International,
CMRC,Phase - 2, Sholinganallur.

Report Number	:	BV/CHEN/22/05/4072-008	Report Date	:	12.05.2022
Internal Sample Number	:	899908	Page	:	1 of 1
Sample Details:					
Product Name	:	Ambient Noise Level	Received on	:	04.05.2022
Sample description	:	Noise Level Measurement	Analysis :		
Location	:	Near Batching Plant-Kovilambakkam	Commenced on	:	10.05.2022
Sample drawn by	:	Lab Rep: Mr. N.P Ilango	Completed on	:	11.05.2022
Sampling Date	:	02&03.05.2022			
Sampling Protocol	:	IS 9989 : 1981			

TIME	RESULTS LAVG dB(A)
09.50 AM	63.1
10.50 AM	60.7
11.50 AM	62.3
12.50 PM	64.4
01.50 PM	61.9
02.50 PM	66.8
03.50 PM	69.2
04.50 PM	67.5
05.50 PM	63.8
06.50 PM	60.0
07.50 PM	61.8
08.50 PM	64.3
09.50 PM	62.1
10.50 PM	64.4
11.50 PM	60.0
12.50 AM	62.2
01.50 AM	64.7
02.50 AM	67.8
03.50 AM	63.2
04.50 AM	67.7
05.50 AM	60.1
06.50 AM	61.1
07.50 AM	74.3
08.50 AM	72.2
09.50 AM	70.6

** The Gazette of India : Extraordinary [Part II – Sec.3 (ii)] under Ministry of Environment & Forests Notification with respect to Noise as per The Noise Pollution (Regulation and Control) (Amendment) Rules, 2010. 6.00 AM to 10.00 PM – 75 dBA (Max) 10.00PM to 06.00 AM – 70 dBA (Max)

.....End.....

Report Prepared By : S.Arunbabu

Authorised Signatory

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Sl No. : 09591/ 2022-23

TEST REPORT

SAMPLE DRAWN BY LABORATORY

TC 8057

Issued to:
M/s. KEC International,
CMRC,Phase - 2, Sholinganallur.

Report Number	:	BV/CHEN/22/05/4072-009	Report Date	:	12.05.2022
Internal Sample Number	:	899907	Page	:	1 of 1
Sample Details:					
Product Name	:	Ambient Noise Level	Received on	:	04.05.2022
Sample description	:	Noise Level Measurement	**Analysis :**		
Location	:	Near TP - 6 CMRL Main Office	Commenced on	:	10.05.2022
Sample drawn by	:	Lab Rep: Mr. N.P Ilango	Completed on	:	11.05.2022
Sampling Date	:	02&03.05.2022			
Sampling Protocol	:	IS 9989 : 1981			

TIME	RESULTS LAVG dB(A)
09.40 AM	71.1
10.40 AM	73.4
11.40 AM	70.6
12.40 PM	74.9
01.40 PM	70.8
02.40 PM	71.0
03.40 PM	73.3
04.40 PM	69.8
05.40 PM	67.1
06.40 PM	66.6
07.40 PM	66.3
08.40 PM	67.4
09.40 PM	62.3
10.40 PM	66.4
11.40 PM	62.1
12.40 AM	60.5
01.40 AM	64.3
02.40 AM	65.7
03.40 AM	61.9
04.40 AM	66.9
05.40 AM	63.3
06.40 AM	67.4
07.40 AM	65.8
08.40 AM	69.2
09.40 AM	71.7

** The Gazette of India : Extraordinary [Part II – Sec.3 (ii)] under Ministry of Environment & Forests Notification with respect to Noise as per The Noise Pollution (Regulation and Control) (Amendment) Rules, 2010. 6.00 AM to 10.00 PM – 75 dBA (Max) 10.00PM to 06.00 AM – 70 dBA (Max)

.....End.....

Report Prepared By : S.Anathanesu

Authorised Signatory
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Sl No. : 99592/ 2022-23

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TEST REPORT

SAMPLE DRAWN BY LABORATORY

TC 8057

Issued to:
M/s. KEC International,
CMRC,Phase - 2, Sholinganallur.

Report Number	:	BV/CHEN/22/05/4072-010	Report Date	:	12.05.2022
Internal Sample Number	:	899908	Page	:	1 of 1
Sample Details:					
Product Name	:	Ambient Noise Level	Received on	:	04.05.2022
Sample description	:	Noise Level Measurement	**Analysis :**		
Location	:	Near TP - 8 Elcot Sholinganallur	Commenced on	:	10.05.2022
Sample drawn by	:	Lab Rep: Mr. N.P Ilango	Completed on	:	11.05.2022
Sampling Date	:	02&03.05.2022			
Sampling Protocol	:	IS 9989 : 1981			

TIME	RESULTS LAVG dB(A)
10.10 AM	67.4
11.10 AM	65.9
12.10 PM	70.5
01.10 PM	71.4
02.10 PM	69.3
03.10 PM	71.5
04.10 PM	73.6
05.10 PM	74.9
06.10 PM	73.6
07.10 PM	75.0
08.10 PM	73.9
09.10 PM	74.6
10.10 PM	70.0
11.10 PM	60.6
12.10 AM	70.0
01.10 AM	66.8
02.10 AM	69.3
03.10 AM	65.6
04.10 AM	61.8
05.10 AM	67.4
06.10 AM	66.7
07.10 AM	68.9
08.10 AM	71.8
09.10 AM	75.3
10.10 AM	71.8

** The Gazette of India : Extraordinary [Part II – Sec.3 (ii)] under Ministry of Environment & Forests Notification with respect to Noise as per The Noise Pollution (Regulation and Control) (Amendment) Rules, 2010. 6.00 AM to 10.00 PM – 75 dBA (Max) 10.00PM to 06.00 AM – 70 dBA (Max)

.....End.....

Report Prepared By : K.Ilavarasi

Authorised Signatory

M.RAMESH
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TEST REPORT

SAMPLE DRAWN BY LABORATORY

BUREAU VERITAS

TC 8057

Issued to:
M/s. KEC International,
CMRC,Phase - 2, Sholinganallur.

Report Number	:	BV/CHEN/22/05/4072-011	Report Date	:	12.05.2022
Internal Sample Number	:	899909	Page	:	1 of 1

Sample Details:

Product Name	:	Ambient Noise Level	Received on	:	04.05.2022
Sample description	:	Noise Level Measurement	**Analysis :**		
Location	:	Near Casting Yard Office Area - Kolapakkam	Commenced on	:	10.05.2022
Sample drawn by	:	Lab Rep: Mr. N.P Ilango	Completed on	:	11.05.2022
Sampling Date	:	02&03.04.2022			
Sampling Protocol	:	IS 9989 : 1981			

TIME	RESULTS LAVG dB(A)
09.00 AM	63.3
10.00 AM	60.7
11.00 AM	59.9
12.00 PM	64.8
01.00 PM	61.6
02.00 PM	66.3
03.00 PM	62.4
04.00 PM	65.8
05.00 PM	63.4
06.00 PM	67.9
07.00 PM	65.3
08.00 PM	68.4
09.00 PM	70.3
10.00 PM	65.1
11.00 PM	63.3
12.00 AM	60.1
01.00 AM	62.4
02.00 AM	64.8
03.00 AM	66.6
04.00 AM	69.3
05.00 AM	61.1
06.00 AM	63.8
07.00 AM	74.1
08.00 AM	71.8
09.00 AM	72.5

** The Gazette of India : Extraordinary [Part II – Sec.3 (ii)] under Ministry of Environment & Forests Notification with respect to Noise as per The Noise Pollution (Regulation and Control) (Amendment) Rules, 2010. 6.00 AM to 10.00 PM – 75 dBA (Max) 10.00PM to 06.00 AM – 70 dBA (Max)

……………………End……………………

Report Prepared By : S.Asaikumbi

Authorised Signatory

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Sl No. : 09594/ 2022-23

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3749	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larsen & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-390-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 15.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 15.06.2022
Sampling Date	: 14.06.2022 to 15.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **DLF**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Lutron/SL-4023SD	PCEI/EQ/45	07.02.2022	06.02.2023

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	06:00 - 07:00	58.0	-
14.06.2022	07:00 - 08:00	60.3	-
14.06.2022	08:00 - 09:00	59.1	-
14.06.2022	09:00 - 10:00	57.8	-
14.06.2022	10:00 - 11:00	56.6	-
14.06.2022	11:00 - 12:00	58.4	-
14.06.2022	12:00 - 13:00	54.3	-
14.06.2022	13:00 - 14:00	58.1	-
14.06.2022	14:00 - 15:00	59.8	-
14.06.2022	15:00 - 16:00	59.5	-
14.06.2022	16:00 - 17:00	65.3	-
14.06.2022	17:00 - 18:00	63.8	-
14.06.2022	18:00 - 19:00	64.3	-
14.06.2022	19:00 - 20:00	62.5	-
14.06.2022	20:00 - 21:00	59.2	-
14.06.2022	21:00 - 22:00	54.0	-

Verified By

Authorised Signatory

Note: 1.The test results are only to the sample submitted for test. 2.Any Correction of the test report in full or part shall invalidate the report. 3.Sample will be retained for 15 days from the date of reporting except in case of regulatory samples or specifically instructed by client. 4.Perishable samples will be discarded immediately after reporting. 5.Under no circumstances lab accepts any liability or loss/damage caused by use or misuse of test report after invoicing or issued of test report

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Web : www.pollucareindia.com

TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: POEI/TR-N-3749		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	22:00 - 23:00	-	51.6
14.06.2022	23:00 - 00:00	-	51.1
15.06.2022	00:00 - 01:00	-	44.7
15.06.2022	01:00 - 02:00	-	48.0
15.06.2022	02:00 - 03:00	-	47.3
15.06.2022	03:00 - 04:00	-	46.2
15.06.2022	04:00 - 05:00	-	48.9
15.06.2022	05:00 - 06:00	-	49.2
Day Time		Leq (Day)	60.6
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	48.9
		Night Time Limit	55 dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))

Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)

1.Day time shall mean from 6.00 a.m. to 10.00 p.m.

2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.

In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

***** End of Report *****

Verified By

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3750	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-391-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 15.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 15.06.2022
Sampling Date	: 14.06.2022 to 15.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Sathiya Nagar**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Lutron/SL-4023SD	PCEI/EQ/05	07.02.2022	06.02.2023

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	06:00 - 07:00	54.8	-
14.06.2022	07:00 - 08:00	56.6	-
14.06.2022	08:00 - 09:00	54.0	-
14.06.2022	09:00 - 10:00	59.0	-
14.06.2022	10:00 - 11:00	61.6	-
14.06.2022	11:00 - 12:00	63.1	-
14.06.2022	12:00 - 13:00	58.0	-
14.06.2022	13:00 - 14:00	57.3	-
14.06.2022	14:00 - 15:00	56.7	-
14.06.2022	15:00 - 16:00	55.1	-
14.06.2022	16:00 - 17:00	62.7	-
14.06.2022	17:00 - 18:00	63.3	-
14.06.2022	18:00 - 19:00	58.5	-
14.06.2022	19:00 - 20:00	56.2	-
14.06.2022	20:00 - 21:00	54.0	-
14.06.2022	21:00 - 22:00	52.6	-

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3750		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	22:00 - 23:00	-	50.8
14.06.2022	23:00 - 00:00	-	47.5
15.06.2022	00:00 - 01:00	-	47.6
15.06.2022	01:00 - 02:00	-	45.4
15.06.2022	02:00 - 03:00	-	45.6
15.06.2022	03:00 - 04:00	-	46.4
15.06.2022	04:00 - 05:00	-	48.8
15.06.2022	05:00 - 06:00	-	50.2
Day Time		Leq (Day)	59.0
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	48.2
		Night Time Limit	55dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.
In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

*** End of Report ***

Verified By

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3751	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-392-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 15.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 15.06.2022
Sampling Date	: 14.06.2022 to 15.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Chennai Trade Centre**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Hemsun/HD82202	PCEI/EQ/97	07.02.2022	06.02.2023

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	06:00 - 07:00	58.8	-
14.06.2022	07:00 - 08:00	58.2	-
14.06.2022	08:00 - 09:00	58.7	-
14.06.2022	09:00 - 10:00	56.8	-
14.06.2022	10:00 - 11:00	62.0	-
14.06.2022	11:00 - 12:00	63.6	-
14.06.2022	12:00 - 13:00	59.7	-
14.06.2022	13:00 - 14:00	61.8	-
14.06.2022	14:00 - 15:00	62.4	-
14.06.2022	15:00 - 16:00	63.2	-
14.06.2022	16:00 - 17:00	62.8	-
14.06.2022	17:00 - 18:00	61.9	-
14.06.2022	18:00 - 19:00	58.6	-
14.06.2022	19:00 - 20:00	58.1	-
14.06.2022	20:00 - 21:00	56.8	-
14.06.2022	21:00 - 22:00	54.8	-

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3751		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	22:00 - 23:00	-	49.1
14.06.2022	23:00 - 00:00	-	51.0
15.06.2022	00:00 - 01:00	-	52.7
15.06.2022	01:00 - 02:00	-	46.6
15.06.2022	02:00 - 03:00	-	44.8
15.06.2022	03:00 - 04:00	-	44.1
15.06.2022	04:00 - 05:00	-	48.4
15.06.2022	05:00 - 06:00	-	50.2
Day Time		Leq (Day)	60.6
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	49.2
		Night Time Limit	55 dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000, Schedule (as amended till 10/08/2017 vide.S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015,
In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide.S.O.2555(E))

***** End of Report *****

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3752	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Atmospheric Pollution
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: IS 9989 – 1981 (RA 2008)		
Sampled by	: Laboratory Representative - Mr.Muthukumar		
Sample Description	: Noise Monitoring	**Sample Reference No**	: PCEI/N-393-06-22
Category of Area	: **Commercial Area**	**Sample Received On**	: 15.06.2022
Equipment Installed	: **1.5 m from Ground Level**	**Test Commenced On**	: 15.06.2022
Sampling Date	: 14.06.2022 to 15.06.2022	**Test Completed On**	: 22.06.2022
Sampling Location	: **Casting yard**		

EQUIPMENT USED FOR SAMPLING

Equipment Name	Make/Model	Equipment ID	Calibration Date	Due Date
Sound Level Meter with Data Logger	Hemsun/HDB2202	PCEI/EQ/79	07.02.2022	06.02.2023

Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	06:00 - 07:00	51.6	-
14.06.2022	07:00 - 08:00	50.5	-
14.06.2022	08:00 - 09:00	55.9	-
14.06.2022	09:00 - 10:00	53.2	-
14.06.2022	10:00 - 11:00	55.6	-
14.06.2022	11:00 - 12:00	50.7	-
14.06.2022	12:00 - 13:00	53.4	-
14.06.2022	13:00 - 14:00	53.9	-
14.06.2022	14:00 - 15:00	55.2	-
14.06.2022	15:00 - 16:00	51.6	-
14.06.2022	16:00 - 17:00	50.0	-
14.06.2022	17:00 - 18:00	55.0	-
14.06.2022	18:00 - 19:00	52.4	-
14.06.2022	19:00 - 20:00	51.2	-
14.06.2022	20:00 - 21:00	49.7	-
14.06.2022	21:00 - 22:00	49.3	-

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-N-3752		Report Date : 22.06.2022
Sampling Date	Sampling Time	Day Time	Night Time
		Readings dB(A)	Readings dB(A)
14.06.2022	22:00 - 23:00	-	51.4
14.06.2022	23:00 - 00:00	-	52.5
15.06.2022	00:00 - 01:00	-	47.3
15.06.2022	01:00 - 02:00	-	48.1
15.06.2022	02:00 - 03:00	-	40.1
15.06.2022	03:00 - 04:00	-	40.8
15.06.2022	04:00 - 05:00	-	42.9
15.06.2022	05:00 - 06:00	-	44.8
Day Time		Leq (Day)	53.0
		Day Time Limit	65 dB(A)
Night Time		Leq (Night)	48.0
		Night Time Limit	55 dB(A)

Note:

Limit as per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000; Schedule (as amended till 10/08/2017 vide S.O.2555(E))
Ambient Air Quality Standards in respect of Noise in Commercial Area Daytime 65 dB(A) & Night Time 55 dB(A)
1.Day time shall mean from 6.00 a.m. to 10.00 p.m.
2.Night time shall mean from 10.00 p.m. to 6.00 a.m

INTERPRETATION:

The Noise level were monitored as per IS 9989-1981 and CPCB Protocol for Ambient Noise Level Monitoring, Jul 2015.
In the following Noise results, The Day time and Night time Noise levels meets the NAAQS for Noise levels for Commercial Area (THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000) (as amended till 10/08/2017 vide S.O.2555(E))

***** End of Report *****

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7-4. Soil

J.M. EnviroLab Pvt. Ltd.
INTERNATIONAL ENVIRONMENTAL RESEARCH AND DEVELOPMENT CENTRE
Environmental, Mineral & Food Testing Laboratory
Accredited from MoEF-EPA (Govt. of India), NABL, MSME, NSIC, ISO 9001 : 2008, ISO 14001 : 2004 & OHSAS 18001 : 2007
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TEST REPORT

Sample Number	: JME/S/RL/10	Report No.	: JME/S/160801010
Name & Address of Unit	: M/s Rites Limited Rites Bhawan No. 1, Sector-29, Gurgaon (HR)-122001 (Chennai Metro Rail Project Phase-II)		: 5.10 F-05
Sample Description	: SOIL	Party Reference No.	Nil
Sampling Location	: Alwar Thiru Nagar Junction	Reporting Date	: 10/08/2016
Client Representative (Name & Designation)	: Mr.Sanjay Raut (Manager)	Receipt Date	: 01/08/2016
Sample collected by (Name & Designation)	Baby	Sampling Date	: -
		Sampling Type	: —
Latitude	: —	Sample Quantity	: 2.0 Kg
Longitude	: —	Depth of Sampling	:
Sampling & Analysis Protocol	: IS-2720,USDA,Method Manual of Soil Testing in Ind.	Packing Status	: Temp.Sealed

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
1	pH (at 25.0C)(1:2.5 soil water sus.)	IS : 2720 (P-26,1987)	7.11	-
2	Conductivity(1:2soil water sus.)	IS:14767,2000	0.19	mS/cm
3	Chloride	USDA :1954 Reaffirmed 2010(Page-133)	24.79	mg/kg
4	Available Phosphorus	Method manual of soil Testing in India,(Dept. of Ag.,& Co.Ministry of Ag.Govt.of Ind.)2011,4.6.3(13)	28.24	kg. /hec.
5	Total Zinc as Zn	JMELPL/STOP/02(37)	12.35	mg/kg
6	Manganese as Mn	JMELPL/STOP/02(37)	166.32	mg/kg
7	Total Lead as Pb	JMELPL/STOP/02(37)	9.85	mg/kg
8	Total Copper as Cu	JMELPL/STOP/02(37)	14.82	mg/kg
9	Organic Carbon	IS:2720 (P-22, 1972)	0.73	%
10	Water Soluble Sulphate	USDA :1954 Reaffirmed 2010(	20.12	mg/kg
11	Boron	USDA :1954 Reaffirmed 2010(	1.86	mg/kg
12	Iron	USDA :1954 Reaffirmed 2010(	420.37	mg/kg
13	Nikel	USDA :1954 Reaffirmed 2010(	18.27	mg/kg
14	Bicarbonates	USDA :1954 Reaffirmed 2010(	125.69	mg/kg
15	Calcium	Method manual of soil Testing in india, (Department of Ag.,and Corporation Ministry of Ag. Govt.of I	140.09	mg/kg
16	Magnesium	Method manual of soil Testing in india, (Department of Ag.,and Corporation	27.28	mg/kg

Tested by   Checked by   Authorized Signatory

Note:
1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]

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Environmental, Mineral & Food Testing Laboratory

Accredited from MoEF-EPA (Govt. of India), NABL, MSME, NSIC, ISO 9001 : 2008, ISO 14001 : 2004 & OHSAS 18001 : 2007

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TEST REPORT

Sample Number : JME/S/RL/10 Report No. : JME/S/1508001010

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
16		Ministry of Ag. Govt.of I		
17	Sand	USDA :1964 Reaffirmed 2010\	34.93	%
18	Silt	USDA :1954 Reaffirmed 2010\	38.88	%
19	Clay	USDA :1954 Reaffirmed 2010\	26.19	%
20	Sodium	USDA :1954 Reaffirmed 2010\	56.45	mg/kg
21	Potassium	Method manual of soil Testing in india, (Department of Ag.,and Corporation Ministry of Ag. Govt.of I	70.16	kg. /hec.
22	Sulphur	USDA :1954 Reaffirmed 2010\	29.15	kg. /hec.
23	Organic Matter	IS:2720 (P-22, 1972) 2001	1.26	%
24	Orthophosphate	USDA :1954 Reaffirmed 2010\	70.65	mg/kg
25	Carbonates	USDA :1954 Reaffirmed 2010\	2.99	mg/kg
25	Arsenic	JMELPL/STOP/02(37)	BDL(DL-0.05mg/kg)	mg/kg
27	Mercury	USDA :1954 Reaffirmed 2010\	BDL(DL-0.1mg/kg)	mg/kg
28	Cadmium as Cd	JMELPL/STOP/02(37)	1.24	mg/kg
29	Molybdenum	USDA :1954 Reaffirmed 2010\	0.60	mg/kg
30	Available Nitrogen	IS:14684, 1999	199.97	kg. /hec.

End of Report

Tested by Checked by Authorized Signatory

Note:

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Approved from MoEF-EPA, Haryana State Pollution Control Board & Certified ISO 9001:2008, ISO 14001:2015, OHSAS 18001:2007

TEST REPORT

Sample Number	: JME/R/TES/S/02	Report No	: JME/S/180516002
Name & Address of Unit	: M/s.RITES Limited RITES Bhawan No.-1, Sector-29, Gurgaon-122001 (HR)		5.10 F-05
Sample Description	: SOIL	Party Reference No.	Nil
Sampling Location	: Palur Jn	Reporting Date	23/05/2018
Client Representative (Name & Designation)	: Mr. Manish Indurkar (Assistant Manager/UE)	Receipt Date	16/05/2018
Sample collected by (Name & Designation)	: Party	Sampling Date	- -
Latitude	: ----	Sampling Type	–
Longitude	: ----	Sample Quantity	2.0 kg.
Sampling & Analysis Protocol	: IS-2720,USDA,Method Manual of Soil Testing in Ind.	Depth of Sampling	–
		Packing Status	Temp. Seald Packed

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
1	pH (at 25°C)(1:2.5 soil water sus.)	IS : 2720 (P-26,1987)	8.05	-
2	Conductivity(1:2soil water sus.)	IS:14767,2000	0.24	mS/cm
3	Chloride	USDA :1954 Reaffirmed 2010(Page-133)	359.93	mg/kg
4	Available Phosphorus	Method manual of soil Testing in India,(Dept. of Ag.,& Co.Ministry of Ag.Govt.of Ind.)2011,4.6.3(13)	24.60	kg. /hec.
5	Total Zinc as Zn	JMELPL/STOP/02(37)	68.14	mg/kg
6	Manganese as Mn	JMELPL/STOP/02(37)	141.38	mg/kg
7	Total Lead as Pb	JMELPL/STOP/02(37)	BDL(DL: 5.0)	mg/kg
8	Total Copper as Cu	JMELPL/STOP/02(37)	14.80	mg/kg
	Organic Carbon	IS:2720 (P-22, 1972)	0.35	%
10	Water Soluble Sulphate	USDA :1954 Reaffirmed 2010\	40.16	mg/kg
11	Boron	USDA :1954 Reaffirmed 2010\	1.66	mg/kg
12	Iron	USDA :1954 Reaffirmed 2010\	1299.51	mg/kg
13	Nikel	USDA :1954 Reaffirmed 2010\	BDL(DL: 5.0)	mg/kg
14	Bicarbonates	USDA :1954 Reaffirmed 2010\	158.44	mg/kg
15	Calcium	Method manual of soil Testing in India, (Department of Ag.,and Corporation Ministry of Ag. Govt.of I	480.96	mg/kg
16	Magnesium	Method manual of soil Testing in India, (Department of Ag.,and Corporation	41.34	mg/kg

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TEST REPORT

Sample Number : JME/RITES/S/02

Report No : JME/S/180516002

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
16		Ministry of Ag. Govt.of I		
17	Sand	USDA :1954 Reaffirmed 2010\	32.97	%
18	Silt	USDA :1954 Reaffirmed 2010\	59.34	%
19	Clay	USDA :1954 Reaffirmed 2010\	7.69	%
20	Sodium	USDA :1954 Reaffirmed 2010\	129.33	mg/kg
21	Potassium	Method manual of soil Testing in India, (Department of Ag.,and Corporation Ministry of Ag. Govt.of I	271.60	kg /hec
22	Sulphur	USDA :1954 Reaffirmed 2010\	42.55	kg /hec
23	Organic Matter	IS:2720 (P-22, 1972) 2001	0.60	%
24	Orthophosphate	USDA :1954 Reaffirmed 2010\	5.80	mg/kg
25	Carbonates	USDA :1954 Reaffirmed 2010\	10.20	mg/kg
26	Arsenic	JMELPL/STOP/02(37)	BDL(DL 0.5)	mg/kg
27	Mercury	USDA :1954 Reaffirmed 2010\	BDL(DL 0.6)	mg/kg
28	Cadmium as Cd	JMELPL/STOP/02(37)	BDL(DL 5.0)	mg/kg
29	Molybdenum	USDA :1954 Reaffirmed 2010\	BDL(DL 5.0)	mg/kg
30	Available Nitrogen	IS:14684, 1999	172.50	kg /hec

End of Report

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TEST REPORT

Sample Number	JME/S/RL/09	Report No	JME/S/160801009
Name & Address of Unit	M/s.Rites Limited Rites Bhawan No. 1, Sector-29, Gurgaon (HR)-122001 (Chennai Metro Rail Project Phase-II)		5.10 F-05
Sample Description	SOIL	Party Reference No.	Nil
Sampling Location	MIOT Hospital	Reporting Date	10/08/2016
Client Representative (Name & Designation)	Mr.Sanjay Raut (Manager)	Receipt Date	01/08/2016
Sample collected by (Name & Designation)	Party	Sampling Date	-
		Sampling Type	---
Latitude	--	Sample Quantity	2.0 Kg
Longitude	--	Depth of Sampling	
Sampling & Analysis Protocol	IS-2720,USDA,Method Manual of Soil Testing in Ind.	Packing Status	Temp.Sealed

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
1	pH (at 25.0C)(1:2.5 soil water sus.)	IS : 2720 (P-26,1987)	7.75	-
2	Conductivity(1:2soil water sus.)	IS:14767,2000	0.22	mS/cm
3	Chloride	USDA :1954 Reaffirmed 2010(Page-133)	33.37	mg/kg
4	Available Phosphorus	Method manual of soil Testing in india,(Dept. of Ag.,& Co.Ministry of Ag.Govt.of Ind.)2011,4.8.3(13)	25.83	kg. /hec.
5	Total Zinc as Zn	JMELPL/STOP/02(37)	12.37	mg/kg
6	Manganese as Mn	JMELPL/STOP/02(37)	190.32	mg/kg
7	Total Lead as Pb	JMELPL/STOP/02(37)	10.77	mg/kg
8	Total Copper as Cu	JMELPL/STOP/02(37)	19.45	mg/kg
9	Organic Carbon	IS:2720 (P-22, 1972)	0.63	%
10	Water Soluble Sulphate	USDA :1954 Reaffirmed 2010\	18.99	mg/kg
11	Boron	USDA :1954 Reaffirmed 2010\	2.27	mg/kg
12	Iron	USDA :1954 Reaffirmed 2010\	446.5	mg/kg
13	Nikel	USDA :1954 Reaffirmed 2010\	20.18	mg/kg
14	Bicarbonates	USDA :1954 Reaffirmed 2010\	136.62	mg/kg
15	Calcium	Method manual of soil Testing in india,(Department of Ag.,and Corporation Ministry of Ag. Govt.of I	160.24	mg/kg
16	Magnesium	Method manual of soil Testing in india,(Department of Ag.,and Corporation	27.98	mg/kg

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Authorized Signatory

Note:

1. [illegible] received.
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]

TUV

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TEST REPORT

Sample Number : JME/S/RL/09 Report No. : JME/S/160801009

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
16		Ministry of Ag. Govt.of I		
17	Sand	USDA :1954 Reaffirmed 2010\	31.97	%
18	Silt	USDA :1954 Reaffirmed 2010\	39.05	%
19	Clay	USDA :1954 Reaffirmed 2010\	28.98	%
20	Sodium	USDA :1954 Reaffirmed 2010\	45.56	mg/kg
21	Potassium	Method manual of soil Testing in India, (Department of Ag.,and Corporation Ministry of Ag. Govt.of I	78.03	kg. /hec.
22	Sulphur	USDA :1954 Reaffirmed 2010\	26.78	kg. /hec.
23	Organic Matter	IS:2720 (P-22, 1972) 2001	1.09	%
24	Orthophosphate	USDA :1954 Reaffirmed 2010\	67.08	mg/kg
25	Carbonates	USDA :1954 Reaffirmed 2010\	5.01	mg/kg
26	Arsenic	JMELPL/STOP/02(37)	BDL(DL-0.05mg/kg)	mg/kg
27	Mercury	USDA :1954 Reaffirmed 2010\	BDL(DL-0.1mg/kg)	mg/kg
28	Cadmium as Cd	JMELPL/STOP/02(37)	1.66	mg/kg
29	Molybdenum	USDA :1954 Reaffirmed 2010\	0.82	mg/kg
30	Available Nitrogen	IS:14684, 1999	305.36	kg /hec.

End of Report

Tested by Checked by Authorised Signatory

Note:

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015 & ISO 14001:2015

Report No	: PCEI/TR-Soil-4409	**Report Date**	: 16.12.2019
ULR No.	: ULR-TC744619000342P		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107.		
Sampling Method	: PCEI/SOP/SOIL/01		
Sampled by	: Laboratory		
Sample Collected Date	: 11.12.2019	**Sample Reference No**	: PCEI/Soil-N322-12-19
Sample Description	: **Soil**	**Sample Received On**	: 12.12.2019
Qty of Sample Received	: 2Kg	**Test Commenced On**	: 12.12.2019
Sample Condition	: Fit for Analysis	**Test Completed On**	: 16.12.2019
Sampling Location	: **Madipakkam Koot Road Junction**		

S.No	Parameters	Units	Test Method	Results
1	pH @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2002)	5.34
2	Electrical Conductivity @ 25°C	µmhos/cm	IS 14767:2000 (RA 2016)	35
3	Available Nitrogen (as N)	%	IS 5194 : 1969 (RA 2010)	0.31
4	Ortho Phosphate	mg/kg	IS: 10158:1982 (Reaff. 2003)	214
5	Potassium (as K)	mg/kg	EPA 3050 B & 7610	98
6	Boron	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	14
7	Available Nitrogen (as N)	Kg/Hec	IS: 10158:1982 (Reaff. 2003)	5813
8	Manganese (as Mn)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	16.2
9	Iron (as Fe)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	318
10	Zinc (as Zn)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	32.2
11	Copper (as Cu)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	24.3
12	Organic Matter	%	IS 2720 (Part 22) 1972 (RA 2006)	1.45
13	Lead (as Pb)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)

Verified By

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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Report No	: PCEI/TR-Soil-4409	Report Date	: 16.12.2019

S.No	Parameters	Units	Test Method	Results
14	Nickel (as Ni)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
15	Sodium (as Na)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	2154
16	Bicarbonates as HCO_3	mg/kg	PCEI/SOP/S/013	16
17	Carbonates as CO_3	mg/kg	PCEI/SOP/S/013	12.6
18	Chlorides	mg/kg	PCEI/SOP/S/006	18.3
19	Mercury	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
20	Molybdenum	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
21	Magnesium	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	38.6
22	Calcium	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	7.39
23	Organic carbon	%	IS 2720 (Part 22) 1972	0.84
24	Sulphates	mg/kg	IS 2720 (Part 27) 1977	82
25	Sulphur (S)	mg/kg	PCEI/SOP/S/045	27.4
26	Arsenic (as As)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
27	Cadmium (as Cd)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
Texture				
28	Sand	%	Manual for Soil Analysis	55.7
29	Clay	%	Manual for Soil Analysis	22
30	Silt	%	Manual for Soil Analysis	20.3

..... End of Report .....

Verified By

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

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TEST REPORT

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Report No	: PCEI/TR-Soil-4410	**Report Date**	: 16.12.2019
ULR No.	: ULR-TC744615000342JP		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method	: PCEI/SOP/SOIL/01		
Sampled by	: Laboratory		
Sample Collected Date	: 11.12.2019	**Sample Reference No**	: PCEI/Soil-N323-12-19
Sample Description	: **Soil**	**Sample Received On**	: 12.12.2019
Qty of Sample Received	: 2Kg	**Test Commenced On**	: 12.12.2019
Sample Condition	: Fit for Analysis	**Test Completed On**	: 16.12.2019
Sampling Location	: **Vellakal Bus Stop**		

S.No	Parameters	Units	Test Method	Results
1	pH @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2002)	5.94
2	Electrical Conductivity @ 25°C	umhos/cm	IS 14767:2000 (RA 2016)	61
3	Available Nitrogen (as N)	%	IS 5194 :1969 (RA 2010)	0.51
4	Ortho Phosphate	mg/kg	IS: 10158:1982 (Reaff. 2003)	12.3
5	Potassium (as K)	mg/kg	EPA 3050 B & 7610	148
6	Boron	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	24
7	Available Nitrogen (as N)	Kg/hac	IS: 10158:1982 (Reaff. 2003)	9563
8	Manganese (as Mn)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	14.3
9	Iron (as Fe)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	184
10	Zinc (as Zn)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	16.2
11	Copper (as Cu)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	14.3
12	Organic Matter	%	IS 2720 (Part 22) 1972 (RA 2006)	1.84
13	Lead (as Pb)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)

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Report No	: PCEI/TR-Soil-4410	Report Date	: 16.12.2019

S.No	Parameters	Units	Test Method	Results
14	Nickel (as Ni)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
15	Sodium (as Na)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	1430
16	Bicarbonates as HCO_3	mg/kg	PCEI/SOP/S/013	32
17	Carbonates as CO_3	mg/kg	PCEI/SOP/S/013	14
18	Chlorides	mg/kg	PCEI/SOP/S/006	68.3
19	Mercury	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
20	Molybdenum	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
21	Magnesium	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	44.3
22	Calcium	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	27.4
23	Organic carbon	%	IS 2720 (Part 22) 1972	0.86
24	Sulphates	mg/kg	IS 2720 (Part 27) 1977	16.3
25	Sulphur (S)	mg/kg	PCEI/SOP/S/045	5.46
26	Arsenic (as As)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
27	Cadmium (as Cd)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
Texture				
28	Sand	%	Manual for Soil Analysis	44.4
29	Clay	%	Manual for Soil Analysis	23
30	Silt	%	Manual for Soil Analysis	32.6

..... End of Report .....

Verified By

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TEST REPORT

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Report No	: PCEI/TR-Soil-4400	**Report Date**	: 16.12.2019
ULR No.	: ULR-TC744619000342IP		
Issued to	: **M/s Chennai Metro Rail Limited** CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107		
Sampling Method	: PCEI/SOP/SOIL/01		
Sampled by	: Laboratory		
Sample Collected Date	: 11.12.2019	**Sample Reference No**	: PCEI/Soil-N32L-12-19
Sample Description	: **Soil**	**Sample Received On**	: 12.12.2019
Qty of Sample Received	: 2Kg	**Test Commenced On**	: 12.12.2019
Sample Condition	: Fit for Analysis	**Test Completed On**	: 16.12.2019
Sampling Location	: **Near Adambakkam MRTS**		

S.No	Parameters	Units	Test Method	Results
1	pH @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2002)	6.15
2	Electrical Conductivity @ 25°C	µmhos/cm	IS 14767:2000 (RA 2016)	102
3	Available Nitrogen (as N)	%	IS: 10158:1982 (Reaff. 2003)	0.28
4	Ortho Phosphate	mg/kg	IS: 10158:1982 (Reaff. 2003)	294
5	Potassium (as K)	mg/kg	EPA 3050 B & 7610	45.6
6	Available Nitrogen (as N)	Kg/hec	IS: 10158:1982 (Reaff. 2003)	5250
7	Boron	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	0.039
8	Manganese (as Mn)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	15
9	Iron (as Fe)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	245
10	Zinc (as Zn)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	14.2
11	Copper (as Cu)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	22.3
12	Organic Matter	%	IS 2720 (Part 22) 1972 (RA 2006)	1.6
13	Lead (as Pb)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)

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Report No	: PCEI/TR/Soil-4408	Report Date	: 16.12.2019

S.No	Parameters	Units	Test Method	Results
14	Nickel (as Ni)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
15	Sodium (as Na)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	1458
16	Bicarbonates as HCO_3	mg/kg	PCEI/SOP/S/013	24.3
17	Carbonates as CO_3	mg/kg	PCEI/SOP/S/013	18.6
18	Chlorides	mg/kg	PCEI/SOP/S/006	42.6
19	Mercury	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
20	Molybdenum	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
21	Magnesium	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	24.6
22	Calcium	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	17.1
23	Organic carbon	%	IS 2720 (Part 22) 1972	0.92
24	Sulphates	mg/kg	IS 2720 (Part 27) 1977	145
25	Sulphur (S)	mg/kg	PCEI/SOP/S/045	48.4
26	Arsenic (as As)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
27	Cadmium (as Cd)	mg/kg	USEPA 3050 B: 1996 USEPA 6020B: 1996	BDL(DL:0.1)
Texture				
28	Sand	%	Manual for Soil Analysis	53.5
29	Clay	%	Manual for Soil Analysis	18
30	Silt	%	Manual for Soil Analysis	28.5

..... End of Report .....

Verified By

Authorised Signatory
Name: Krishnan G
Designation: Technical Manager

J.M. EnviroLab Pvt. Ltd.

INTERNATIONAL ENVIRONMENTAL RESEARCH AND DEVELOPMENT CENTRE

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TEST REPORT

Sample Number : JME/S/RL/12

Name & Address of Unit : M/s.Rites Limited
Rites Bhawan No. 1, Sector-29,
Gurgaon (HR)-122001
(Chennai Metro Rail Project Phase-II)

Report No. : JME/S/160801012
5.10 F-05

Sample Description : SOIL

Party Reference No: Nil

Sampling Location : Medavakkam Junction

Client Representative (Name & Designation) : Mr.Sanjay Raut (Manager)

Sample collected by (Name & Designation) : Party

Latitude : --

Longitude : --

Sampling & Analysis Protocol : IS-2720,USDA,Method Manual of Soil Testing in Ind.

Reporting Date : 10/08/2016

Receipt Date : 01/08/2016

Sampling Date : -

Sampling Type : ---

Sample Quantity : 2.0 Kg

Depth of Sampling :

Packing Status : Temp.Sealed

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
1	pH (at 25.0C)(1:2.5 soil water sus.)	IS : 2720 (P-26,1987)	7.56	-
2	Conductivity(1:2soil water sus.)	IS;14767,2000	0.25	mS/cm
3	Chloride	USDA :1954 Reaffirmed 2010(Page-133)	19.11	mg/kg
4	Available Phosphorus	Method manual of soil Testing in India,(Dept. of Ag.,& Co.Ministry of Ag.Govt.of Ind.)2011.4.6.3(13)	23.97	kg. /hec.
5	Total Zinc as Zn	JMELPL/STOP/02(37)	13.20	mg/kg
6	Manganese as Mn	JMELPL/STOP/02(37)	118.37	mg/kg
7	Total Lead as Pb	JMELPL/STOP/02(37)	11.40	mg/kg
8	Total Copper as Cu	JMELPL/STOP/02(37)	16.23	mg/kg
9	Organic Carbon	IS:2720 (P-22, 1972)	0.59	%
10	Water Soluble Sulphate	USDA :1954 Reaffirmed 2010\	22.53	mg/kg
11	Boron	USDA :1954 Reaffirmed 2010\	1.76	mg/kg
12	Iron	USDA :1954 Reaffirmed 2010\	428.23	mg/kg
13	Nikel	USDA :1954 Reaffirmed 2010\	18.21	mg/kg
14	Bicarbonates	USDA :1954 Reaffirmed 2010\	126.35	mg/kg
15	Calcium	Method manual of soil Testing in India, (Department of Ag.,and Corporation Ministry of Ag. Govt.of I	86.82	mg/kg
16	Magnesium	Method manual of soil Testing in India, (Department of Ag.,and Corporation	22.36	mg/kg

Tested by | Checked by | Authorized Signatory

Note:
1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]

1/2

JM
J.M. EnviroLab Pvt. Ltd.
INTERNATIONAL ENVIRONMENTAL RESEARCH AND DEVELOPMENT CENTRE
Environmental, Mineral & Food Testing Laboratory
Accredited from MoEF-EPA (Govt. of India), NABL, MSME, NSIC, ISO 9001 : 2008, ISO 14001 : 2004 & OHSAS 18001 : 2007
SCO-16, Sector-10A, Gurgaon-122 001 (Haryana) INDIA • TEL.: +91-124-4873400 • FAX: +91-124-4141029
E-mail: jmenvirolab@hotmail.com • Website : www.jmenvirolab.com

TEST REPORT

Sample Number : JME/S/RL/12

Report No. : JME/S/160801012

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
16		Ministry of Ag. Govt.of I		
17	Sand	USDA :1954 Reaffirmed 2010\	35.17	%
18	Silt	USDA :1954 Reaffirmed 2010\	39.06	%
19	Clay	USDA :1954 Reaffirmed 2010\	26.77	%
20	Sodium	USDA :1954 Reaffirmed 2010\	47.46	mg/kg
21	Potassium	Method manual of soil Testing in india, (Department of Ag.,and Corporation Ministry of Ag. Govt.of I	98.53	kg. /hec.
22	Sulphur	USDA :1954 Reaffirmed 2010\	26.27	kg. /hec.
23	Organic Matter	IS:2720 (P-22, 1972) 2001	1.03	%
24	Orthophosphate	USDA :1954 Reaffirmed 2010\	73.91	mg/kg
25	Carbonates	USDA :1954 Reaffirmed 2010\	5.03	mg/kg
26	Arsenic	JMELPL/STOP/02(37)	BDL(DL-0.05mg/kg)	mg/kg
27	Mercury	USDA :1954 Reaffirmed 2010\	BDL(DL-0.1mg/kg)	mg/kg
28	Cadmium as Cd	JMELPL/STOP/02(37)	1.31	mg/kg
29	Molybdenum	USDA :1954 Reaffirmed 2010\	0.69	mg/kg
30	Available Nitrogen	IS:14684, 1999	258.66	kg. /hec.

End of Report

Tested by

Checked by

Authorized Signatory

Note:

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]

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E-mail: jmenvirolab@hotmail.com • Website : www.jmenvirolab.com

TEST REPORT

Sample Number : JME/S/RL/13

Report No. : JME/S/160801013

: 5.10 F-05

Name & Address of Unit : M/s.Rites Limited
Rites Bhawan No. 1, Sector-29,
Gurgaon (HR)-122001
(Chennai Metro Rail Project Phase-II)

Sample Description : SOIL

Party Reference No. Nil

Sampling Location : Near Global Hospital

Client Representative (Name & Designation) : Mr.Sanjay Raut (Manager)

Sample collected by (Name & Designation) : Party

Latitude : --

Longitude : --

Sampling & Analysis Protocol : IS-2720,USDA,Method Manual of Soil Testing in Ind.

Reporting Date : 10/08/2016

Receipt Date : 01/08/2016

Sampling Date : --

Sampling Type : ---

Sample Quantity : 2.0 Kg

Depth of Sampling :

Packing Status : Temp.Sealed

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
1	pH (at 25 0C)(1:2.5 soil water sus.)	IS : 2720 (P-26,1987)	7.28	-
2	Conductivity(1:2soil water sus.)	IS:14767,2000	0.17	mS/cm
3	Chloride	USDA :1954 Reaffirmed 2010(Page-133)	47.67	mg/kg
4	Available Phosphorus	Method manual of soil Testing in india,(Dept. of Ag.,& Co.Ministry of Ag.Govt.of Ind.)2011,4.6.3(13)	22.16	kg. /hec.
5	Total Zinc as Zn	JMELPL/STOP/02(37)	14.36	mg/kg
6	Manganese as Mn	JMELPL/STOP/02(37)	157.08	mg/kg
7	Total Lead as Pb	JMELPL/STOP/02(37)	8.78	mg/kg
8	Total Copper as Cu	JMELPL/STOP/02(37)	16.88	mg/kg
9	Organic Carbon	IS:2720 (P-22, 1972)	0.66	%
10	Water Soluble Sulphate	USDA :1954 Reaffirmed 2010\	27.84	mg/kg
11	Boron	USDA :1954 Reaffirmed 2010\	1.33	mg/kg
12	Iron	USDA :1954 Reaffirmed 2010\	455.84	mg/kg
13	Nikel	USDA :1954 Reaffirmed 2010\	20.02	mg/kg
14	Bicarbonates	USDA :1954 Reaffirmed 2010\	126.36	mg/kg
15	Calcium	Method manual of soil Testing in india, (Department of Ag.,and Corporation Ministry of Ag. Govt.of I	76.28	mg/kg
16	Magnesium	Method manual of soil Testing in india, (Department of Ag.,and Corporation	20.36	mg/kg

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Authorized Signatory

Note:

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E-mail: jmenvirolab@hotmail.com • Website : www.jmenvirolab.com

TEST REPORT

Sample Number : JME/S/RL/13 Report No. : JME/S/160901013

TEST RESULTS

Sl. No.	Parameters	Testing Protocol	Result	Unit
16		Ministry of Ag. Govt.of I		
17	Sand	USDA :1954 Reaffirmed 2010\	35.78	%
18	Silt	USDA :1954 Reaffirmed 2010\	37.66	%
19	Clay	USDA :1954 Reaffirmed 2010\	28.56	%
20	Sodium	USDA :1954 Reaffirmed 2010\	42.32	mg/kg
21	Potassium	Method manual of soil Testing in India, (Department of Ag..and Corporation Ministry of Ag. Govt.of I	92.75	kg. /hec.
22	Sulphur	USDA :1954 Reaffirmed 2010\	19.27	kg. /hec.
23	Organic Matter	IS:2720 (P-22, 1972) 2001	1.05	%
24	Orthophosphate	USDA :1954 Reaffirmed 2010\	76.20	mg/kg
25	Carbonates	USDA :1954 Reaffirmed 2010\	3.88	mg/kg
26	Arsenic	JMELP/STOP/02(37)	BDL(DL-0.05mg/kg)	mg/kg
27	Mercury	USDA :1954 Reaffirmed 2010\	BDL(DL-0.1mg/kg)	mg/kg
28	Cadmium as Cd	JMELP/STOP/02(37)	1.36	mg/kg
29	Molybdenum	USDA :1954 Reaffirmed 2010\	0.83	mg/kg
30	Available Nitrogen	IS:14684, 1999	264.53	kg. /hec.

End of Report

Tested by Checked by Authorized Signatory

Note:

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Web : www.pollucareindia.com

TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	:PCEI/TR-Soil-3802	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	:**M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	:-		
Sampled by	:Laboratory		
Sample Collected Date	:15.06.2022	**Sample Reference No**	: PCEI/Soil-443-06-22
Sample Description	:**Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	:Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	:**Adyar River**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	6.88
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	489
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.58
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	5.83
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	1.25
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.14
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	4.26
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.14
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.15
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.18
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.59
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	2.3
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.82
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.51
15	Boron (as B)*	mg/kg	USEPA 3050 B	1.02
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.54

Note :*Mentioned Parameters are not Covered Under Our Scope

..... End of Report .....

Verified By

Authorised Signatory

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	:PCEI/TR-Soil-3803	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	:**M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	:-		
Sampled by	:Laboratory		
Sample Collected Date	:15.06.2022	**Sample Reference No**	: PCEI/Soil-444-06-22
Sample Description	:**Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	:Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	:**Mugalivakkam**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	6.91
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	501
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.7
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	6.15
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	1.34
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.18
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	4.16
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.14
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.16
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.17
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.54
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	2.19
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.57
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.46
15	Boron (as B)*	mg/kg	USEPA 3050 B	1.11
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.68

Note :*Mentioned Parameters are not Covered Under Our Scope

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TEST REPORT

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Report No	: PCEI/TR-Soil-3804	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	:-		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/Soil-445-06-22
Sample Description	: **Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Steel Yard**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	7.01
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	524
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.71
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	6.13
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	1.39
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.15
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	4.12
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.13
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.15
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.16
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.59
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	2.19
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.79
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.51
15	Boron (as B)*	mg/kg	USEPA 3050 B	1.05
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.58

Note : *Mentioned Parameters are not Covered Under Our Scope

..... End of Report .....

M. Hamsad...
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Authorised Signatory

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TEST REPORT

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Report No	:PCEI/TR-Soil-3805	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	**:M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	:-		
Sampled by	:Laboratory		
Sample Collected Date	:15.06.2022	**Sample Reference No**	: PCEI/Soil-446-06-22
Sample Description	:**Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	:**Batching Plant**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	7.12
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	511
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.73
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	5.54
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	1.19
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.16
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	4.29
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.17
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.15
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.21
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.49
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	2.28
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.76
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.43
15	Boron (as B)*	mg/kg	USEPA 3050 B	1.15
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.46

Note :*Mentioned Parameters are not Covered Under Our Scope

..... End of Report .....

Verified By

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-Soil-3806	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	:-		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/Soil-447-06-22
Sample Description	: **Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Vanuvampet**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	7.22
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	489
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.54
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	5.64
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	1.19
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.16
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	4.13
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.18
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.15
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.21
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.54
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	2.05
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.72
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.46
15	Boron (as B)*	mg/kg	USEPA 3050 B	1.16
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.54

Note :*Mentioned Parameters are not Covered Under Our Scope

..... End of Report .....

Verified By

Authorised Signatory

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TEST REPORT

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Report No	: PCEI/TR-Soil-3807	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	:-		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/Soil-448-06-22
Sample Description	: **Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Koyampet**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	6.28
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	488
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.57
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	5.28
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	1.34
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.14
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	4.16
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.17
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.15
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.22
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.54
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	2.19
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.84
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.56
15	Boron (as B)*	mg/kg	USEPA 3050 B	1.09
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.52

Note : *Mentioned Parameters are not Covered Under Our Scope

..... End of Report .....

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-Soil-3808	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	:-		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/Soil-449-06-22
Sample Description	: **Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Alandur**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	7.15
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	509
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.71
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	5.88
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	1.31
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.17
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	4.19
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.18
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.15
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.2
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.54
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	2.19
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.82
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.51
15	Boron (as B)*	mg/kg	USEPA 3050 B	1.12
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.54

Note :*Mentioned Parameters are not Covered Under Our Scope

..... End of Report .....

Verified By

Authorised Signatory

POLLUCARE ENGINEERS INDIA PVT.LTD.,
(Laboratory Services Division)
P HIG - 6152, TNHB Phase I & II,
Kamarajar Road, Ayapakkam,
Chennai - 600 077.
Ph : +91 44 2682 3190 / +91 73977 96831
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Web : www.pollucareindia.com

POLLUCARE® solution for pollution

TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-Soil-3757	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: -		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/Soil-398-06-22
Sample Description	: **Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **DLF**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	6.08
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	396
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.48
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	4.54
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	0.96
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.10
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	3.24
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.11
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.07
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.12
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.03
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	1.46
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.57
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.33
15	Boron (as B)*	mg/kg	USEPA 3050 B	0.65
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	0.97

Note :*Mentioned Parameters are not Covered Under Our Scope

..... End of Report .....

Verified By

Authorised Signatory

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-Soil-3758	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	: -		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/Soil-399-06-22
Sample Description	: **Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Sathiya Nagar**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	6.53
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	427
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.55
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	5.21
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	1.11
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.12
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	3.89
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.14
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.10
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.16
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.37
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	1.94
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.75
14	Nickel (as NI)*	mg/kg	USEPA 3050 B	0.43
15	Boron (as B)*	mg/kg	USEPA 3050 B	0.86
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.29

Note :*Mentioned Parameters are not Covered Under Our Scope

..... **End of Report** .....

Verified By

Authorised Signatory

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TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-Soil-3759	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	:-		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/Soil-400-06-22
Sample Description	: **Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Chennai Trade Centre**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	6.10
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	325
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.42
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	3.98
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	0.85
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.09
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	2.92
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.11
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.08
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.13
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.12
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	1.58
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.61
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.36
15	Boron (as B)*	mg/kg	USEPA 3050 B	0.72
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.08

Note :*Mentioned Parameters are not Covered Under Our Scope

..... **End of Report** .....

Verified By

Authorised Signatory

POLLUCARE ENGINEERS INDIA PVT.LTD.,
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Web : www.pollucareindia.com

TEST REPORT

Accredited by NABL & NABET, Certified ISO 9001:2015, ISO 14001:2015 & ISO 45001 : 2018

Report No	: PCEI/TR-Soil-3760	**Report Date**	: 22.06.2022
Discipline	: Chemical	**Group**	: Pollution & Environment
Issued to	: **M/s Larson & Toubro Limited Heavy Civil Infrastructure** CMRL- Phase 2 - Corridor 5 - ECV02 No.48,Mugalivakkam Main Road, Kamakshi Nagar,Mugalivakkam, Chennai -600 125.		
Sampling Method	:-		
Sampled by	: Laboratory		
Sample Collected Date	: 15.06.2022	**Sample Reference No**	: PCEI/Soil-401-06-22
Sample Description	: **Soil**	**Sample Received On**	: 16.06.2022
Qty of Sample Received	: 2 Kg	**Test Commenced On**	: 16.06.2022
Sample Condition	: Fit for Analysis	**Test Completed On**	: 22.06.2022
Sampling Location	: **Casting yard**		

S.No	Parameters	Units	Test Method	Results
1	pH value @ 25°C	-	IS 2720 (Part 26) 1987 (RA 2016)	6.82
2	Water Soluble Salts Electrical Conductivity @ 25°C	µS/cm	IS 14767:2000 (RA 2016)	473
3	Organic Matter	%	IS 2720 (Part 22) 1972	0.61
4	Moisture Content @105° C	%	IS 2720 (Part 2) 1973	5.79
5	Chloride (as Cl-)	meq/L	PCEI/SOP/SOIL/015	1.24
6	Sulphates	mg/kg	PCEI/SOP/SOIL/010	0.13
7	Manganese (as Mn)*	mg/kg	USEPA 3050 B	4.22
8	Copper (as Cu)*	mg/kg	USEPA 3050 B	0.16
9	Cadmium (as Cd)*	mg/kg	USEPA 3050 B	0.13
10	Lead (as Pb)*	mg/kg	USEPA 3050 B	0.19
11	Chromium (as Cr)*	mg/kg	USEPA 3050 B	1.64
12	Selenium (as Se)*	mg/kg	USEPA 3050 B	2.32
13	Arsenic (as As)*	mg/kg	USEPA 3050 B	0.90
14	Nickel (as Ni)*	mg/kg	USEPA 3050 B	0.54
15	Boron (as B)*	mg/kg	USEPA 3050 B	1.08
16	Zinc (as Zn)*	mg/kg	USEPA 3050 B	1.62

Note :*Mentioned Parameters are not Covered Under Our Scope

..... End of Report .....

Verified By

Authorised Signatory

Updated Environmental Impact Assessment

April 2024
Revision 01

India: Chennai Metro Rail Investment Project
Balance Corridor 5

Annexure 8 - 9

Prepared by the Chennai Metro Rail Limited (CMRL) for the Project Lenders.

Annexure 8. COVID-19 SOP

Chennai Metro Rail Limited

CMRL - Standard Operating Procedure (SOP)

for metro operation after restoration of metro services

1. **Preparatory Works for Commencing Operation:**

(i) It shall be ensured that all the systems are in safe and healthy condition before resumption of revenue service.

(ii) Train Operation involves systems pertaining to Electrical, S&T, Civil, Track, Rolling Stock, Traction etc. therefore its safe functionality shall be ensured before start of passenger services.

(iii) Metro personnel shall be given proper counselling so that they themselves gain confidence and handle the situation in a proper manner.

(iv) Advance planning for mobilizing staff, equipment and materials for cleaning and maintenance, pre-checks of essential equipment at stations & in trains shall be ensured.

(v) Advisories to public through electronic/print/social media to avoid unnecessary travel to manage the crowd inside stations and trains in order to maintain social distancing shall be issued be issued regularly. Necessary Do's and Don'ts shall be displayed at metro Stations/other prominent locations.

2. Train Services:

(i) Trial run shall be done on all lines before introduction of revenue services.

(ii) CMRL shall start revenue service of Line-1 from 7-9-2020 and Line -2 from 9-9-2020 with operational hours from 8:00 to 20:00 hrs and headway of 10 min. during peak hours & 15 min. during Non-peak. The services shall be reviewed based on Public response from time to time.

(iii) Number of passengers shall be regulated at the entry of the stations itself to ensure social distancing inside the trains and at stations.

(iv) Social distancing shall also be monitored through CCTV.

(v) During boarding and travel, all passengers will have to observe social distancing.

(vi) Suitable marking like 'X' shall be put on alternate seats so that passengers sit on alternate seats to ensure social distancing.

(vii) Passengers shall be advised to sit on alternate seats or stand keeping distance of 6 feet to maintain social distancing through announcements at stations, trains and awareness through social media, posters etc.

(viii) The dwelling time of trains shall be increased to 50 seconds, so that passengers have sufficient time to board and alight following social distancing. This will avoid unnecessary crowding during entry/exit into/from the train. Dwelling time may be

reviewed and suitably altered depending upon the commuter footfall. Additional Metro trains may be introduced to clear the extra rush of the commuters.

(ix) Intake of fresh air in air conditioning system of the coaches shall be increased to the extent possible so that more fresh air is available to passengers. Temperature inside the train shall be maintained in the range of 24-30 degree Celsius.

(x) The trains shall not stop at the stations falling in containment zone and such stations shall not be opened for public.

(xi) Some of the stations may be skipped to ensure proper social distancing.

(xii) Train doors shall remain open for minimum 2 minutes at terminal stations to let fresh air infuse in the train.

3. Stations:

(i) Proper functionality of the systems like lifts, escalators, AFC, Signalling and Communication etc. prior to operation for public shall be examined and checked. Proper cleanliness and hygiene shall be maintained inside the stations.

(ii) Wearing of face mask/cover shall be mandatory for all commuters during entry into the stations/trains and during the entire journey.

(iii) Use of' Aarogya Setu App' shall be encouraged at the time of entry into the station.

(iv) Social distancing shall be followed at stations by controlling the crowd at station entry points.

(v) All passengers shall be thermally screened by Security/Metro officials.

(vi) Only two gates on either side of the road shall be kept open for entry/exit. However, other gates shall remain functional for exit or entry during contingencies.

(vii) Sanitizers will be provided to all passengers at the entry points.

(Viii) Use of lifts shall be permitted only for aged and physically handicapped persons. In this regard, proper signage shall be pasted and regular sanitization of these lifts be ensured. Instructions at all lifts shall be displayed for limiting 2-3 persons per lift, depending upon the size of the lift. Foot operated switches have also been retrofitted in a few stations and such measures shall be taken in all stations.

(ix) Passengers may be advised to stand on alternate steps on escalators to maintain social distance.

4. Ticketing

(i) Cashless transactions to be encouraged to avoid spreading of COVID 19 through currency notes/coins. Use of Smart cards shall be encouraged. Smart card recharge may be done through internet or other cashless methods. Digitized transactions through available modes to be encouraged.

(ii) QR code based mobile ticketing shall be introduced to encourage contactless journey.

(iii) Tokens may be issued for single journey tickets based on demand, however such usage shall be discouraged and proper measures to sanitize before and after usage.

5. Crowd Control:

(i) Whenever excess passengers are observed in concourse or platform area, entry of the passengers at the gate may be restricted.

(ii) The areas of concentration where crowding can take place are as under:

Entry gates & Frisking area near gates

Ticket Counters, Customer Care

Ticketing Vending Machines (TVM)

AFC Gates at entry and Exit.

Lifts, Escalators & Platforms

(iii) Strip markers or any other markers on floor at interval of 6 feet to maintain social distancing at above locations shall be provided.

(iv) Additional supervisory staff shall be deployed at all stations to maintain social distancing by the passengers at crowding points. It may also be regularly monitored through OCC & Security control.

6. Cleanliness and Sanitisation:

a) Stations:

(i) All kinds of equipment and working areas, which are frequented by management/ security personnel/ commuters in Metro premises like concourse, passages, platforms, stairs, glass work, Auto Fare collection (AFC), Lifts, Escalators, Hand Rails, holding areas, Sitting areas, Shopping areas etc. shall be disinfected / sanitized and logs/ records shall be maintained accordingly.

(ii) Public toilets shall be given special attention. These shall be cleaned, disinfected more frequently as per requirement.

(iii) All human contact areas e.g. Lift buttons, Escalator hand rails, customer handling points to be disinfected frequently at stations preferably every 4 hours or earlier as per requirement.

b) Trains:

(iv) Metro trains shall be cleaned/disinfected thoroughly during non-revenue hours at depots before putting them into passenger services.

7. Heating, Ventilation and Air Conditioning (HV AC) system:

Central Public Works Department (CPWD) vide Office Memorandum No. CE CSO(E)/COVID-19/2020/028 Dated 13.05.2020 has issued "Guidelines for Running of Air Circulation, Air Cooling and Air Conditioning Equipment's during COVID-19" for guidance of field units of CPWD

Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE) has also issued guidelines for Air Conditioning and Ventilation during COVID-19. These guidelines shall strictly be adhered to.

8. Feeder Services, Parking and Shops at stations:

(i) For maintaining social distancing, adequate number of metro feeder services/ e-rickshaws for passengers shall be deployed as per local conditions and guidelines.

(ii) All the Parking spaces shall be opened.

(iii) Shops/Kiosks/Food Points at stations may be opened.

9. Safety and Security:

(i) The aspect of safety and security of Metro operation shall be ensured in accordance with the laid down direction of Government of India and as per Disaster Management Act 2005.

(ii) Under all conditions including for operation and security related issues, social distancing shall be ensured. Pre-recorded advisories to commuter to adhere to the norms of social distancing while boarding and travelling in Metro shall be played at appropriate places.

(iii) Proper PPE kit and sanitisers shall be provided to employee's/ security personnel, who are likely to be in proximate contact with commuters and for longer duration.

(iv) Availability of liquid soaps in washrooms shall be ensured

(v) Staff shall be sensitized to maintain social distancing at all times especially in crew controls, OCC and SCR

(vi) Detailed instructions containing Dos and Don'ts shall be prepared and displayed at prominent work places for educating the staff

(vii) Considering the potential of Corona to spread quickly, security personnel/ private guards Shall resort to contactless frisking of commuters.

(viii) There shall be a Q manager mechanism both at the entry and exit gates. Further, it shall be ensured that passengers should not loiter in metro premises especially between entry gates.

(ix) The security deployed at the Metro stations shall remain in touch and suitably liaise with State Police to supplement the existing security network on the emerging law and order situation.

10. Attention to suspected COVID-19 passengers

Only asymptomatic passengers shall be allowed to enter into the stations. Symptomatic passengers or those having high temperature shall not be allowed to use metro and after recording his/her contact number name and address, he/she shall be directed to report to nearest medical Centre. The details of such persons shall be communicated to local administrations also.

11. Information, Education and Communication (IEC)

(i) There shall be a detailed communication plan prior to commencing operation of services duly indicating measures being taken towards cleanliness and hygiene, screening of passengers for detecting COVID-19 symptoms, social distancing, mandatory wearing of face mask/cover, use of Arogya Setu App, supply of sanitisers to commuters at the entry of stations, Do's and Don'ts, train timing, dwelling time at stations, stopping stations, entry/exit gates to be opened etc. in English/Hindi/Local languages and circulate through Information, Education and Communication (IEC) campaign for their staff and passengers using electronic/print/social media, posters, banners, website etc.

(ii) Wide publicity shall be given suggesting passengers to carry minimum possible luggage and avoid metallic items etc.

(iii) As a part of awareness campaign, management may also formulate a mechanism of pre-recorded advisories to commuter to adhere to the norms of social distancing while boarding and travelling in Metro shall be evolved. Regular announcement in the trains and at stations shall also be made for awareness of passengers.

Annexure 9. Stakeholder Engagement Minutes

9-1. PWD

29.10.2020

Minutes of the Meeting in the Chamber of PWD

Sub: Chennai Metro Rail Ltd., - Phase II project – Elevated Corridor C-5 crossing Adyar river and Adambakkam lake.

Ref: 1. CMRL/CON/CGM(A&CM)/P2C5/P6/026/2020 dt. 08/07.2020.

In connection with the subject matter, the following officers from PWD and CMRL met today (29.10.2020) at CE, PWD WRO, Chepauk, Chennai and the following minutes are drawn.

PWD:

Sl. NO.	Name & Designation
1.	K. Asokan, CE, CR, HRD
2.	A. Muthiah, SE, Polar, HRD
3.	H. Yogapriya, AEE, HRD
4.	V. Manonmani, AE, HRD

CMRL:

Sl. No.	Name & Designation
1.	B.S Srinivas CGM(A&CM)
2.	S. Ashok Kumar GM (Tracks)
3.	A. Ramakrishnan RE (Civil)
4.	Koventhan (DDC)
5.	Anbu Ganapathy (DDC)

The elevated corridor C-5 from CMBT to Shollinganallur crosses Adyar river near Miot Hospital and also passes through Adambakkam lake . The general arrangement of elevated corridor, its pier arrangement etc., have already been shared for information by CMRL to PWD vide reference (1) above.

In this regard WRO, PWD has perused the arrangement and found it to be satisfactory. CMRL may accordingly proceed with the construction as per the arrangement submitted.

29/x/2020

PWD

CE/CR

SE/Polar

CMRL

CGM(A&CM)

9-2. Fisheries Department

Chennai Metro Rail Limited

(A Joint Venture of Govt. of India and Govt. of Tamil Nadu)

MEETING WITH TAMILNADU FISHERIES DEPARTMENT

Lr No: CMRL/CONS/ES/612/2020 **Dated: 22.10.2020**

Sir,

Sub: CMRL – Chennai Metro Rail Project – Phase II – Metro Crossing at Adyar River near MIOT Hospital – Fishing activities.

We wish to inform you that the Phase II of the Chennai Metro Rail Project Corridor 5 (C5) passes along the Mount Poonamallee High Road, the elevated viaduct of the Corridor crosses the Adyar River near MIOT Hospital with the arrangements of 8 piers within the river.

This location inspected by Environmental Team of Chennai Metro Rail Limited and found there is no fishing activities or any habitats of fishermen in the nearby vicinity. Moreover the water condition etc., are not congenial for promotion of aqua culture for this location.

This is for your kind information and for necessary instructions.

Regards,

M.Premnath 22/10/20.
Environment Specialist
CMRL, Chennai.

XXX.

Tamil Nadu Fisheries Department
Teynampet, Chennai.

Today discussed with Tamil Nadu Fisheries Department officers Namely:
1. ALAN BRINDO Additional Director Saidapet 9444054385
2. ELANGO Joint Director Thoranpet. Incharge for Chennai, Kanchipuram, Chingleput and Vellore District. 9443519820.

The Adayar River Not comes Under the Control of Tamil Nadu Fisheries Department because there is no Aqua Culture or fishing activities in this River.

23.10.20.
ES/CMRL.

CMRL Depot, Admin Building, Poonamallee High Road, (Opposite to Daniel Thomas School),
Koyambedu, Chennai - 600 107.
Phone : 23792000 Fax : 23792200
Email : chennaimetrorail@gmail.com website : chennaimetrorail.gov.in

9-3. Defense Estate Officer

Attachment ; A-6

Chennai Metro Rail Limited

(A Joint Venture of Govt. of India and Govt. of Tamil Nadu)

o/c

CMRL/CON/PH-II/GM(T&E)/EXT/0013

17/10/2020

To

The Defence Estate Officer
Madras Circle,
306 Anna Salai, Teynampet,
Chennai - 600018.

CHENNAI METRO RAIL LIMITED
DESPATCHED BY
BP / OP / RP / SP / RPAD / SPAD
17 OCT 2020
TPL. REF. No:
TIME: 11.58am

Dear Sir,

Sub: Chennai Metro Rail Limited (CMRL) - Phase II Project - Alignment of C5 Corridor along Mt poonamallee road near Defense premises of Madras war Cemetery at Nandambakkam - Reg.

Ref: i) CMRL meeting with Estate officer at Teynampet office

CMRL has taken up the implementation of Phase II Chennai Metro project with 3 additional corridors C3, C4 and C5. In connection with the work we had a meeting at your office in Teynampet on 15.10.2020 and shared the corridor 5 alignment information along Mt poonamallee high road. The piers for the viaduct of corridor C5 is proposed in the median of Mt Poonamallee high road passing along Butt road and the War Cemetery is located away from the highways.

During the meeting with CMRL Resident Engineer and Estate officer discussion it was clarified that the alignment is passing on the road which is owned by Highways dept. Though we understand that No NOC is required since the premises of cemetery are away, for purpose of information the arrangement of alignment and a typical cross section of the elevated viaduct passing through this location is attached.

Thanking you,

Encl:

Alignment drawings and a cross section - 3dwgs.

Yours faithfully

General Manager (Tracks and EC)

CMRL Depot, Admin Building, Poonamallee High Road, Koyambedu, Chennai - 600 107.
Phone : 23792000 Fax : 23792200
Email : chennaimetrorail@cmrl.in website : www.chennaimetrorail.org
CIN : U60100TN2007SGC065596

9-4. AAI

Annexure : 4

Note

Date: 20.10.2020

Sub: Phase II project of CMRL – C5 Corridor – Airport Authority of India installation at Mugalivakkam – Reg.

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In connection with the Corridor C5 the undersigned contacted Thiru V. Muruganandam, General Manager, CNS, Airport Authority of India, Chennai on 16.10.2020 and the arrangement of metro viaduct, its height etc., were appraised by CMRL to General Manager, CNS, Airport Authority of India. During the discussions, it was opined that an NOC is not required. However, GM, CNS, AAI advised to send the details of the alignment along with cross section for their information. He has further informed that , in case, if any NOC is required, he would advise as to how to proceed with the same and also assured that it would be given at the quickest possible time. Consequent to the discussions, a letter was issued to GM, CNS, AAI by CGM (A & CM) along with the details about the Elevated Corridor as per attachment vide lr.No.CMRL/CON/CGM(A&CM)/Phase II/Ext/014/2020 dt. 17.10.2020

CGM (A & CM)

DP

23/10/2020

9-5. TNFD

P.R. C.No. 223/2020 Dated : 23.10.2020

Chennai Metro Rail Limited

(A Joint Venture of Govt. of India and Govt. of Tamil Nadu)

MEETING WITH GUINDY NATIONAL PARK FOREST RANGE OFFICER

Lr No : CMRL/CONS/ES/613/2020 **Dated: 23.10.2020**

Today discussed with Forest Range Officer (FRO) in charge of Guindy National Park (GNP) comes under Tamil Nadu Forest Department (TNFD).

The Range Officer gave a brief note on Guindy National Park as follows:

1. In Tamil Nadu the Chennai the fourth largest city in the country. It has a spot of interest for the wildlife. One of the natural spectaculus of the city is a small but renowned Guindy National Park spreading over an area of 2.7 km^2. It is a great habitat of varied species of Fauna coupled with the Tropical Evergreen Forest of the Coromandel Coast. It is 8^{th} smallest national park. Initially it's game reserve spreading over 5 km^2. In 1672-1678 it is transferred into a space of residence called Guindy Lodge, Established by the Governor William Longhome.
2. The balance forest area owned by a British named Gilbert Roderick. He sold the Forest Land to Government for Thirty Five Thousand Indian Rupees.
3. This dry evergreen forest consists of 24 trees species. 350 plant species, 60 butterfly species and 130 bird species.

Then CMRL Environmental Team explained GNP FRO about the CMRL Phase II project profile and we handed over the copy of GoI letters and notifications perlaining to Environment, Forest and Wildlife Clearance about the exemption of Railways and Metros from Clearances.

M.Ponnaiah
Environment Specialist
CMRL, Chennai.
23/10/20.

Thiru N. Jothilingam,
Forest Range Officer
Guindy National Park,
Chennai.
Cell: 8428670692

Received

CMRL Depot, Admin Building, Poonamallee High Road, (Opposite to Daniel Thomas School),
Koyambedu, Chennai - 600 107.
Phone : 23792000 Fax : 23792200
Email : chennaimetrorail@gmail.com website : chennaimetrorail.gov.in

9-6. Additional Chief Secretary to Government

Annexure 6.

Chennai Metro Rail Limited

(A Joint Venture of Govt. of India and Govt. of Tamil Nadu)

PRADEEP YADAV, I.A.S.
Managing Director

Letter No.CMRL/CON/CGM(A&GM)/Phase-II/2020/16 Dated 23.10.2020

To

The Additional Chief Secretary to Government,
Environment and Forests Department,
Secretariat, Fort St. George,
Chennai – 600 009.

Dear Sir,

Sub: Chennai Metro Rail Limited – Phase-II Project – Corridor-5 – Transfer of Forest land to CMRL at Nanmangalam Reserve Forest at Medavakkam.

Ref: Minutes of the 20th High Power Committee Meeting held on 06.02.2020 (Item No.81).

****

In connection with the subject matter, it is brought to your kind notice that the Elevated Corridor C-5 between Vellakkal and Medavakkam Koot Road junction passes through the Nanmangalam Reserve Forest area along the side existing road.

To construct the elevated viaduct and one station, an area of 7570 sq.m. is required to be transferred to CMRL and the break-up of the same is as below:

1) Land for implanting permanent structure is 2535 sq.m.
2) The shadow area of viaduct is 4585 sq.m. wherein only the viaduct structure will be at a higher level thereby the land below can still be retained by Forest Department.
3) This subject was placed before the 20th HPC on 06.02.2020 as an agenda point under Sl.No.81 and it was decided by HPC that the Special Secretary (Environment and Forests) will further provide directions on this subject to CMRL and Forest Department.

In continuity, CMRL contacted the local DFO and CMRL was directed by him to apply online for the required land. However, CMRL is facing difficulty in filing online application as the same is not being accepted in the portal.

In addition, it has also come to the notice, that part of this land is with Quaid-E-Millath Educational and Social Trust, Chennai. In light of the above, it is requested that an Officer may please be nominated from Forest Department as the Nodal Officer on the subject matter and necessary directions may please be given to the concerned in this regard.

Thanking you,

Yours faithfully,

Pradeep

Managing Director

Updated Environmental Impact Assessment

April 2024
Revision 01

India: Chennai Metro Rail Investment Project
Balance Corridor 5

Annexure 10

Prepared by the Chennai Metro Rail Limited (CMRL) for the Project Lenders.

Biodiversity Assessment and Biodiversity Management Plan of Nanmangalam Reserve Forest, Chennai

Report Submitted to

Chennai Metro Rail Limited,
CMRL Depot, Admin Building,
Poonamallee High Road, Koyambedu,
Chennai – 600107.

by

Dr.C. Arivazhagan
Indo American Wildlife Society
Ecologist

March 2021

INDEX

1.0 Assessment of Biodiversity

The biological diversity in an area, which is determined by the variety and variability of multiple organisms occupying that area, is an important measure of the health and functionality of the ecosystem. The environmental conditions prevail in the tropical and sub-tropical regions of the world is proven to provide optimum condition for the evolution and co-existence of multiple species in a habitat. This high species diversity and complexity in the functionality provides the tropical systems an inherent resilience to disturbances exerted by different sources, such as, anthropogenic, and natural. In other words, higher the species diversity is, higher the resilience of an ecosystem to disturbance.

India is one of the mega-diversity countries. A nation is designated as a mega-diversity country when a major share of the earth's biodiversity is held within its geo-political limits. Unfortunately, the large human (and livestock) population and the intensive use of land (for agriculture, industries, and urban development) in India have together decimated habitats, weakened ecosystems and exterminated species extensively.

2.0 Ecosystem stability and Species diversity

Ecosystem stability is the ability of an ecosystem to maintain a steady state, even after a stress or disturbance has occurred. In order for an ecosystem to be considered stable, it needs to have mechanisms in place that help it return to its original state after a disturbance occurs. It has been shown that biodiversity of an area has a large impact on the ecosystem stability of that area. Areas with high levels of species and genetic diversity are likely to have a more complex ecosystem, with a variety of food webs and biotic interactions. This increase in complexity makes it more likely that the ecosystem will return to a stable state after a disturbance, because the ecosystem has more ways to respond to a disturbance and fix problems.

2.1 Ecological Indicators

Species diversity in an area is a great indicator of change influenced by any change in the environment over space and time. Ecological indicators are scientific constructs that use quantitative data to measure aspects of biodiversity, ecosystem condition, services, or drivers of change, but no single ecological indicator captures

all the dimensions of biodiversity. Ecological indicators form a critical component of monitoring, assessment, and decision-making and are designed to communicate information quickly and easily to policymakers. Moreover, evaluating the importance of a particular habitat in biodiversity/species conservation point of view is necessary to ascertain or predict the potential causes of any modification to habitat (eg. developmental projects) on its biodiversity in a long run. Accordingly, the present study was carried out in Nanmangalam Reserve Forest (hereafter called NRF) to assess the biodiversity, and threats on biodiversity due to Chennai Metro Rail Phase 2 - Corridor 5.

3.0 Urban Biodiversity

Conservation of biodiversity in urban landscapes is a challenging and daunting task especially where rapid growth in human population and the concurrent infrastructure to sustain a diverse community of people and their livelihoods are evolving at an unprecedented rate. The city of Chennai (erstwhile Madras) is the 34th largest metropolitan city in the world with a current population of about 4.34 million people. It is viewed as one of the most progressive cities of the country, according to ample opportunities for education, employment, and infrastructure (Drescher et al, 2007). Consequently, the boundaries of the city have transformed to include adjacent habitations and villages resulting in the formation of ‘Greater Chennai’. This has resulted in ‘the natural’ being confined to a few habitat islands. The management of these habitat islands though is rather varied. While some are protected and managed by the Tamil Nadu Forest Department, others exist within campuses of educational institutions such as IIT-Madras and Madras Christian College and within campuses maintained by private groups such as the Theosophical Society.

Chennai is amongst the few Indian cities that maintain state-owned nature reserves within and around the metropolitan limits. While the Guindy National Park, Vedanthangal Bird Sanctuary and the Pulicat Lake are amongst the better-protected and publicized nature reserves in and around the City, there are also many others that can be described as ‘little-known’. The Nanmangalam Reserve Forest is one of such nature reserves that has received limited attention, despite being home to a diverse community of plants and animals including several endangered species.

4.0 History of Reserve Forest in Kanchipuram Forest Division

The Kanchipuram (Erstwhile Chengalpattu) forest division was revived on 16th July 1945 largely as a plantation division with headquarters at Kanchipuram. In addition to the planting programme, the division had jurisdiction over 17 panchayat forests and three unreserved lands. It originally consisted of four forest ranges viz. Chengalpattu, Tiruporur, Sriperumpadur and Marakannam. A fifth range viz Tirukoilur was formed during May 1947 and included in Chengalpattu division. Subsequently, Nellore division of Sathiavedu range was also transferred to Chengalpattu division.

During 1954, Chengalpattu division was reconstituted into six ranges viz, Sathiavedu, Tiruvallur, Chingalput, Marakanam, Tirukoilur and Vridachalam. The redistribution of the forest areas in the division became necessary with the implementation of several schemes contemplated under the second five-year plan and consequenty the following three special division were formed in addition to the Chingalpattu territorial division in 1956, namely Cashew division, Adyar Fodder and Pasture division, Chengalpattu, and Rehabilitation division, Cuddalore.

The general reorganization of forest divisions in the state in order to obviate overlapping jurisdictions and to enforce effective divisions lead to the constitution of three independent territorial divisions viz, Saidapet, Chingalpattu and Cuddalore divisions respectively.

With rearrangement of the boundary between Tamilnadu and Andhra Pradesh on the recommendation of the Pataskar Award, a total forest area of 329.06 sq.km of Sathiavedu and a portion of Tiruvallur range was transferred to Andhra Pradesh and Pullur East Block comprising of an area of 7.59 sq.km was taken over from Andhra Pradesh on April 1, 1960. Guindy Reserve Forest of Tambaram range was reconstituted into a separate unit during October 1959 and was transferred to control of the State Wildlife officer during 1960.

Chengalpattu division was primarily a plantation division. The past management of this division was built on the notion of improving the dry and poor forests to meet human demands for livelihood, notably firewood for domestic and cashewnut processing in the adjacent district of South Arcot. . It also had to fulfill the demands imposted by emerging industrial estates, housing colonies, hospitals, agricultural

farms, etc. It is to be highlighted though that as early as 1969, the Conservator of Forests had cautioned about the rapid rate of deforestation. He also remarked that at the prevailing rate, the forests of Chengalpattu would disappear in about 30 to 40 years time unless the demands were discouraged.

Another factor contributing to irretrievable deforestation and permanent damage to the ecology of the division was the large-scale quarrying of granite in the forest near Madras city. For quarrying granite from the reserve forest, fee was collected on the basis of quantity removed; the permit was issued for quarrying and transporting. In 1963, as the system was found defective, the area allotted for quarrying was sold in public auction.

The passing of the Forest Conservation Act in 1982 stopped the quarrying since the Act mandates that prior permission of the Central Government is essential for quarrying in forest areas. As a phase out process, permission was obtained to withdraw the operation over a two-year period. (G.OMs.No.1029/Forest and Fisheries/dt.26.08.1983). There are about 139 quarries in the four forest ranges of Chengalpattu forest division: Tiruvallur Range - 33 quarries, Tambaram Range - 100 quarries, Chingalpattu Range - 1 quarry and Madurandakam Range – 5 quarries. Since 1985, there is a total ban on quarrying in reserve forests.

The Tambaram Forest Range currently consists of 16 reserve forests, namely Mannur RF 223.80 Ha, Pudupair RF145.29Ha, Nallur RF 365.44 Ha, Erumaiyur 68.79Ha, Maganium 368.48Ha, Tambaram 92.52Ha, Pulikaradu 74.92Ha, Nanmangalam 320.92Ha, Vandalur 641.01Ha, Maduraipakkam 182.52Ha, Perumbakkam 85.73Ha, Kumili 487.94Ha, Unamajeri 307.17Ha, Gadalur 718.10Ha, Vadakkupattu 287.34Ha, Vattampakkam 329.43Ha.

5.0 Objectives

The overall objective of the project is to study the impact of metro rail activities affect the biodiversity of Nanmangalam Reserve Forest, and measures to be taken to conserve the biodiversity of Nanmangalam RF.

The specific objectives of the project are as follows:

- To assess the impact of metro rail Phase 2 corridor 5 activities and pressures on the Nanmangalam Reserve Forest and suggest means of

mitigating the detrimental pressures

- To enumerate the flora of Nanmangalam RF and identify flora and their significance in the habitats.
- To enumerate the fauna, their significance, and habitats.

6.0 Methodology

The current study was Carried out in Nanmangalam Reserve Forests of Tambaram Range that were historically leased for quarrying in past. A detailed habitat and biodiversity assessment Nanmangalam RF, the efforts were limited to assessments, primarily due to the limited duration and resources for the study.

In addition to the study of secondary data primarily Working Plans of the TamilNadu Forest Department and literature on flora and fauna, a set of primary methods of data collection were used for the study.

7.0 Description of the study area

The biodiversity study was carried out in the Nanmangalam Reserve Forest (hereafter referred to as NRF) which is located on the eastern side of Tambaram town (about 10km) along the Tambaram and Velachery Road. Spread over an area of 320.92 ha, NRF lies between 12^{o}.91' to 12^{o}.93 N and longitude of 080^{o}.16 'to 080^{o}.18' E. It is administered as part of the Tambaram Forest Range (See Fig1).

The Tamil Nadu Forest Department, in its effort to protect and conserve the Nanmangalam Forest Reserve had initiated a number of plantation programmes, the details of which are provided in the following series of tables. The premise of these efforts was that a) the existing forest was highly degraded b) tree cover needs to be enhanced and c) commercially useful plantations need to be raised for sustainable forestry.

Fig. 1 Map of the Nanmangalam Reserve Forest /Satellite Imagery

NRF is bounded by the erstwhile villages of Sempakkam, Pallikarani, Santhoshapuram and Keezhkatalai. These villages currently constitute the suburban urban habitations of south Chennai.

Results of the ecological demarcation of NRF provide a description of the habitat; as detailed in the following section.

Hillocks

There are about three isolated hillocks ranging from 30m-70m MSL elevation; occupying nearly one half of the habitat in the RF. Hillocks harbour about 90 per cent of dense scrub of NRF. Thorny shrubs and stragglers dominate the vegetation of the hillocks and with sparsely distributed trees. Common plants present in the hillocks are *Lannea coromandelica, Albizia lebbeck*, and shrubs such as *Scutia myrtina, Canthium parviflorum, Tarena asiatica* and *Benkara malabarica*. Ground orchid *Eulophia epidendraea* is also very common in the hillocks.

Plains

Except for the central part of the RF the rest of the area is plains that are covered with plantations, thickets and grasslands. While Eucalyptus plantation occupies most of the plains; there are other plantations as well. The shrub *Carissa spinarum* is common in the plains than the hillocks. The Tamilnadu Afforestation

programme has attempted to improve vegetation cover by planting native tree species in the plains.

Small patches of grasslands dominated by *Aristida setacea* (Broom grass), *Heteropogon contortus* (love grass) and an endemic Lemon grass *Cymbopogon travancorensis* are also found in the plains. These grasslands support a large number of fauna in RF.

Water Bodies

There are five abandoned quarries and three ponds inside the RF. During rainy season, these quarries and ponds are flooded, while continuing to hold water during the drier seasons thereby supporting the resident fauna. *Hydrilla verticillata*, *Ottelia alismoides, Aponogeton natans* and *Nymphaea nouchali* are the common aquatic plants present in the water bodies. Grasses such as *Eragrostis natans, E.unioloides* and *Vetiveria zizanioides* are present along the margins of the water bodies. Birds such as Little Cormorant, White Throated Kingfisher, Common kingfisher, and Pied Kingfisher are commonly seen near quarries. The present study is to assess the biodiversity of Nanmangalam RF for Chennai Metro Rail Phase 2 - Corridor 5.

Flora of the Nanmangalam Reserve Forest

The vegetation of NRF is strictly a scrub with plantations. Eucalyptus plantations (117 ha) dominate the forest. The current study enumerates 449 different species and 4 varieties of flowering plants (angiosperms) belonging to 313 and genera representing 89 different families (Appendix 1). It is the most remarkable species representation anywhere in and around Chennai, including more well known areas such as the Guindy National park and IIT-Madras. This representation is dominated by thorny shrubs such as *Scutia myrtina, Benkara malabarica, Canthium parviflorum* and *Carissa spinarum*, stragglers such as *Mimosa intsia, Pterolobium hexapetalum, Ziziphus oenoplia* and *Acacia caesia* and trees such as *Ziziphus xylopyrus, Z.mauritiana, Acacia leucophloea* and *Eucalyptus tereticornis*. *Leucas diffusa*, *Cymbopogon travancorensis*, *Cynodon barberi*, *Tragus roxburghii, Chrysopogon*

asper, Dimeria acutipes and *Euphorbia corrigioloides* are endemic plants present in Nanmangalam RF. Seasonally flooded areas of NRF provide suitable habitat for the growth of several ephemerals. Insectivorous plants like *Drosera burmannii* and *Drosera indica* and ground orchid's viz., *Eulophia epidendraea* and *Habenaria viridiflora* are common in NRF, where as rare in the other adjoining forests and protected areas in and around Chennai (see Vegetation Map).

The economically important Sandal wood tree is also found in the RF. Single mature individuals of three tree species *Buchanania axillaries, Butea monosperma* and *Lepisanthes tetraphylla* are standing as remnants of past vegetation.

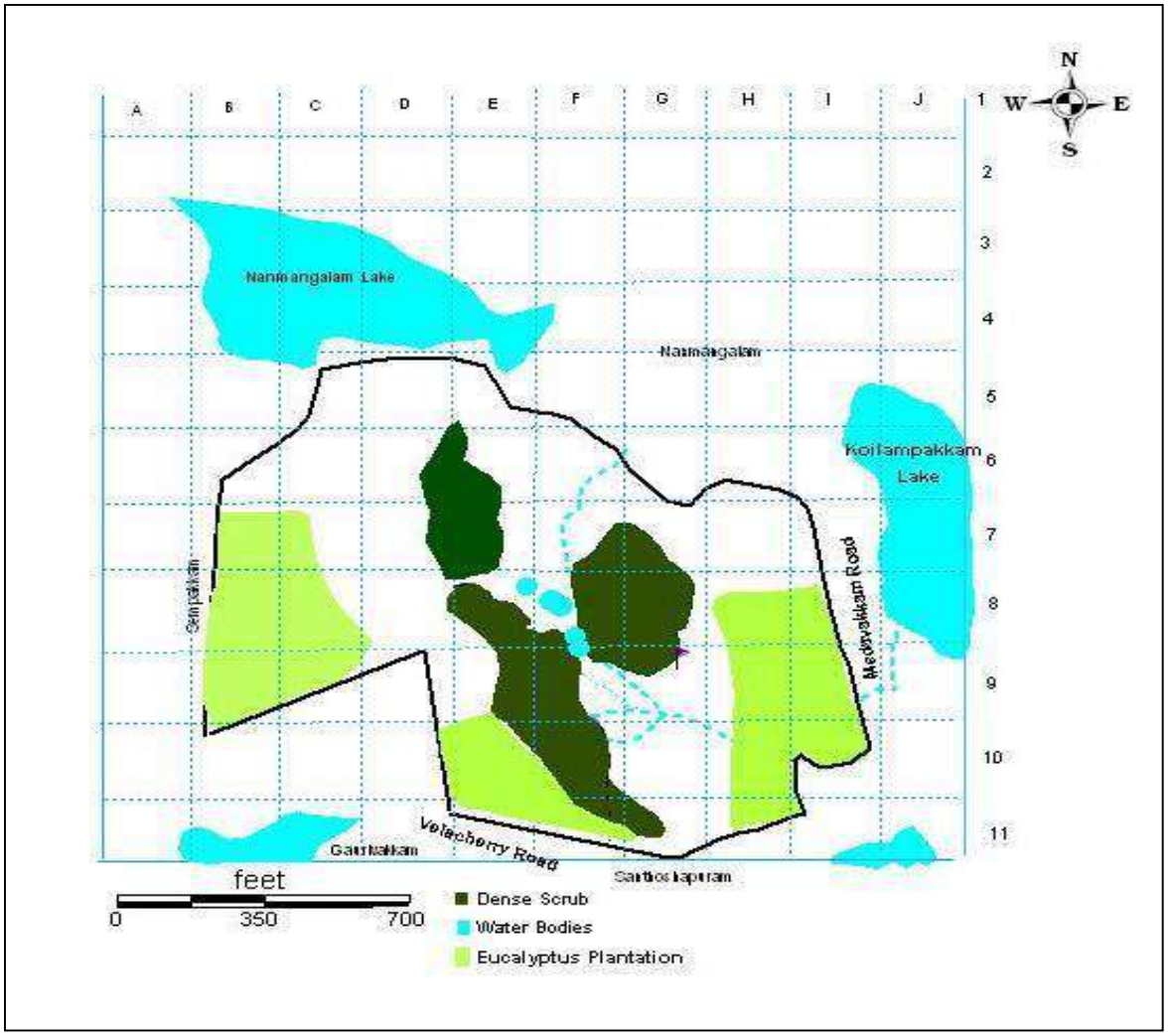

Fig 2. Vegetation Map of Nanmangalam Reserve Forest

8.0 Floral diversity assessment

The diversity of flora was assessed using quadrat method. A total of 10 quadrats of 10 x 10 m were randomly established across the Nanmangalam reserve forest considering the habitat heterogeneity and different vegetation categories. We maintained a minimum of 200 m spatial distance between each plot to cover the heterogeneity in the habitat. All the trees (≥ 20 cm GBH) were enumerated from the quadrats. Shrubs (< 20 cm GBH and >1 cm GBH) were enumerated from nested subplots of 3 x 3 m established at the center of the plot. Similarly, herbs and grasses (< 1.3 m height) were enumerated from the nested subplots of 1 x 1m established at the center of the quadrat. Specimens were collected for species that could not be identified in the field and were identified using regional floras (Gamble & Fischer 1951; Livingstone & Hendry 1994).

Table.1. GPS Location of plot laid in Nanmangalam RF

Plot No.	Latitude	Longitude
1	12.933938	80.167927
2	12.933403	80.171432
3	12.931947	80.165184
4	12.929274	80.16358
5	12.929571	80.17067
6	12.92562	80.164209

7	12.928412	80.175638
8	12.923452	80.172529
9	12.920481	80.172865
10	12.919709	80.176278

8.1 Data analysis

Basic ecological details pertain to the vegetation were calculated using standard protocols (Curtis and Mclntosh 1951). Shannon index (*H'*) was used to calculate the diversity among the vegetation categories (ie. tress, shrubs and herbs) in the quadrats. Importance value index (IVI) for each species was calculated by the following formula for trees. While, for shrubs and herbs the modified IVI was used where only relative density and relative frequency are considered following Rasingam and Parthasarathy (2008). Formula used for calculating the IVI as follows,

$$\text{Relative abundance} = \frac{\text{No. of individuals of a species}}{\text{No. of individuals of all species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Dominance of a species}}{\text{Dominance of all species}} \times 100$$

IVI = Relative density + Relative frequency + Relative dominance

Data analysis was carried out in Microsoft XL 2016 and R statistical package (ver. 4.0.3).

8.2 Results

We identified a total of 92 plant species from the study plots. The number of species observed for herbs, shrubs and trees were highly varied (Table 1). The ground layer occupied by herbs and grasses showed an exceptionally high species diversity than shrubs and trees. Shannon diversity index and other considered variables (i.e. individuals / plot, species / plot) have also depicted the same pattern. The earlier study found that there about 451 species of flora recorded in Nanmangalam RF (Nehru et al. 2009, Given in Appendix 1 and 2).

Table 2: Ecological values for the vegetation parameters studied.

Variable	Tree	Shrub	Herb
Species encountered	9	17	66
Individuals counted	23	28	255
Species / Plot	1.1±0.74	2.00±1.16	8±2.45
Individuals / Plot	2.5±1.90	2.80±2.25	25.5±13.14
Shannon 'H	0.2±0.33	0.59±0.46	1.78±0.32

Plant species dominance

Eucalyptus tereticornis and *Acacia leucophloea*, both were planted trees, showed the highest IVI values among the trees. Among the native trees *Ziziphus xylopyrus* and *Butea monosperma* showed the highest IVI value (Table 3). Among the shrubs, *Catunaregam spinosa* and *Carmona retusa* were most dominant followed by *Cleistanthus collinus* and *Benkara malabarica* (Table 4). While among the herbs and grasses, *Mitracarpus villosus* and *Plumbago zeylanica* were commonly occurring species followed by *Evolvulus nummularius* and *Eriocaulon quinquangulare* (Table 4). Additionally, many other grass species, namely, *Eragrostiella brachyphylla, Heteropogon contortus,* and *Aristida spp.* are also commonly occurring in the plains.

8.4 Rare species occurrence

In addition to the many species that are commonly found in the tropical dry ever-green forest across the east coast of India, the Nanmangalam reserve forest (NRF) has some species that are very rare. For example, the ground orchids *Habenaria viridiflora* and *Eulophia epidendraea* are found commonly in the marshy areas and hillocks, respectively, inside the NRF. Other such rare species includes, *Utricularia* spp., *Drosera burmanii* (insectivorous plant) and the endemic grass species *Dimeria acutipes* are common in the seasonally flooded eucalyptus plantations in the westward boundary of the NRF. Additionally, there were three endemic species namely *Leucas diffusa, Cymbopogon travancorensis,* and *Chrysopogon asper* are also encountered in our quadrats. The occurrences of the above mentioned rare and endemic plant species highlights the high conservation significance of the Nanmangalam reserve forest.

Table 3 : List of tree species found in the quadrats established at Nanmangalam reserve forest. (R.abu – Relative abundance; R.frq – relative frequency; IVI – Importance value index).

S_No	Species	R_abu	R_frq	R_dom	IVI
1	*Acacia ferruginea* DC.	13.04	9.09	9.51	31.64
2	*Acacia leucophloea* Willd.	8.70	18.18	12.42	39.29
3	*Acacia planifrons* Wight and Arn.	4.35	9.09	2.96	16.40
4	*Albizia lebbeck* (L.) Benth.	4.35	9.09	2.87	16.31
5	*Buchanania axillaris* Ramam.	4.35	9.09	2.59	16.03
6	*Butea monosperma* (Lam.) Taub.	4.35	9.09	6.67	20.11
7	*Eucalyptus tereticornis* Sm.	47.83	18.18	56.18	122.19
8	*Lepisanthes tetraphylla* Radlk.	4.35	9.09	3.46	16.90
9	*Ziziphus xylopyrus* Willd.	8.70	9.09	3.34	21.12
	Grand Total	100	100	100	300

Table 4 : List of shrub species found in the quadrats established at Nanmangalam reserve forest. (R.abu – Relative abundance; R.frq – relative frequency; IVI – Importance value index).

S.No	Species	R_abu	R_Frq	IVI
1	*Atalantia monophylla* DC.	7.14	5.00	12.14
2	*Benkara malabarica* (L.) Tirveng	7.14	10.00	17.14
3	*Breynia vitis-idaea* (Burm.f.) C.E.C. Fisch.	3.57	5.00	8.57
4	*Canthium parviflorum* Lam.	3.57	5.00	8.57
5	*Capparis brevispina* DC.	3.57	5.00	8.57
6	*Carissa spinarum* L	3.57	5.00	8.57
7	*Carmona retusa* (Vahl) Masam.	14.29	5.00	19.29
8	*Catunaregam spinosa* (Thunb.) Tirveng.	14.29	10.00	24.29

9	*Cleistanthus collinus* (Roxb.) Benth. ex Hook. f.	7.14	10.00	17.14
10	*Dodonaea viscosa* (L.) Jacq.	3.57	5.00	8.57
11	*Flacourtia indica* (Burm. f.) Merr.	7.14	5.00	12.14
12	*Lantana camara* L. (weed)	3.57	5.00	8.57
13	*Memecylon edule* Roxb.	3.57	5.00	8.57
14	*Memecylon umbellatum* Burm. f.	3.57	5.00	8.57
15	*Ochna squarrosa* L.	7.14	5.00	12.14
16	*Phyllanthus reticulatus* Poir.	3.57	5.00	8.57
17	*Ziziphus oenopolia* (L.) Mill.	3.57	5.00	8.57
	Grand Total	100	100	200.00

Table 5 : List of herb and grass species found in the quadrats established at Nanmangalam reserve forest.

S_No	species	R_abu	R_Frq	IVI
1	*Acalypha indica* L.	0.78	1.25	2.03
2	*Achyranthes aspera L. var. aspera*	0.39	1.25	1.64
3	*Aerva lanata* (L.) Juss. ex Schul.	2.35	2.5	4.85
4	*Aeschynomene indica* L.	0.39	1.25	1.64
5	*Alysicarpus monilifer* (L.) DC.	1.18	1.25	2.43
6	*Aristida hystrix* L. f. G	3.92	1.25	5.17
7	*Aristida setacea* Retz.	1.57	1.25	2.82
8	*Asystasia gangetica* (L.) T. And.	1.18	1.25	2.43
9	*Basilicum polystachyon* (L.) Moench	1.18	1.25	2.43
10	*Blepharis maderaspatensis* (L.) B. Heyne ex Roth	0.39	1.25	1.64
11	*Bothriochloa pertusa* (L.) A. Camus	0.78	1.25	2.03

12	*Bulbostylis barbata* (Rottb.) C.B. Clarke	1.18	2.5	3.68
13	*Cassia occidentalis* L.	0.39	1.25	1.64
14	*Cassia pumila* Lam	2.75	1.25	4.00
15	*Chrysopogon asper* (B. Heyne) Heyne ex Blatter and McCann	2.35	1.25	3.60
16	*Cleome aspera* Koenig ex. DC.	0.78	1.25	2.03
17	*Cleome viscosa* L.	1.18	1.25	2.43
18	*Corchorus aestuans* L.	0.39	1.25	1.64
19	*Crotalaria prostrata* Rottler ex Willd.	0.39	1.25	1.64
20	*Crotalaria retusa* L.	2.75	2.5	5.25
21	*Cymbopogon travancorensis* Bor	2.75	2.5	5.25
22	*Cynodon dactylon* (L.) Pers.	4.71	1.25	5.96
23	*Cyperus rotundus* L.	1.57	1.25	2.82
24	*Datura metel* L.	0.39	1.25	1.64
25	*Dimeria acutipes* Bor	2.75	1.25	4.00
26	*Drosera burmannii* Vahl	0.39	1.25	1.64
27	*Eleusine indica* (L.) Gaertn.	0.39	1.25	1.64
28	*Emilia sonchifolia* (L.) DC.	0.78	1.25	2.03
29	*Eragrostiella brachyphylla* (Stapf.) Bor	3.53	2.5	6.03
30	*Eragrostis tenella* (L.) P. Beauv. ex Roem. and Schult.	0.39	1.25	1.64
31	*Eriocaulon quinquangulare* L.	5.88	1.25	7.13
32	*Eulophia epidendraea* C.E.C. Fisch.	0.78	1.25	2.03
33	*Euphorbia hirta* L.	1.18	1.25	2.43

34	*Evolvulus alsinoides* (L.) L.	1.18	2.5	3.68
35	*Evolvulus nummularius* (L.) L.	5.10	2.5	7.60
36	*Habenaria viridiflora* (Rottl. ex Sw.) R. Br.	0.39	1.25	1.64
37	*Heliotropium bracteatum* R. Br.	0.78	1.25	2.03
38	*Hemidesmus indicus* (L.) R. Br.	2.75	2.5	5.25
39	*Heteropogon contortus* (L.) P. Beauv. ex Roem. and Schult.	0.39	1.25	1.64
40	*Indigofera trifoliata* L.	0.39	1.25	1.64
41	*Ipomoea pes-tigridis* L.	0.39	1.25	1.64
42	*Kyllinga nemoralis* (J.R. Forst. and G. Forst.) Dandy ex Hutch. and Dalziel	0.78	1.25	2.03
43	*Leucas diffusa* Benth.	0.78	1.25	2.03
44	*Merremia emarginata* (Burm. f.) Hallier f.	1.18	1.25	2.43
45	*Mitracarpus villosus* (Sw.) DC.	5.88	2.5	8.38
46	*Osbeckia zeylanica* Steud. ex Naudin	0.39	1.25	1.64
47	*Panicum psilopodium* Trin.	1.96	1.25	3.21
48	*Pavonia odorata* Willd.	2.75	2.5	5.25
49	*Perotis indica* (L.) Kuntze	0.39	1.25	1.64
50	*Phyllanthus maderaspatensis* L.	0.78	1.25	2.03
51	*Physalis angulata* L.	0.78	1.25	2.03
52	*Plumbago zeylanica* L.	4.31	3.75	8.06
53	*Pupalia lappacea* (L.) Juss.	0.39	1.25	1.64
54	*Pycreus pumilus* (L.) Nees	2.35	3.75	6.10

55	*Scoparia dulcis* L.	0.78	1.25	2.03
56	*Solanum virginianum* L.	0.39	1.25	1.64
57	*Spermacoce hispida* L.	1.18	1.25	2.43
58	*Sporobolus coromandelianus* (Retz.) Kunth	0.39	1.25	1.64
59	*Tephrosia pumila* (Lam.) Pers.	0.78	1.25	2.03
60	*Tephrosia villosa* (L.) Pers.	0.39	1.25	1.64
61	*Theriophonum minutum* (Willd.) Baill.	1.57	1.25	2.82
62	*Tribulus lanuginosus* L.	1.18	1.25	2.43
63	*Tridax procumbens* L.	1.57	1.25	2.82
64	*Utricularia polygaloides* Edgew.	4.31	1.25	5.56
65	*Utricularia scandens* Benj.	1.18	1.25	2.43
66	*Vernonia cinerea* (L.) Less.	0.39	1.25	1.64
	Grand Total	100	100	200

Utricularia polygaloides

Drosera burmannii

Buchanania axillaris

Ziziphus xylopyrus

Carmona retusa

Benkara malabarica

Gloriosa superb (state flower)

Andrographis paniculata

Jatropha gossypifolia

Calotropies gigantia

Phyllanthus madraspatensis

Tribulus terrestris

Fig 3: Some of the rare and important plant species found in the study site.

Medicinal Plants of the Nanmangalam RF

The following medicinal plants are collected from NRF *Corallocarpus epigaeus, Sarcostemma acidum, Cissus quadrangularis, Andrographis paniculata, Gloriosa superba* and *Cleistanthus collinus.*

Botanical Significance of NRF

Nanmangalam RF is home to six endemic species (India and Sri Lanka) of plants. These are *Leucas diffusa*, *Cymbopogon travancorensis*, *Cynodon barberi*, *Chrysopogon asper, Euphorbia corrigioloides* and *Dimeria acutipes*. Among the six, two plants namely *Dimeria acutipes and Cynodon barberi* are strict endemics to Tamil Nadu, with their distribution being restricted only to Chennai and Kanchipuram District.

Some plants that are locally very rare and are drastically disappearing from Chennai and its surrounding areas are also present in considerable numbers at NRF (see table). Five species namely *Drosera indica, Gloriosa superba, Madhuca longifolia, Pseudarthria viscida* and *Santalum album* that are found within NRF are redlisted medicinal plants for South India (Ravikumar, 2000). On other hand we are noticed lots of regeneration of plant species in Nanmangalam RF, this may be due to seed dispersal by frugivores birds in RF.

Table 6. Locally rare plants found in abundance at NRF

S.No	Binomial	S.No	Binomial
1	*Butea monosperma*	15	*Osbeckia zeylanica*
2	*Cadaba fruticosa*	16	*Premna tomentosa*
3	*Capparis brevispina*	17	*Reissantia indica*
4	*Capparis zeylanica*	18	*Santalum album*
5	*Caralluma adscendens*	19	*Sapindus emarginatus*
6	*Chrysopogon asper*	20	*Sarcostemma acidum*
7	*Drosera burmannii*	21	*Strychnos lenticellata*
8	*Drosera indica*	22	*Utricularia caerulea*
9	*Habenaria viridiflora*	23	*Curculigo orchioides*
10	*Iphigenia indica*	24	*Dimeria acutipes*
11	*Lepisanthes tetraphylla*	25	*Dopatrium junceum*
12	*Leucas biflora*	26	*Eulophia epidendraea*
13	*Manilkara hexandra*	27	*Gloriosa superba*
14	*Ochna obtusata*	28	*Tiliacora acuminata*

9.0 Invasive and Alien Species and Management

Alien species are non-native or exotic organisms that occur outside their natural adapted ranges and dispersal potential. Many alien species support our farming and forestry systems in a big way. However, some of the alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and compete with the native species. International Union for Conservation of Nature and Natural Resources (IUCN) defines Invasive alien species as an alien species which becomes established in natural or semi-natural ecosystems or habitat, an agent of change, and threatens native biological diversity. These invasive are widely distributed in all kinds of ecosystems throughout the world, and include all categories of living organisms. Nevertheless, plants, mammals and insects comprise the most common types of invasive alien species in terrestrial environments. The threat to biodiversity due to invasive alien species is considered second only to that of habitat destruction. Invasive species cause loss of biodiversity including species extinctions, and changes in hydrology and ecosystem function. Differences between native and exotic plant species in their requirements and modes of resource acquisition and consumption may cause a change in soil structure, its profile, decomposition, nutrient content of soil, moisture availability, etc.

Invasive species are thus a serious hindrance to conservation and sustainable use of biodiversity, with significant undesirable impacts on the goods and services provided by ecosystems. Biological invasions now operate on a global scale and will undergo rapid increase in this century due to interaction with other changes such as increasing globalization of markets, rise in global trade, travel and tourism. For effective management of invasive species, knowledge about their ecology, morphology, phenology, reproductive biology, physiology and phytochemistry is essential. Generally invasive species put forth profound ecological impacts on biotic communities and

ecological functions of the ecosystems at invaded locations and adversely reduce the biodiversity of ecosystems. Available scientific information (Ramakrishnan, 1991; Williamson, 1996; Rilov and Crooks, 2009) strongly suggests that these invasive species as one of the greatest and significant threat to ecosystem services generated by the native communities. Mechanical, Chemical and biological control programmes are commonly employed to eradicate the exotic plants from the invaded sites. However, the positive utilization of exotic organisms is one of the viable option to manage the menace of the invasive plants. The term positive utilization refers to the use huge biomass of such weeds for human–welfare purposes instead of destroying them either chemically or biologically. Invasive species such as *Lantana camara*, *Parthenium hysterophorus and Prosopis juliflora* were recorded in the Nanmangalam RF, *Lantana camara* found mosly close to the water bodies. These invasive species should be removed in phased manner, and should be monitored regularaly. As management point of view these invasive species management is essential, because these invasive species are suppressing native species regeneration, therefore invasive species management is essential.

Invasive Species Management Choice of control method is based on a number of considerations like the size of the infestation, the amount of vegetation that should be retained, and resources available to the group (both labour and money). Broadly, control methods fall into three categories: 1. Mechanical- Mechanical methods are those that stop the invasive plant from growing and spreading without the use of chemical herbicides. They include hand pulling, cutting, pulling with tools, mowing, etc. 2. Mechanical with application of systemic herbicide 3. Herbicide alone

Lantana camara

Lantana camara L. commonly known as Wild sage is a one among the worst invasive species in the world having the South American origin that threatens the biodiversity of

tropical and sup tropical regions of the world. The native range of *Lantana camara* includes Mexico, parts of the Caribbean, Central America, Venezuela, and Colombia. With the help of frugivorous birds, the shrubs invade natural ecosystems, where they transform the indigenous vegetation into impenetrable thickets of *Lantana*, which diminish natural pasturage, reduce productivity of stock-farming, poison cattle, obstruct access to water sources and plantations, reduce biodiversity and devalue the land (Day *et al.* 2003). An extended competitive advantage gained through the presence of allele chemicals is a plausible explanation for the success and persistence of *L. camara* invasions within certain communities. Potential allelopathic chemicals such as triterpenes have been isolated from *L. camara* and these compounds have been implicated in allel opathic responses (Fischer *et al*. 1994; Langenheim 1994).

It was introduced into India during the 19th century as a garden plant or bio-hedge plant and now it is virtually invaded all the tropical and subtropical forests regions in the country. Especially in the dry tropical forest habitats that constitute the largest forest cover in India is greatly affected by the invasion of *Lantana*.

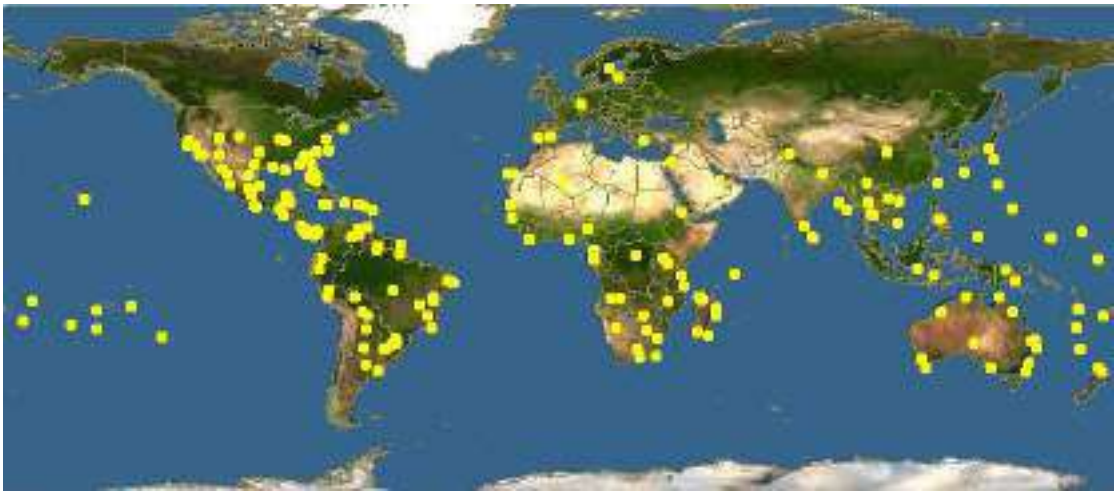

Fig 4. Global distribution of *Lantana camara* (Source:http://www.discoverlife.org/mp/20q)

Prosopis juliflora

Prosopis juliflora (Sw.) Dc. commonly known as Mesquite belong to the family Fabaceae. It is native to Mexico, South America and the Caribbean (Figure 1). It has become established as an invasive weed in tropical regions of Africa, Asia, Australia and elsewhere (Duke, 1983).

Fig 5. Global distribution of *Prosopis juliflora*(Source: http://www.discoverlife.org/mp/20q)

Description

A large shrub or tree, c. 5 m tall, generally armed with stipular spines. Leaves alternate, bipinnate, with 1-3 pairs of pinnae, rachis 1-8 cm long, prolonged beyond the last pinnae as a soft bristle. Leaflets 10-20 pairs, 7-17 mm long, 2-3 mm broad, entire, oblong, obtuse, sometimes mucronate. Stipules spiny, generally 1.0 cm or less long, in pair. Inflorescence dense axillary pedunculate spikes 4-8.5 cm long, peduncle c. 6-12 mm long. Flowers greenish yellow, pedicel 1 mm. Calyx c. 1 mm long, cup-shaped, 5 toothed, teeth small. Petals 5, free, c. 3 mm long, tip and margin hairy. Stamens 10, free, exserted, c. 4 mm long, anthers tipped with deciduous glands. Pod pedicel late, c. 16-23 cm long, c. 10-12 mm broad, almost straight to semi-circular, light yellow, glabrous, pedicel c. 5-7 mm long. Seeds 10-18, oblong.

10.0 Faunal Diversity

NRF is rich in faunal diversity too, there are about 70 species of birds, around 37 species of butterflies, 7 species of mammals, 14 species of dragonflies and damselflies and 19 species of herpto fauna were recorded during the study period, when compare with earlier study the number of faunal community recorded relative less, it because of duration of the present study was very short.

Mammals

Mammals are not as common as birds, because of the hunting pressures of the past. Mammals such as Grey Mongoose, Indian Palm Squirrel, Blacknaped Hare, House Shrew and Large Bandicoot Rat are common. Other mammals present in the NRF are

the Golden Jackal and Jungle cat which is very rare. Presumably, this area had a good number of Jackal and Jungle cat in the past. The list of Mammals recorded in NRF from direct and indirect evidence is provided in the Table 7.

Table 7. List of mammals recorded in Nanmangalam Reserve Forest

S.No	Common Name	Scientific Name	IUCN Status
1	Grey Mongoose	*Herpestes edwardsii*	Least Concern
2	Blacknaped Hare	*Lepus nigricollis*	Least Concern
3	Indian Palm Squirrel	*Funambulus palmarum*	Least Concern
4	Golden Jackal	*Canis aureus*	Least Concern
5	Jungle Cat	*Felis chaus*	Least Concern
6	House Shrew	*Suncus murinus*	Least Concern
7	Large Bandicoot Rat	*Bandicota indica*	Least Concern

Fig 6. Pellets of Black- Naped hare

Birds

The fauna community of NRF is dominated by birds which are found in good numbers. In the current study, 70 species of birds were recorded in NRF, and the numbers could significantly increase with an increase in the duration of the study.

NRF is one of the interesting bird watching areas of Chennai - Bulbuls (Red Vented and Red Whiskered bulbul), Common Myna's, Yellow Billed Babbler, Large Billed Crow, Loughing Dove, Spotted Dove, Asian Koel, Rufous Treepie, Grey Francolin, Rock Pigeon, Greater Coucal, Snipe Sp., Red Wattled Lapwing, three varieties of Sunbird (Purple, Purple Rumped and Loten's), Black Drongo, Blue Tailed Bee-Eater, Little Green Bee-Eater are very commonly seen all over the RF. Important birds are the Common Babbler, Laughing Dove, Common Wood Shrike, Black Headed, Myna and Red Whiskered Bulbul which are extinct in most parts of Chennai, but are commonly found in NRF.

Other interesting birds are the endangered Eurasian Eagle Owl or Great Horned Owl, Black Shouldered Kite, Indian Night-Jar, Brown Shrike, Rosy Starling, Common Kestrel, Pied Kingfisher, Little Cormorant, White Throated Kingfisher, Common Kingfisher. The list of birds recorded in NRF given in the table 8.

Table.8. List birds recorded in Nanmangalam Reserve Forest

S. No	Common Name	Scientific Name	IUCN status
1.	Common Babbler	*Argya caudate*	Least Concern
2.	Yellow-billed Babbler	*Turdoides affinis*	Least Concern
3.	Coppersmith Barbet	*Psilopogon haemacephala*	Least Concern
4.	Blue-tailed Bee-Eater	*Merops philippinus*	Least Concern
5.	Asian Green Bee-eater	*Merops orientalis*	Least Concern
6.	Red-vented Bulbul	*Pyconotus cafer*	Least Concern
7.	Red-whiskered Bulbul	*Pycnonotus jocosus*	Least Concern
8.	White-browed Bulbul	*Pycnonotus luteolus*	Least Concern
9.	Pied Bushchat	*Saxicola caprata*	Least Concern
10.	Shikra	*Accipiter badius*	Least Concern
11.	Little Cormorant	*Microcarbo niger*	Least Concern
12.	Greater Coucal	*Centropus sinensis*	Least Concern
13.	House Crow	*Corvus splendens*	Least Concern
14.	Large-billed Crow	*Corvus macrorhynchos*	Least Concern

15.	Common Hawk Cuckoo	*Hierococcyx varius*	Least Concern
16.	Grey-bellied Cuckoo	*Cacomantis passerines*	Least Concern
17.	Jacobin Cuckoo	*Clamator jacobinus*	Least Concern
18.	Laughing Dove	*Spilopelia senegalensis*	Least Concern
19.	Eastern Spotted Dove	*Spilopelia chinensis*	Least Concern
20.	Ashy Drongo	*Dicrurus leucophaeus*	Least Concern
21.	Black Drongo	*Dicrurus adsimilis*	Least Concern
22.	Cattle Egret	*Bubulcus ibis*	Least Concern
23.	White-browed Fantail	*Rhipidura aureola*	Least Concern
24.	Black-rumped Flameback	*Dinopium benghalense*	Least Concern
25.	Grey Francolin	*Francolinus pondicerianus*	Least Concern
26.	Little Grebe	*Tachybaptus ruficollis*	Least Concern
27.	Indian Pond Heron	*Ardeola grayii*	Least Concern
28.	Common Hoopoe	*Upupa epops*	Least Concern
29.	Common Iora	Aegithina tiphia	Least Concern
30.	Common Kestrel	*Falco tinnunculus*	Least Concern
31.	Common Kingfisher	*Alcedo atthis*	Least Concern
32.	Pied Kingfisher	*Ceryle rudis*	Least Concern
33.	White-throated Kingfisher	*Halcyon smyrnensis*	Least Concern
34.	Black Kite	*Milvus migrans*	Least Concern
35.	Black-shouldered Kite	*Elanus caeruleus*	Least Concern
36.	Western Koel	*Eudynamys scolopaceus*	Least Concern
37.	Red-wattled Lapwing	*Vanellus indicus*	Least Concern
38.	Yellow-wattled Lapwing	*Vanellus malabaricus*	Least Concern
39.	Ashy-crowned Sparrow Lark	*Eremopterix griseus*	Least Concern

40.	Small Minivet	*Pericrocotus cinnamomeus*	Least Concern
41.	Scaly-breasted Munia	*Lonchura punctulata*	Least Concern
42.	Indian Silver Bill or White-throated Munia	*Euodice malabarica*	Least Concern
43.	Common Myna	*Acridotheres tristis*	Least Concern
44.	Indian Nightjar	*Caprimulgus asiaticus*	Least Concern
45.	Eurasian Golden Oriole	*Oriolus oriolus*	Least Concern
46.	Indian Eagle Owl	*Bubo bengalensis*	Least Concern
47.	Spotted Owlet	*Athene brama*	Least Concern
48.	Rose-ringed Parakeet	*Alexandrinus krameri*	Least Concern
49.	Rock Pigeon or Rock Dove	*Columba livia*	Least Concern
50.	Indian Pitta	*Pitta brachyura*	Least Concern
51.	Ashy Prinia	*Prinia socialis*	Least Concern
52.	Plain Prinia	*Prinia inornata*	Least Concern
53.	Common Quail	*Coturnix coturnix*	Least Concern
54.	Indian Robin	*Saxicoloides fulicata*	Least Concern
55.	Oriental Magpie Robin	*Copsychus saularis*	Least Concern
56.	Indian Roller	*Coracias benghalensis*	Least Concern
57.	Brown Shrike	*Lanius cristatus*	Least Concern
58.	House Sparrow	*Passer domesticus*	Least Concern
59.	Brahminy Starling	*Sturnus pagodarum*	Least Concern
60.	Rosy Starling	*Sturnus roseus*	Least Concern
61.	Asian Openbill Stork	*Anastomus oscitans*	Least Concern
62.	Loten’s Sunbird	*Nectarinia lotenia*	Least Concern
63.	Purple Sunbird	*Nectarinia asiatica*	Least Concern
64.	Purple-rumped Sunbird	*Nectarinia zeylonica*	Least Concern
65.	White-breasted	*Amaurornis phoenicurus*	Least Concern

	waterhen		
66.	Barn Swallow	*Hirundo rustica*	Least Concern
67.	Asian Palm Swift	*Cypsiurus balasiensis*	Least Concern
68.	Little Swift	*Apus affinis*	Least Concern
69.	Common Tailorbird	*Orthotomus sutorius*	Least Concern
70.	Rufous Treepie	*Dendrocitta vagabunda*	Least Concern

Fig 7. Red-vented bulbul nest was observed in the *Lantana* bush

Plate 2. Some of the birds observed in Nanmangalam Reserve Forest

White-throated Kingfisher

Red-vented Bulbul

Little Green Bee-eater

Grey-Heron

Yellow-billed Babbler

Cattle-Egret

Butterflies

Besides vertebrates, NRF is home to fascinating invertebrate life. The large number of butterflies and other insects make the Reserve an enchanting place. The second largest representation of fauna is of the butterflies; the current study recorded about 37 species of butterflies. The commonly see butterflies are Tawny Coster, Common Leopard, Common Grass Yellow, Mottled Emigrant, Angled Castor, Blue Pansy, Dark Grass Blue, Lime Blue, Crimson Rose, Grey Pansy, Common Pierrot, Danaid-Eggfly, Lime Butterfly, Plain Tiger, Common Gull and Common Indian Crow given in table 9.

Table 9. List of Butterflies recorded in Nanmangalam Reserve Forest

S. No	Common Name	Scientific Name	Wildlife Protection Act 1972
1.	Lime Blue	*Chilades laius*	Schudle I Part IV
2.	Pale Grass Blue	*Pseudozizeeria maha*	Schudle I Part IV
3.	Tiny Grass Blue	*Zizula hylax*	Schudle I Part IV
4.	Angled Castor	*Ariadne ariadne*	Schudle I Part IV
5.	Common Caster	*Ariadne merione*	Schudle I Part IV
6.	Tawny Coster	*Acraea violae*	Schudle I Part IV
7.	Crimson Tip	*Colotis danae*	Schudle I Part IV
8.	Common Indian Crow	*Euploea core*	Schudle I Part IV
9.	Danaid Eggfly	*Hypolimnas missippus*	Schudle I Part IV
10.	Great Eggfly	*Hypolimnas bolina*	Schudle I Part IV
11.	Common Emigrant	*Catopsilia Pomona*	Schudle I Part IV
12.	Mottled Emigrant	*Catopsilia pyranthe*	Schudle I Part IV
13.	Common Five-ring	*Yphthima baldus*	Schudle I Part IV
14.	Spotted Small Flat	*Sarangesa purendra*	Schudle I Part IV
15.	Common Gull	*Cepora nerissa*	Schudle I Part IV
16.	Common Jezebel	*Delias eucharis*	Schudle I Part IV
17.	Common Leopard	*Phalanta phalantha*	Schudle I Part IV

18.	Lime Butterfly	*Papilio demoleus*	Schudle I Part IV
19.	Common Mormon	*Papilio polytes*	Schudle I Part IV
20.	Great Orange Tip	*Hebomoia glaucippe*	Schudle I Part IV
21.	Yellow Orange Tip	*Ixias pyrene*	Schudle I Part IV
22.	Blue Pansy	*Junonia orithya*	Schudle I Part IV
23.	Chocolate Pansy	*Junonia iphita*	Schudle I Part IV
24.	Lemon Pansy	*Junonia lemonias*	Schudle I Part IV
25.	Peacock Pansy	*Junonia almanac*	Schudle I Part IV
26.	Yellow Pansy	*Junonia hierta*	Schudle I Part IV
27.	Common Pierrot	*Castalius rosimon*	Schudle I Part IV
28.	Psyche	*Leptosia nina*	Schudle I Part IV
29.	Common Rose	*Pachliopta hector*	Schudle I Part IV
30.	Common Sailor	*Neptis hylas*	Schudle I Part IV
31.	Common Silverline	*Spindasis vulcanus*	Schudle I Part IV
32.	Indian Skipper	*Spialia galba*	Schudle I Part IV
33.	Rice Swift	*Borbo cinnara*	Schudle I Part IV
34.	Blue Tiger	*Tirumala limniace*	Schudle I Part IV
35.	Plain Tiger	*Danaus chrysippus*	Schudle I Part IV
36.	Common Wanderer	*Pareronia valeria*	Schudle I Part IV
37.	Common Grass Yellow	*Eurema hecabe*	Schudle I Part IV

Plate 3. Some of the butterflies observed in Nanmangalam Reserve Forest

Crimson Tip

Peacock Pansy

Common Leopard

Lime Butterfly

Danaid Egg Fly

Common Indian Crow

Dragon and Damselflies

Besides butterflies, the other commonly seen invertebrates are the Dragon and Damselflies. There are about 14 species dragon and damselflies in NRF, some of which may be endangered. These include the Crimson Marsh Glider, Ruddy Marsh Skimmer, Common Picture Wing, Ground Skimmer, Long-Legged Marsh Glider, Wandering Glider, Trumpet Tail and Ditch Jewel. Damselflies such as Golden Dartlets, Coromandel Marsh Dart and Emerald Spreadwing are also found in Nanmangalam RF given table. 10. Apart from butterflies, dragon and damselflies other insects recorded was nursery web spider

(*Dendrolycosa putiana*) and orb-weaver spider (*Argiope aemula*) were recorded in the Nanmangalam RF.

Table .10.Dragonflies and Damselflies recorded in Nanmangalam Reserve Forest

S. No	Common Name	Scientific Name	Wildlife Protection Act 1972
1.	Coromandel Marsh Dart	*Ceriagrion coromandelianum*	Schudle I Part IV
2.	Golden Dartlet	*Ischnura aurora*	Schudle I Part IV
3.	Grass Dartlet	*Pseudagrion decorum*	Schudle I Part IV
4.	Crimson Marsh Gligder	*Trithemis aurora*	Schudle I Part IV
5.	Long-legged Marsh Glider	*Trithemis pallidinervis*	Schudle I Part IV
6.	Wandering Glider	*Pantala flavescens*	Schudle I Part IV
7.	Green Marsh Hawk	*Orthetum sabina*	Schudle I Part IV
8.	Ditch Jewel	*Brachythemis contaminata*	Schudle I Part IV
9.	Common Picture-wing	*Rhyothemis variegata*	Schudle I Part IV
10.	Ground Skimmer	*Diplocodes trivialis*	Schudle I Part IV
11.	Red marsh Skimmer	*Crocothemis servilla*	Schudle I Part IV
12.	Emerald Spreadwing	*Lestes elatus*	Schudle I Part IV
13.	Back Marsh Trotter	*Tramea limbata*	Schudle I Part IV
14.	Trumpet-tail	*Acisoma panorpoides*	Schudle I Part IV

Herpto Fauna

Common amphibians found in NRF are frogs and toads. The NRF is home to several amphibians such as the Common Indian Toad, Jerdon's Bull Frog, Indian Pond Frog, Skipper Frog, Common Tree Frog and Paddy Field Frog.

Fifty percent of Indian reptilian species are snakes. There is no detailed list of reptiles available for NRF. The current study recorded Garden Lizards, Indian Fan-throated Lizards, Common Skink and Common Monitor Lizard. Apart from lizards, snakes such as the Rat Snake, Indian Cobra, Common Vine Snake and Checkered Keelback were also recorded (See table below). The Indian Fanthroated Lizards are plenty in number within the NRF given in table11.

Table. 11. List of Herpto fauna recorded in Nanmangalam Reserve Forest

S. No	Common Name	Scientific Name	Wildlife Protection Act 1972
1.	Common Indian Toad	*Bufo melanosticus*	Schudle I Part II
2.	Common Tree Frog	*Polypedates maculates*	Schudle I Part II
3.	Indian Pond Frog	*Euphlyctis hexadactylus*	Schudle I Part II
4.	Indian Skipper Frog	*Euphlyctis cyanophlyctis*	Schudle I Part II
5.	Jerdon's Bull Frog	*Hoplobatrachus crassus*	Schudle I Part II
6.	Paddy Field Frog	*Fejervarya limnocharis*	Schudle I Part II
7.	Indian Burrowing Frog	*Tomopterna breviceps*	Schudle I Part II
8.	Indian Cobra	*Naja naja*	Schudle I Part II
9.	Rat Snake	*Ptyas mucosus*	Schudle I Part II
10.	Checkered Keelback	*Xenochrophis piscator*	Schudle I Part II
11.	Common Vine Snake	*Ahaetulla nasutus*	Schudle I Part II
12.	Garden Lizard	*Calotes versicolor*	Schudle I Part II
13.	Indian Fan-throated Lizard	*Sitana ponticeriana*	Schudle I Part II
14.	Spotted Gecko	*Hemidactylus brooki*	Schudle I Part II
15.	Common Monitor Lizard	*Varanus bengalensis*	Schudle I Part II

16.	Common Skink	*Mabuya carinatus*	Schudle I Part II
17.	Little Skink	*Mabuya macularius*	Schudle I Part II
18.	Star Tortise	*Geochelone elegans*	Schudle I Part II
19.	Fresh water Turtle	*Lissemysnpunctata*	Schudle I Part II

Plate. 4. Some Herpto Fauna recorded in the Nanmangalam Reserve Forest

Bronzed Frog

Indian Bull Frog

Skipper Frog

Garden Lizard

Fishes

The term "fish" most precisely describes any non-tetra pod craniates (i.e. an animal with a skull and in most cases a backbone) that have gills throughout life and whose limbs, if any, are in the shape of fins. Unlike groupings such as birds or mammals, fish are not a single clade but a paraphyletic collection of taxa, including hagfishes, lampreys, sharks and rays, ray finned fish, coelacanths, and lungfish. A typical fish is ectothermic, has a

streamlined body for rapid swimming, extracts oxygen from water using gills or uses an accessory breathing organ to breathe atmospheric oxygen, has two sets of paired fins, usually one or two (rarely three) dorsal fins, an anal fin, and a tail fin, has jaws, has skin that is usually covered with scales, and lays eggs. During the assessment we have recorded two species of fishes in Nanmangalam RF namely Spotted Snakehead, Mozambique Tilapia (invasive species), based on secondary information from the forest field staff.

Table: 12. List of Fishes recorded in Nanmangalam RF

S. No	Common Name	Scientific Name	IUCN status
1.	Spotted snakehead	*Channa punctatus*	Least Concern
2.	BlackTilapia	*Oreochromis placidus*	Vulnurable

11.0 Nature Trail

Continued presernce and use by humans has led to the formation of a number of paths within the RF. In view of the high representation of Bulbuls in NRF, the trails have been designated as Red Whiskered Bulbul (main trail), Red Vented Bulbul trail and White-Browed Bulbul trail. The length of the trails varies from 2 – 4km and they run through various habitats within the RF such as grasslands, dense scrub, meadows and plantations. This RF has diverse habitats such as hillock, plains and abandoned quarries Vegetation is of dense scrub. Shrubs such as ***Flacourtia indica, Atalantia monophylla*** are very common seen. ***Stenosiphonium russellianum***, a close relative to the genus ***Strobilanthus*** (the genus of Kurinji flowers) which produces blue colored flowers gregariously along the slopes and foot hills during January and can be seen until February. It supports the survival large number of bees, butterflies and sunbirds. Abandoned quarries give home to many freshwater creatures. Aquatic plants such as ***Typha angustata, Hydrilla verticellata, Aponogeton natans, Cyperus*** sp., and Chara.., are found in the quarries. Fresh water Turtles, Water snake, Jerdon's Bull Frog, Indian Burrowing Frog, Skipper Frog and birds such as Pied king fisher, Little cormorant, White breasted water hen, Red wattle lapwing and Great horned owl or Eurasian Eagle Owl are also found in this area.

Fig 8. A view of Nature Trail in Nanmangalam RF

The habitat is of hillock and quarry intervened by the main trail. Vegetation constitutes of thick scrub with sparsely distributed trees such *as* ***Lannea coromandelica, Albizia lebbeck*** **and** ***Ficus benghalensi, Tectona grandis, Acacia ferruginea, A.leucoplea*** are found in this area. The hillocks within these grids possess the highest elevation of 70 meters ASL. A rare terrestrial orchid Eulophia epidendraea is present in abundance along the western slope of the hillock adding further conservation value to the habitat. Birds such as Indian **Pitta, Common Iora, Eurasian Golden Oriole, Pied Bushchat, Red-Vented Bulbul, Red Whiskered Bulbul, Yellow-Billed Babbler, White-Browed Bulbul, Pied Kingfisher and Little Cormorant and rare birds like Rosy Starling,** a winter visitor, were also recorded in this area.

12.0 Biodiversity Management Plan

During the construction period there will be disturbance to nature such as Air Pollution, Noise Pollution and Vibration this will cause adverse impact on biodiversity. Therefore, preventive measure needs to be taken to avoid, minimize, mitigate and compensate the impact. In case of removing the tree which come across the metro corridor, that needs to be transplanted or replaced. Also CMRL will explore the possibility of installing bird divertors along the project area.

Air Pollution

Construction work of the metro rail has impact on the air quality at station and at depot only since metro alignment is constructed at an average depth of 18-20 metres. In the previous chapter, the existing conditions of air quality along the alignment are described. The monitoring results of pollutants such as NO2 , SO2 and CO are much below the national standards (NAAQS, CPCB), the dust concentrations monitored are 2.0 – 2.4 times higher than the standard value. Hence, dust could be the problem when the project is under construction. Any development can have associated health impact that can result directly from changes to the biophysical environment or indirectly as the result of other changes caused by the project. The air pollutants such as particulate matter, sulphur dioxides and nitrogen oxide have adverse impact on human health. The impact of air pollution aggravates bronchitis, respiratory diseases, emphysema, cardiovascular diseases and eye irritation. However, the air pollution during construction is localized and only around the station construction sites only.

Noise Pollution

The major sources of noise pollution during construction are movement of vehicles for transportation of construction material and the construction machinery/equipment at the construction site. No major impacts are anticipated due to noise pollution as the major construction works are underground only. Noise levels at source have been forecasted at various distance as reproduced. Exposure to noise may lead to complete hearing loss, tension, fatigue, fast pulse/ respiration rates, dizziness & loss of balance, anger, irritation & in extreme case nervousness. Construction of noise barriers, such as temporary walls between noisy activities reduces noise. Vegetation cover also reduces the noise level.

Vibration Impact

TBM is the worldwide accepted machine having less impact of vibration. Human response to ground-borne vibration is influenced by amplitude, duration and frequency and are subjective in nature. According to the U.S. Department of Transportation, (1998) the perception threshold of humans for particle velocity is about 0.04 mm/s (65 VdB with reference 1e-6 inch/sec). For a person in their residence, the lower threshold for annoyance is 72 VdB (FTA 2006). The vibration may cause the impact on breeding birds or migratory birds.

Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in Suspended Particulate Matter (SPM) emission from vehicles and construction machinery. Though an air quality during construction shows insignificant impact, nevertheless certain mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The contractor shall take all necessary precautions to minimise fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. He shall not allow emissions of fugitive dust from any transport during handling of materials, construction or storage activity. The emission should not remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.
- The Contractor shall use construction equipment to minimise or control of air pollution. He shall maintain evidence of design and equipment to make these available for inspection by Employer.
- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.
- The Contractor shall use cover for materials of dust generating like debris and soil being transported from construction sites. All trucks carrying loose material should

be covered and loaded with sufficient free- board to avoid.

- Contractor shall install barriers around the open construction sites before commencing the work.
- The temporary dumping areas shall be maintained by the Contractor at all times until excavate is re-utilised for backfilling wherever necessary or as directed by Employer. Dust control activities shall continue even during any work stoppage.
- The Contractor shall place material in a manner that will minimize dust production. Material shall be wetted each day, to minimize dust production. During dry weather, dust control measures must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.
- The Contractor shall sprinkle water at construction sites to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.
- The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.

Noise Control Measures

- There will be an increase in noise level during the construction and operation of the Metro corridors. However, noise levels in the core city are expected to go down. The increases in levels are marginal; hence local population will not be adversely affected.
- However the exposure of workers to high noise levels especially, near the engine, vent shaft etc. need to be minimized. This could be achieved by job rotation to the extent possible.

Automation

- Construction of permanent and temporary noise barriers,
- Re-route and regulate the traffic, a main source of noise,
- Use electric instead of diesel powered equipment,

- Use hydraulic tools instead of pneumatic tools,
- Acoustic enclosures should be provided for individual noise generating construction equipment,
- Scheduling of truck loading, unloading and hauling operation,
- Proper operation and maintenance of the construction vehicles and equipment would keep them within noise limit,
    - Schedule work to avoid simultaneous activities,
    - Anti drumming floor and noise absorption material,
    - Low speed compressor, blower and air conditioner,
    - Mounting of under frame equipment on anti-vibration pad,
    - Smooth and gradual control of door,
    - Provision of GRP baffle on the via-duct for elimination of noise transmission,
    - Provision of sound absorbing material in the supply duct and return grill of air conditioner,
    - Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes, and
    - Sound proof compartments/ control rooms etc.
    - The workers employed in high noise level area could be employed in low noise level areas and vice-versa from time to time. Automation of equipment and machineries, wherever possible, should be done to avoid continuous exposure of workers to noise. At work places, where automation of machineries is not possible or feasible, the workers exposed to noise should be provided with protective devices. Special acoustic enclosures should be provided for individual noise generating equipment, wherever possible.
    - Workers in those sections where periodic adjustment of equipment/machinery is necessary, should be provided with sound proof control rooms so that exposure to higher noise level is reduced. Effective measures should be taken during the construction phase to reduce the noise from various sources. The noise from air compressor can be reduced by fitting exhaust and intake mufflers. Noise proof barriers will be provided on the construction boundary near the residential area.

- Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds. The ballast- less track is supported on two layers of rubber pads to reduce track noise and ground vibrations. In addition, baffle walls as parapets will be constructed at up to the rail level so as to reduce sound levels.

Vibration Control Measures

An actual vibration impact shall be carried out prior to the start of construction and during the construction on the basis of detailed soil investigation and TBM activities involved. Detailed geotechnical investigation is required prior to the tunnel construction. By adopting good construction practices, generation of vibration will be controlled during construction and operation. The preventive measure should be taken to minimize the impact on Biodiversity during the construction phase.

Following measures to be taken during construction period, the contractor shall prepare a monitoring scheme prior to construction at such locations.

- Detailed vibration investigation should be carried out prior to construction at locations where the alignment is close to forest area.
- Continuous vibration monitoring equipment shall be installed during construction.
- Vibration monitoring shall also be conducted inside as well as on the top of the building mainly for old structures and heritage buildings.
- Proper vibration mitigation measures to be taken during construction of tunnels and also during operation of metro rail.
- Pre-construction structural integrity inspections of historic and sensitive structures.
- The local residence staying in the buildings close to the proposed metro rail alignment shall be informed about the vibrations and to vacate the location if needed.
- Information dissemination about the construction method, probable effects, quality control measures and precautions to be used.
- Inform the public about the project and potential vibration-related consequences, monitor and record vibration from the activities for sensitive receptors.

- Vibration emanates from rail - wheel interaction and the same can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.
- While designing the track structure for Mass Rapid Transit System all the above points have been taken into consideration in the following ways:
- The vibration generated from rail-wheel interaction will be greatly absorbed by the elastic fastening system proposed to be used.
- The lower vibration will be achieved by providing of bolster less type bogies having secondary air spring.

Impact on Ecology

The Project will seek to minimize impacts on notable species and loss, fragmentation, alteration, disturbance and disruption of sensitive habitats. The approach to be taken is outlined throughout this Metro area. A principal management tool in this will be the use of Biodiversity Specialists. A minimum of one Biodiversity Specialist will be employed for every lot / spread of metro construction. All Biodiversity Specialists will be appropriately skilled for undertaking site supervision and species relocations where required. The Biodiversity Specialists contracted will identify and map potentially sensitive habitats (including potential notable species habitat) along the spread ahead of any works. Habitats will be mapped in sufficient detail that the locations of notable plant (and where practical animal) species (including rare and endangered species) are clearly marked. Mitigation will be applied in all areas where sensitive habitats are identified, The maps will be used to monitor mitigation effectiveness. Where any such habitats or species present impacts will be mitigated as outlined in the metro area

Necessary mitigation measure must be undertaken to reduce the indirect impact of the project to the nearby forest areas and overall ecology. The indirect impact may be due to release of contaminated, polluted or untreated water, debris, or other materials particular to the kind of the project.

Suggested mitigation measures

- 1. Avenue plantation all along the project location should be done and mainly consist of native plant species.
- 2. The water effluent discharge should be as per state guidelines.
- 3. The project proponent must undertake plantation drives to improve native plant diversity of the region

Establishing Green Belt

During the construction time some trees may be removed, therefore establishing green belt is essential. The total area available for plantation has been divided into different zones to prepare a comprehensive plantation strategy. According to the flora diversity and the nature of the existing vegetation along the Reserve Forest, it is suggested to plant Tropical Dry Evergreen tree (Native species) species. On the other hand removal of invasive species mainly *Prosopis juliflora* is foremost important, after removal of *Prosopis*, those area would be planted by native tree species which is recommended. Since the metro rail corridor coming along the RF, hence developing green belt is essential to observe the air pollution in that area. The list of plant species recommended for planting are as follows:

Large tree	Medium Tree
Wrightia tinctoria	*Acacia auriculiformis*
Albizia lebbeck	*Canthium dicoccum*
Pongamia pinnata	*Buchanania axillaris*
Syzygium cumini	*Calophyllum inophyllum*
Terminalia cuneata	*Diospyros Montana*
Diospyros malabarica	*Psydrax dicoccos*
Madhuca longifolia	*Sapindus emarginatus*
Limonia acidissima	*Madhuca indica*
Azadirachta indica	*Anogeissus latifolia*
Pterocarpus santalinus	*Diospyros chloroxylon*
Lannea coromandelica	*Litsea glutinosa*
Manilkara hexandra	*Cassia fistula*
Terminalia chebula	

Outreach / Nature education

Outreach/Nature education programme is very important, to aware about the importance Nanmangalam RF. Already well established an interpretation centre is available. This centre can emphasize the importance and conservation issues of RF and the ecosystem services derived from such ecosystems. Audiovisual centre and museum are also important components of the centre. This can be open for children, students and public. The centre can also organize and conduct camps, workshops and seminars targeting different segments of the society. This centre will also provide information to tourists.

Signage board is another important component for the outreach programme, already some signage boards installed, this may improved further to attract public to aware of the Nanmangalam RF, further developing field guides, nature trails which may attract local public to visit the RF.

Possiblity of implementing the additional mitigation measures will be analysed during construction stage to minimize the residual impacts on biodiversity.

13.0 Summary and Conclusion

A study to assess the biodiversity of Nanmangalam RF, apart from assessing the habitat diversity and quality of the RF, the study enumerated the flora and fauna of the RF.Results indicate that the Nanmangalam RF harbours a notable diversity of flora and fauna, with the potential of functioning as an in situ conservation area for plants. The merit of the RF is further enhanced by the presence of a sizeable number of endemics and endangered organisms. The Metro rail phase 2 and corridor 5 is proposed in the boundary of the Nanmangalam Reserve Forest, since the metro rail activity will take place in the boundary of the RF,therefore the impact may be very minimal, that has to be monitor during the construction phase, every quarter the impact report should be submitted to concern authority of CMRL. A senior ecologist may be appointed to monitor the day to day activities in the corridor 5, phase 2 area metro.

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APPENDICES

1.0 List plants recorded in Nanmangalam Reserve Forest

S.No	Species	Family	Habit
1	*Abrus precatorius*	Fabaceae	Climber
2	*Abutilon hirtum*	Malvaceae	Shrub
3	*Abutilon indicum*	Malvaceae	Shrub
4	*Acacia auriculiformis*	Mimosaceae	Tree
5	*Acacia caesia*	Caesalpiniaceae	Shrub-Stragglar
6	*Acacia ferruginea*	Mimosaceae	Tree
7	*Acacia leucophloea*	Mimosaceae	Tree
8	*Acacia planifrons*	Mimosaceae	Tree
9	*Acalypha indica*	Euphorbiaceae	Herb
10	*Acalypha lanceolata*	Euphorbiaceae	Herb
11	*Acanthospermum hispidum*	Asteraceae	Herb
12	*Achyranthes aspera*	Amaranthaceae	Herb
13	*Aerva lanata*	Amaranthaceae	Herb
14	*Aeschynomene aspera*	Fabaceae	Herb
15	*Aeschynomene indica*	Fabaceae	Herb
16	*Agave angustifolia*	Agavaceae	Shrub
17	*Ageratum conyzoides*	Asteraceae	Herb
18	*Albizia lebbeck*	Mimosaceae	Tree
19	*Allmania nodiflora*	Amaranthaceae	Herb
20	*Allophylus cobbe*	Sapindaceae	Shrub-Straggler
21	*Alloteropsis cimicina*	Poaceae	Herb-Grass
22	*Alternanthera sessilis*	Amaranthaceae	Herb

S.No	Species	Family	Habit
23	*Alternanthera tenella*	Amaranthaceae	Herb
24	*Alysicarpus monilifer*	Fabaceae	Herb
25	*Alysicarpus ovalifolius*	Fabaceae	Herb
26	*Amaranthus spinosus*	Amaranthaceae	Herb
27	*Amaranthus viridis*	Amaranthaceae	Herb
28	*Ammania baccifera*	Lythraceae	Herb
29	*Andrographis paniculata*	Acanthaceae	Herb
30	*Andropogon pumilus*	Poaceae	Herb-Grass
31	*Anisomeles indica*	Lamiaceae	Undershrub
32	*Anisomeles malabarica*	Lamiaceae	Shrub
33	*Annona eticulate*	Annonaceae	Tree-Small
34	*Anogeissus latifolia*	Combretaceae	Tree
35	*Apluda mutica*	Poaceae	Herb-Grass
36	*Aponogeton natans*	Aponogetonaceae	Herb
37	*Aristida adscensionis*	Poaceae	Herb-Grass
38	*Aristida hystrix*	Poaceae	Herb-Grass
39	*Aristida setacea*	Poaceae	Herb-Grass
40	*Asparagus racemosus*	Liliaceae	Liana
41	*Asystasia gangetica*	Acanthaceae	Herb
42	*Atalantia monophylla*	Rutaceae	Tree-Small
43	*Axonopus compressus*	Poaceae	Herb-Grass
44	*Azadirachta indica*	Meliaceae	Tree
45	*Bacopa floribunda*	Scrophulariaceae	Herb
46	Barringtonia acutangula (L.) Gaertn.	Barringtoniaceae	Tree
47	*Barleria prionitis*	Acanthaceae	Undershrub

S.No	*Species*	Family	Habit
48	*Basilicum polystachyon*	Lamiaceae	Herb
49	*Bauhinia racemosa*	Caesalpiniaceae	Tree-Small
50	*Benkara malabarica*	Rubiaceae	Shrub
51	*Blepharis maderaspatensis*	Acanthaceae	Herb
52	*Blepharis repens*	Acanthaceae	Herb
53	*Blumea aurita*	Asteraceae	Herb
54	*Blumea oblique*	Asteraceae	Herb
55	*Boerhavia diffusa*	Nyctaginaceae	Herb
56	*Boerhavia erecta*	Nyctaginaceae	Herb
57	*Borassus flabellifer*	Arecaceae	Tree
58	*Bothriochloa pertusa*	Poaceae	Herb-Grass
59	*Brachiaria distachya*	Poaceae	Herb-Grass
60	*Brachiaria remota*	Poaceae	Herb-Grass
61	*Breynia vitis-idaea*	Euphorbiaceae	Shrub
62	*Buchanania axillaris*	Anacardiaceae	Tree
63	*Bulbostylis barbata*	Cyperaceae	Herb-Sedge
64	*Butea monosperma*	Fabaceae	Tree
65	*Cadaba fruticosa*	Capparidaceae	Shrub
66	*Cajanus scarabaeoides*	Fabaceae	Climber
67	*Calotropis eticulat*	Asclepiadaceae	Shrub
68	*Canavalia virosus*	Fabaceae	Climber
69	*Canscora eticulates*	Gentianaceae	Herb
70	*Cansjera rheedii*	Opiliaceae	Shrub-Straggler
71	*Canthium dicoccum*	Rubiaceae	Tree-Small
72	*Canthium parviflorum*	Rubiaceae	Shrub

S.No	*Species*	Family	Habit
73	*Capparis brevispina*	Capparidaceae	Shrub
74	*Capparis sepiaria*	Capparidaceae	Shrub-Straggler
75	*Capparis zeylanica*	Capparidaceae	Shrub-Straggler
76	*Caralluma adscendens*	Asclepiadaceae	Herb
77	*Cardiospermum halicacabum*	Sapindaceae	Climber
78	*Carissa spinarum*	Apocynaceae	Shrub
79	*Carmona retusa*	Boraginaceae	Shrub
80	*Cassia absus*	Caesalpiniaceae	Herb
81	*Cassia auriculata*	Caesalpiniaceae	Shrub
82	*Cassia fistula*	Caesalpiniaceae	Tree
83	*Cassia hirsute*	Caesalpiniaceae	Undershrub
84	*Cassia mimosoides*	Caesalpiniaceae	Herb
85	*Cassia occidentalis*	Caesalpiniaceae	Undershrub
86	*Cassia pumila*	Caesalpiniaceae	Herb
87	*Cassia roxburghii*	Caesalpiniaceae	Tree
88	*Cassia siamea*	Caesalpiniaceae	Tree
89	*Cassia tora*	Caesalpiniaceae	Undershrub
90	*Cassytha filiformis*	Lauraceae	Parasite
91	*Catharanthus roseus*	Apocynaceae	Herb
92	*Catunaregam spinosa*	Rubiaceae	Shrub
93	*Cereus pterogonus*	Cactaceae	Shrub
94	*Chloris barbata*	Poaceae	Herb-Grass
95	*Chloris eticul*	Poaceae	Herb-Grass
96	*Chlorophytum tuberosum*	Liliaceae	Herb

S.No	Species	Family	Habit
73	*Capparis brevispina*	Capparidaceae	Shrub
74	*Capparis sepiaria*	Capparidaceae	Shrub-Straggler
75	*Capparis zeylanica*	Capparidaceae	Shrub-Straggler
76	*Caralluma adscendens*	Asclepiadaceae	Herb
77	*Cardiospermum halicacabum*	Sapindaceae	Climber
78	*Carissa spinarum*	Apocynaceae	Shrub
79	*Carmona retusa*	Boraginaceae	Shrub
80	*Cassia absus*	Caesalpiniaceae	Herb
81	*Cassia auriculata*	Caesalpiniaceae	Shrub
82	*Cassia fistula*	Caesalpiniaceae	Tree
83	*Cassia hirsute*	Caesalpiniaceae	Undershrub
84	*Cassia mimosoides*	Caesalpiniaceae	Herb
85	*Cassia occidentalis*	Caesalpiniaceae	Undershrub
86	*Cassia pumila*	Caesalpiniaceae	Herb
87	*Cassia roxburghii*	Caesalpiniaceae	Tree
88	*Cassia siamea*	Caesalpiniaceae	Tree
89	*Cassia tora*	Caesalpiniaceae	Undershrub
90	*Cassytha filiformis*	Lauraceae	Parasite
91	*Catharanthus roseus*	Apocynaceae	Herb
92	*Catunaregam spinosa*	Rubiaceae	Shrub
93	*Cereus pterogonus*	Cactaceae	Shrub
94	*Chloris barbata*	Poaceae	Herb-Grass
95	*Chloris eticul*	Poaceae	Herb-Grass
96	*Chlorophytum tuberosum*	Liliaceae	Herb

S.No	Species	Family	Habit
97	*Chrysopogon asper*	Poaceae	Herb-Grass
98	*Chrysopogon fulvus*	Poaceae	Herb-Grass
99	*Cissampelos pareira*	Menispermaceae	Climber
100	*Cissus quadrangularis*	Vitaceae	Shrub-Straggler
101	*Cissus vitiginea*	Vitaceae	Liana
102	*Cleistanthus collinus*	Euphorbiaceae	Shrub
103	*Cleome aspera*	Cleomaceae	Herb
104	*Cleome rutidosperma*	Cleomaceae	Herb
105	*Cleome viscose*	Cleomaceae	Herb
106	*Clitoria ternatea*	Fabaceae	Climber
107	*Coccinia grandis*	Cucurbitaceae	Climber
108	*Coldenia procumbens*	Boraginaceae	Herb
109	*Combretum albidum*	Combretaceae	Liana
110	*Commelina eticulat*	Commelinaceae	Herb
111	*Commelina benghalensis*	Commelinaceae	Herb
112	*Corallocarpus epigaeus*	Cucurbitaceae	Climber
113	*Corchorus aestuans*	Tiliaceae	Herb
114	*Cordia eticul*	Cordiaceae	Tree
115	*Crateva adansonii*	Capparidaceae	Tree-Small
116	*Crinum viviparum*	Amaryllidaceae	Herb
117	*Crotalaria hebecarpa*	Fabaceae	Herb
118	*Crotalaria juncea*	Fabaceae	Undershrub
119	*Crotalaria medicaginea*	Fabaceae	Herb
120	*Crotalaria pallida*	Fabaceae	Undershrub
121	*Crotalaria eticulat*	Fabaceae	Herb

S.No	Species	Family	Habit
122	*Crotalaria retusa*	Fabaceae	Undershrub
123	*Crotalaria verrucosa*	Fabaceae	Undershrub
124	*Croton bonplandianum*	Euphorbiaceae	Herb
125	*Ctenolepis garcinii*	Cucurbitaceae	Climber
126	*Cucumis melo*	Cucurbitaceae	Climber
127	*Curculigo orchioides*	Hypoxidaceae	Herb
128	*Cyanotis eticulate*	Commelinaceae	Herb
129	*Cyanotis cristata*	Commelinaceae	Herb
130	*Cymbopogon travancorensis*	Poaceae	Herb-Grass
131	*Cynodon barberi*	Poaceae	Herb-Grass
132	*Cynodon dactylon*	Poaceae	Herb-Grass
133	*Cyperus clarkei*	Cyperaceae	Herb-Sedge
134	*Cyperus distans*	Cyperaceae	Herb-Sedge
135	*Cyperus iria*	Cyperaceae	Herb-Sedge
136	*Cyperus rotundus*	Cyperaceae	Herb-Sedge
137	*Cyrtococcum trigonum*	Poaceae	Herb-Grass
138	*Dactyloctenium aegyptium*	Poaceae	Herb-Grass
139	*Dalbergia lanceolaria*	Fabaceae	Tree
140	*Dalbergia sissoo*	Fabaceae	Tree
141	*Datura innoxia*	Solanaceae	Undershrub
142	*Datura metal*	Solanaceae	Undershrub
143	*Delonix regia*	Caesalpiniaceae	Tree
144	*Dentella repens*	Rubiaceae	Herb
145	*Desmodium tortuosum*	Fabaceae	Undershrub
146	*Desmodium triflorum*	Fabaceae	Herb

S.No	Species	Family	Habit
147	*Desmostachya bipinnata*	Poaceae	Herb-Grass
148	*Dicanthium armatum*	Poaceae	Herb-Grass
149	*Dicerma biarticulatum*	Fabaceae	Herb
150	*Dichanthium caricosum*	Poaceae	Herb-Grass
151	*Dichrostachys cinerea*	Mimosaceae	Tree-Small
152	*Digitaria ciliaris*	Poaceae	Herb-Grass
153	*Dimeria acutipes*	Poaceae	Herb-Grass
154	*Dioscorea pentaphylla*	Dioscoreaceae	Climber
155	*Diospyros chloroxylon*	Ebenaceae	Tree
156	*Diospyros ferrea*	Ebenaceae	Shrub
157	*Diospyros melanoxylon*	Ebenaceae	Tree-Small
158	*Diplocyclos palmatus*	Cucurbitaceae	Climber
159	*Dipteracanthus eticulate*	Acanthaceae	Herb
160	*Dodonaea viscosa*	Sapindaceae	Shrub
161	*Dolichandrone eticul*	Bignoniaceae	Tree
162	*Dopatrium junceum*	Scrophulariaceae	Herb
163	*Drosera burmannii*	Droseraceae	Herb
164	*Drosera indica*	Droseraceae	Herb
165	*Drypetes sepiaria*	Euphorbiaceae	Tree-Small
166	*Ecbolium viride*	Acanthaceae	Undershrub
167	*Eclipta prostrata*	Asteraceae	Herb
168	*Ehretia pubescens*	Cordiaceae	Tree-Small
169	*Eleusine indica*	Poaceae	Herb-Grass
170	*Emilia sonchifolia*	Asteraceae	Herb

S.No	Species	Family	Habit
171	*Enicostema axillare*	Gentianaceae	Herb
172	*Enterolobium cyclocarpum*	Mimisaceae	Tree
173	*Enteropogon monostachyos*	Poaceae	Herb-Grass
174	*Epaltes divaricata*	Asteraceae	Herb
175	*Eragrostiella bifaria*	Poaceae	Herb-Grass
176	*Eragrostiella brachyphylla*	Poaceae	Herb-Grass
177	*Eragrostis gangetica*	Poaceae	Herb-Grass
178	*Eragrostis macilenta*	Poaceae	Herb-Grass
179	*Eragrostis nutans*	Poaceae	Herb-Grass
180	*Eragrostis tenella var. insularis*	Poaceae	Herb-Grass
181	*Eragrostis tenella var. tenella*	Poaceae	Herb-Grass
182	*Eragrostis unioloides*	Poaceae	Herb-Grass
183	*Eragrostis eticul*	Poaceae	Herb-Grass
184	*Eriocaulon quinquangulare*	Eriocaulaceae	Herb
185	*Erythrina suberosa*	Fabaceae	Tree
186	*Eucalyptus tereticornis*	Myrtaceae	Tree
187	*Eulophia epidendraea*	orchidaceae	Herb
188	*Euphorbia antiquorum*	Euphorbiaceae	Shrub
189	*Euphorbia corrigioloides*	Euphorbiaceae	Herb
190	*Euphorbia hirta*	Euphorbiaceae	Herb
191	*Euphorbia indica*	Euphorbiaceae	Herb
192	*Euphorbia tirucalli*	Euphorbiaceae	Shrub
193	*Evolvulus alsinoides*	Convolvulaceae	Herb-Creeper
194	*Evolvulus nummularius*	Convolvulaceae	Herb-Creeper

S.No	Species	Family	Habit
195	*Ficus amplissima*	Moraceae	Tree
196	*Ficus benghalensis*	Moraceae	Tree
197	*Ficus hispida*	Moraceae	Shrub
198	*Ficus racemosa*	Moraceae	Tree
199	*Ficus religiosa*	Moraceae	Tree
200	*Fimbristylis argentea*	Cyperaceae	Herb-Sedge
201	*Fimbristylis dichotoma*	Cyperaceae	Herb-Sedge
202	*Fimbristylis miliacea*	Cyperaceae	Herb-Sedge
203	*Fimbristylis ovata*	Cyperaceae	Herb-Sedge
204	*Flacourtia indica*	Flocourcaceae	Shrub
205	*Geniosporium tenuiflorum*	Lamiaceae	Herb
206	*Glinus oppositifolius*	Molluginaceae	Herb
207	*Gliricidia sepium*	Fabaceae	Tree-Small
208	*Gloriosa superba*	Liliaceae	Climber
209	*Glycosmis mauritiana*	Rutaceae	Shrub
210	*Gmelina asiatica*	Verbenaceae	Shrub
211	*Gomphrena serrata*	Amaranthaceae	Herb
212	*Grewia eticul*	Tiliaceae	Shrub
213	*Grewia orientalis*	Tiliaceae	Shrub-Straggler
214	*Guazuma ulmifolia*	Sterculiaceae	Tree
215	*Gymnema sylvestre*	Asclepiadaceae	Climber
216	*Gynandropsis gynandra*	Cleomaceae	Herb
217	*Habenaria viridiflora*	Orchidaceae	Herb
218	*Hardwickia binata*	Caesalpiniaceae	Tree
219	*Hedyotis affinis*	Rubiaceae	Herb

S.No	Species	Family	Habit
220	*Hedyotis biflora*	Rubiaceae	Herb
221	*Hedyotis brachiata*	Rubiaceae	Herb
222	*Hedyotis corymbosa*	Rubiaceae	Herb
223	*Hedyotis herbacea*	Rubiaceae	Herb
224	*Hedyotis puberula*	Rubiaceae	Herb
225	*Helicteres isora*	Sterculiaceae	Shrub
226	*Heliotropium bracteatum*	Boraginaceae	Herb
227	*Heliotropium indicum*	Boraginaceae	Herb
228	*Hemidesmus indicus*	Periplocaceae	Climber
229	*Heteropogon contortus*	Poaceae	Herb-Grass
230	*Heteropogon polystachyos*	Poaceae	Herb-Grass
231	*Hibiscus micranthus*	Malvaceae	Undershrub
232	*Hibiscus rosa-sinensis*	Malvaceae	Shrub
233	*Hibiscus vitifolius*	Malvaceae	Undershrub
234	*Holoptelea integrifolia*	Ulmaceae	Tree
235	*Hugonia mystax*	Linaceae	Liana
236	*Hybanthus enneaspermus*	Violaceae	Herb
237	*Hydrilla verticillata*	Hydrocharitaceae	Herb
238	*Hydrolea zeylanica*	Hydrophyllaceae	Herb
239	*Hyptis suaveolens*	Lamiaceae	Undershrub
240	*Ichnocarpus frutescens*	Apocynaceae	Climber
241	*Indigofera aspalathoides*	Fabaceae	Herb
242	*Indigofera linifolia*	Fabaceae	Herb
243	*Indigofera linnaei*	Fabaceae	Herb
244	*Indigofera tinctoria*	Fabaceae	Herb

S.No	Species	Family	Habit
245	*Indigofera trifoliata*	Fabaceae	Herb
246	*Indoneesiella echioides*	Acanthaceae	Herb
247	*Iphigenia indica*	Liliaceae	Herb
248	*Ipomoea aquatica*	Convolvulaceae	Herb
249	*Ipomoea carnea*	Convolvulaceae	Shrub
250	*Ipomoea coptica*	Convolvulaceae	Herb-twiner
251	*Ipomoea pes-tigridis*	Convolvulaceae	Climber
252	*Ipomoea sepiaria*	Convolvulaceae	Climber
253	*Iseilema prostratum*	Poaceae	Herb-Grass
254	*Ixora pavetta*	Rubiaceae	Tree
255	*Jasminum angustifolium*	Oleaceae	Climber
256	*Jatropha gossypifolia*	Euphorbiaceae	Shrub
257	*Justicia adhatoda*	Acanthaceae	Shrub
258	*Justicia eticulat*	Acanthaceae	Herb
259	*Kyllingia nemoralis*	Cyperaceae	Herb-Sedge
260	*Lannea coromandelica*	Anacardiaceae	Tree
261	*Lantana camara*	Verbenaceae	Shrub
262	*Lemna perpusilla*	Lemnaceae	Herb
263	*Lepidagathis cristata*	Acanthaceae	Herb
264	*Lepisanthes tetraphylla*	Sapindaceae	Tree
265	*Leptadenia eticulate*	Asclepiadaceae	Climber
266	*Leptochloa uniflora*	Poaceae	Herb-Grass
267	*Leucaena leucocephala*	Mimosaceae	Tree
268	*Leucas aspera*	Lamiaceae	Herb
269	*Leucas biflora*	Lamiaceae	Herb

S.No	Species	Family	Habit
270	*Leucas diffusa*	Lamiaceae	Herb
271	*Leucas indica*	Lamiaceae	Herb
272	*Limnophila indica*	Scrophulariaceae	Herb
273	*Lindernia ciliata*	Scrophulariaceae	Herb
274	*Lindernia eticulate*	Scrophulariaceae	Herb
275	*Lindernia oppositifolia*	Scrophulariaceae	Herb
276	*Lindernia parviflora*	Scrophulariaceae	Herb
277	*Lipocarpha raynaleana*	Cyperaceae	Herb-Sedge
278	*Ludwigia adscendens*	Onagraceae	Herb
279	*Ludwigia perennis*	Onagraceae	Herb
280	*Luffa eticulates*	Cucurbitaceae	Climber
281	*Madhuca longifolia*	Sapotaceae	Tree
282	*Malvastrum coromandelianum*	Malvaceae	Undershrub
283	*Manilkara hexandra*	Sapotaceae	Tree
284	*Mariscus paniceus*	Cyperaceae	Herb-Sedge
285	*Maytenus emarginata*	celastraceae	Shrub
286	*Melochia corchorifolia*	Sterculiaceae	Herb
287	*Memecylon edule*	Melastamataceae	Shrub
288	*Memecylon umbellatum*	Melastomataceae	Shrub
289	*Merremia emarginata*	Convolvulaceae	Herb-Creeper
290	*Merremia tridentata*	Convolvulaceae	Herb-twiner
291	*Micrococca mercurialis*	Euphorbiaceae	Herb
292	*Mimosa intsia*	Mimosaceae	Shrub-Straggler
293	*Mimosa pudica*	Mimosaceae	Herb
294	*Mitracarpus villosus*	Rubiaceae	Herb

S.No	Species	Family	Habit
295	*Mnesithea laevis*	Poaceae	Herb-Grass
296	*Mollugo nudicaulis*	Molluginaceae	Herb
297	*Mollugo pentaphylla*	Molluginaceae	Herb
298	*Momordica charantia*	Cucurbitaceae	Climber
299	*Morinda pubescens*	Rubiaceae	Tree-Small
300	*Mukia maderaspatana*	Cucurbitaceae	Climber
301	*Muntingia calabura*	Elaeocarpaceae	Tree
302	*Murdannia nudiflora*	Commelinaceae	Herb
303	*Murdannia spirata*	Commelinaceae	Herb
304	*Nerium oleander*	Apocynaceae	Shrub
305	*Nopalea cochenillifera*	Cactaceae	Shrub
306	*Nymphaea pubescens*	Nympheaceae	Herb
307	*Nymphaea nouchali*	Nympheaceae	Herb
308	*Ochna obtusata*	Ochnaceae	Shrub
309	*Ocimum adscendens*	Lamiaceae	Herb
310	*Ocimum americanum*	Lamiaceae	Herb
311	*Ocimum tenuiflorum*	Lamiaceae	Undershrub
312	*Oplismenus compositus*	Poaceae	Herb-Grass
313	*Opuntia elatior*	Cactaceae	Shrub
314	*Opuntia stricta*	Cactaceae	Shrub
315	*Orthosiphon thymiflorus*	Lamiaceae	Herb
316	*Osbeckia zeylanica*	Melastamataceae	Herb
317	*Ottelia alismoides*	Hydrocharitaceae	Herb
318	*Oxystelma secamone*	Asclepiadaceae	Climber
319	*Pachygone ovata*	Menispermaceae	Climber

S.No	Species	Family	Habit
320	*Panicum psilopodium*	Poaceae	Herb-Grass
321	*Parthenium hysterophorus*	Asteraceae	Herb
322	*Paspalidium flavidum*	Poaceae	Herb-Grass
323	*Paspalum distichum*	Poaceae	Herb-Grass
324	*Paspalum scrobiculatum*	Poaceae	Herb-Grass
325	*Passiflora foetida*	Passifloraceae	Climber
326	*Pavonia odorata*	Malvaceae	Herb
327	*Pavonia zeylanica*	Malvaceae	Herb
328	*Pedalium murex*	Pedaliaceae	Herb
329	*Pedilanthus tithymaloides*	Euphorbiaceae	Undershrub
330	*Peltophorum pterocarpum*	Caesalpiniaceae	Tree
331	*Pergularia daemia*	Asclepiadaceae	Climber
332	*Perotis indica*	Poaceae	Herb-Grass
333	*Phoenix pusilla*	Arecaceae	Shrub
334	*Phoenix sylvestris*	Arecaceae	Tree
335	*Phyla nodiflora*	Verbenaceae	Herb
336	*Phyllanthus amarus*	Euphorbiaceae	Herb
337	*Phyllanthus debilis*	Euphorbiaceae	Herb
338	*Phyllanthus emblica*	Euphorbiaceae	Tree
339	*Phyllanthus maderaspatensis*	Euphorbiaceae	Herb
340	*Phyllanthus eticulates*	Euphorbiaceae	Shrub-Straggler
341	*Phyllanthus virgatus*	Euphorbiaceae	Herb
342	*Physalis angulata*	Solanaceae	Herb
343	*Physalis lagascae*	Solanaceae	Herb
344	*Pistia stratiotes*	Araceae	Herb

S.No	Species	Family	Habit
345	*Pithecellobium dulce*	Mimosaceae	Tree
346	*Plumbago zeylanica*	Plumbaginaceae	Herb
347	*Polyalthia longifolia*	Annonaceae	Tree
348	*Polycarpaea corymbosa var. corymbosa*	Caryophyllaceae	Herb
349	*Polycarpaea corymbosa var. longipetala*	Caryophyllaceae	Herb
350	*Polygala arvensis*	Polygalaceae	Herb
351	*Pongamia pinnata*	Fabaceae	Tree
352	*Portulaca quadrifida*	Portulacaceae	Herb
353	*Portulaca suffruticosa*	Portulacaceae	Herb
354	*Premna corymbosa*	Verbenaceae	Shrub-Straggler
355	*Premna tomentosa*	Verbenaceae	Shrub
356	*Prosopis juliflora*	Mimosaceae	Tree
357	*Pseudarthria viscida*	Fabaceae	Herb
358	*Psidium guajava*	Myrtaceae	Tree-Small
359	*Psilanthus wightianus*	Rubiaceae	Shrub
360	*Pterolobium hexapetalum*	Caesalpiniaceae	Shrub-Straggler
361	*Pupalia lappacea*	Amaranthaceae	Herb
362	*Pycnospora lutescens*	Fabaceae	Herb-Twiner
363	*Pycreus pumilus*	Cyperaceae	Herb-Sedge
364	*Reissantia indica*	celastraceae	Shrub-Straggler
365	*Rhynchosia aurea*	Fabaceae	Herb-Creeper
366	*Rhynchosia rufescens*	Fabaceae	Herb-Twiner
367	*Richardia scabra*	Rubiaceae	Herb
368	*Ricinus communis*	Euphorbiaceae	Shrub

S.No	Species	Family	Habit
369	*Rivea hypocrateriformis*	Convolvulaceae	Liana
370	*Rotala rosea*	Lythraceae	Herb
371	*Rotala verticillaris*	Lythraceae	Herb
372	*Ruellia tuberosa*	Acanthaceae	Herb
373	*Sansevieria roxburghiana*	Dracenaceae	Herb
374	*Santalum album*	Santalaceae	Tree
375	*Sapindus emarginatus*	Sapindaceae	Tree
376	*Sarcostemma acidum*	Asclepiadaceae	Climber
377	*Sauropus bacciformis*	Euphorbiaceae	Herb
378	*Scoparia dulcis*	Scrophulariaceae	Herb
379	*Scutia myrtina*	Rhamnaceae	Shrub
380	*Sebastiania chamaelea*	Euphorbiaceae	Herb
381	*Secamone emetica*	Asclepiadaceae	Climber
382	*Securinega leucopyrus*	Euphorbiaceae	Shrub
383	*Setaria pumila*	Poaceae	Herb-Grass
384	*Setaria verticillata*	Poaceae	Herb-Grass
385	*Sida acuta*	Malvaceae	Herb
386	*Sida cordata*	Malvaceae	Herb
387	*Sida cordifolia*	Malvaceae	Undershrub
388	*Sida schimperiana*	Malvaceae	Undershrub
389	*Solanum americanum*	Solanaceae	Herb
390	*Solanum torvum*	Solanaceae	Shrub
391	*Solanum trilobatum*	Solanaceae	Climber

S.No	Species	Family	Habit
392	*Solanum virginianum*	Solanaceae	Herb
393	*Solena amplexicaulis*	Cucurbitaceae	Climber
394	*Spermacoce articularis*	Rubiaceae	Herb
395	*Spermacoce hispida*	Rubiaceae	Herb
396	*Spirodela polyrhiza*	Lemnaceae	Herb
397	*Sporobolus coromandelianus*	Poaceae	Herb-Grass
398	*Sporobolus indicus*	Poaceae	Herb-Grass
399	*Stachytarpheta jamaicensis*	Verbenaceae	Herb
400	*Stenosiphonium russellianum*	Acanthaceae	Undershrub
401	*Streblus asper*	Moraceae	Tree
402	*Striga angustifolia*	Scrophulariaceae	Herb
403	*Strychnos lenticellata*	Loganiaceae	Liana
404	*Stylosanthes fruticosa*	Fabaceae	Herb
405	*Synedrella nodiflora*	Asteraceae	Herb
406	*Syzygium cumini*	Myrtaceae	Tree
407	*Tamarindus indica*	Caesalpiniaceae	Tree
408	*Tarenna asiatica*	Rubiaceae	Shrub
409	*Tectona grandis*	Verbenaceae	Tree
410	*Tephrosia maxima*	Fabaceae	Herb
411	*Tephrosia pumila*	Fabaceae	Herb
412	*Tephrosia purpurea*	Fabaceae	Herb
413	*Tephrosia villosa*	Fabaceae	Herb
414	*Teramnus labialis*	Fabaceae	Herb

S.No	Species	Family	Habit
415	*Terminalia bellirica*	Combretaceae	Tree
416	*Terminalia catappa*	Combretaceae	Tree
417	*Terminalia chebula*	Combretaceae	Tree
418	*Theriophonum minutum*	Araceae	Herb
419	*Thespesia populnea*	Malvaceae	Tree
420	*Tiliacora acuminata*	Menispermaceae	Liana
421	*Tinospora cordifolia*	Menispermaceae	Climber
422	*Toddalia asiatica*	Rutaceae	Shrub-Straggler
423	*Tragia involucrata*	Euphorbiaceae	Climber
424	*Tragus roxburghii*	Poaceae	Herb-Grass
425	*Trianthema portulacastrum*	Aizoaceae	Herb
426	*Tribulus lanuginosis*	Zygophyllaceae	Herb
427	*Trichuriella monsoniae*	Amaranthaceae	Herb
428	*Tridax procumbens*	Asteraceae	Herb
429	*Triumfetta rhomboidea*	Tiliaceae	Undershrub
430	*Turnera subulata*	Turneraceae	Undershrub
431	*Tylophora indica*	Asclepiadaceae	Climber
432	*Typha angustifolia*	Typhaceae	Rheed
433	*Urena lobata*	Malvaceae	Undershrub
434	*Utricularia caerulea*	Lentibulariaceae	Herb
435	*Utricularia graminifolia*	Lentibulariaceae	Herb
436	*Utricularia polygaloides*	Lentibulariaceae	Herb
437	*Utricularia scandens*	Lentibulariaceae	Herb
438	*Ventilago madraspatana*	Rhamnaceae	Liana
439	*Vernonia cinerea*	Asteraceae	Herb

S.No	Species	Family	Habit
440	*Vetiveria zizanioides*	Poaceae	Grass
441	*Vicoa indica*	Asteraceae	Herb
442	*Vitex negundo*	Verbenaceae	Shrub
443	*Waltheria indica*	Sterculiaceae	Herb
444	*Wattakaka volubilis*	Asclepiadaceae	Liana
445	*Wrightia tinctoria*	Apocynaceae	Tree
446	*Xanthium indicum*	Asteraceae	Undershrub
447	*Xyris pauciflora*	Xyridaceae	Herb
448	*Ziziphus mauritiana*	Rhamnaceae	Tree-Small
449	*Ziziphus oenoplia*	Rhamnaceae	Shrub-Straggler
450	*Ziziphus xylopyrus*	Rhamnaceae	Tree-Small
451	*Zornia diphylla*	Fabaceae	Herb

Source: Nehru et al 2009

15.0 APPENDICES

Family level contribution to the Flora of Nanmangalam Reserve Forest

S.No.	Family	Species	Genus
1	Acanthaceae	13	11
2	Agavaceae	1	1
3	Aizoaceae	1	1
4	Amaranthaceae	10	8
5	Amaryllidaceae	1	1
6	Anacardiaceae	2	2
7	Annonaceae	2	2
8	Apocynaceae	5	5
9	Aponogetonaceae	1	1
10	Araceae	2	2
11	Arecaceae	3	2
12	Asclepiadaceae	10	10
13	Asteraceae	13	12
14	Barringtoniaceae	1	1
15	Bignoniaceae	1	1
16	Boraginaceae	4	3
17	Cactaceae	4	3
18	Caesalpiniaceae	16	7
19	Capparidaceae	5	3
20	Caryophyllaceae	1	1
21	Celastraceae	2	2
22	Cleomaceae	4	2
23	Combretaceae	5	3
24	Commelinaceae	6	4
25	Convolvulaceae	10	4
26	Cordiaceae	2	2
27	Cucurbitaceae	9	9
28	Cyperaceae	13	7
29	Dioscoreaceae	1	1
30	Dracenaceae	1	1
31	Droseraceae	2	1

32	Ebenaceae	3	1
33	Elaeocarpaceae	1	1
34	Eriocaulaceae	1	1
35	Euphorbiaceae	25	15
36	Fabaceae	40	22
37	Flocourcaceae	1	1
38	Gentianaceae	2	2
39	Hydrocharitaceae	2	2
40	Hydrophyllaceae	1	1
41	Hypoxidaceae	1	1
42	Lamiaceae	13	7
43	Lauraceae	1	1
44	Lemnaceae	2	2
45	Lentibulariaceae	4	1
46	Liliaceae	4	4
47	Linaceae	1	1
48	Loganiaceae	1	1
49	Lythraceae	3	2
50	Malvaceae	14	7
51	Melastamataceae	3	2
52	Meliaceae	1	1
53	Menispermaceae	4	4
54	Mimosaceae	13	8
55	Molluginaceae	3	2
56	Moraceae	6	2
57	Myrtaceae	3	3
58	Nyctaginaceae	2	1
59	Nymphaeceae	2	1
60	Ochnaceae	1	1
61	Oleaceae	1	1
62	Onagraceae	2	1
63	Opiliaceae	1	1
64	Orchidaceae	2	2
65	Passifloraceae	1	1
66	Pedaliaceae	1	1
67	Periplocaceae	1	1

68	Plumbaginaceae	1	1
69	Poaceae	52	34
70	Polygalaceae	1	1
71	Portulacaceae	2	1
72	Rhamnaceae	5	3
73	Rubiaceae	19	12
74	Rutaceae	3	3
75	Santalaceae	1	1
76	Sapindaceae	5	5
77	Sapotaceae	2	2
78	Scrophulariaceae	9	6
79	Solanaceae	7	3
80	Sterculiaceae	4	4
81	Tiliaceae	4	3
82	Turneraceae	1	1
83	Typhaceae	1	1
84	Ulmaceae	1	1
85	Verbenaceae	8	7
86	Violaceae	1	1
87	Vitaceae	2	2
88	Xyridaceae	1	1
89	Zygophyllaceae	1	1
Total		**449**	**313**

Source: Nehru et al 2009

Updated Environmental Impact Assessment

April 2024
Revision 01

India: Chennai Metro Rail Investment Project
Balance Corridor 5

Annexure 11

Prepared by the Chennai Metro Rail Limited (CMRL) for the Project Lenders.

Noise Modeling Report

Report on Noise Level Forecasting
for
Chennai Metro Rail - Phase II (Corridor 5)

Report Submitted to

M/s. Chennai Metro Rail Limited
Admin Building,CMRL Depot,
Poonamallee High Road,Koyambedu,
Chennai – 600107,
Tamil Nadu.

Prepared and Submitted by

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Guindy, Chennai- 600 032

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1 INTRODUCTION

Chennai Metro Rail Limited (CMRL) a joint venture of the Government of india and Government of Tamilnadu with equal equity ownership, is responsible for implementing, operating, and maintaining the city's metro system. CMRL developed the Comprehensive Mobility Plan for Chennai Metropolitan Area (CMA) in 2015 to identify the present and future mobility patterns of CMA. The detailed study identified three corridors (corridors 3, 4, and 5) for the second phase of the Chennai Metro Rail to alleviate CMA's transportation capacity constraints.

The existing transportation system in CMA is marked by high traffic density, carbon emissions, and frequent road incidents. In addition to the high volume of vehicles and already congested roads, inadequate parking space and the encroachment of street space by vendors on major road have exacerbated the traffic congestion. Major roads along the proposed project alignments are forecast to function beyond respective design service volume in year 2035 in absence of the project lines. The accelerating use of private vehicles has put Chennai in the fifth rank in carbon emission from the transport sector among 54 South Asian cities.3

Inadequate transportation infrastructure and poor service have resulted in an unfavorable decrease in the share of public transport from 54 percent in 1970 to 28 percent in 2014.4 The Chennai Second Master Plan 2026 proposes to increase the public and private mode split to 70:30. The mass transit transportation, especially an integrated metro system will be essential to achieve this intended split.

The city has two mainline railway terminals. Urban Mass Rapid Transit System (MRTS) of 19.35 km from Chennai Beach to Velachery is in operation, land acquisition for balance MRTS section from Velachery to St Thomas Mount is in process. Chennai Metro Phase 1 of 45 kms is in operation, work on extension to Thiruvottiyur is in progress. Chennai suburban railway network supplements MRTS. Schematic diagram of urban mass rapid transit network is in Figure 1.1.

Figure 1-1: Rail Transport Network in Chennai (Source: CMRL website)

1.1 CHENNAI METRO NETWORK

1.1.1 PHASE 1

Phase 1 of Chennai metro as shown in Figure 1.2 covers 54.05 km in two corridors - Washermanpet to Airport (23.09 Km), Chennai Central to St. Thomas Mount (21.96 Km) via Koyambedu and extension from Washermanpet to Wimco Nagar (9.00 km) in Thiruvottiyur. As on February 2020, Phase 1 excluding the extension from Washermanpet to Thiruvottiyur is in commercial operation.

Figure 1-2: Metro Network Phase 1 (Source: CMRL website)

1.2 PHASE 2

Phase 2 includes Corridor 3, 4 and 5 as shown in Figure 3. The final alignments will be decided based on engineering designs

Figure 1-3: Metro Network Phase 2

Proposed alignment of Corridor-5 starts from Madhavaram as underground and heads in south direction upto Sholinganallur. Total length of the corridor is 47.0 km including 41.17 km elevated and 5.83 km underground section.

- Switch Over Ramp
  - Switch over Ramp (SWR) have been provided at three locations viz a viz. after Madhavaram station, second between Retteri junction & Kolathur Junction and third between Nathmuni & Anna Nagar Bus Depot.
- 48 stations have been proposed in Corridor-5 consisting of 41 elevated stations, 1 at-grade station and 6 underground stations.

1.2.1 CORRIDOR 5

Corridor 5 is being funded by MDBs AIIB and ADB. The MDB funding arrangement is as follows:

- Asian Development Bank (ADB): Alignment and formation/tunneling (10.3 km from Lighthouse to Meenakshi College), 10 underground stations structural civil cost.
- Asian Infrastructure Investment Bank (AIIB): Alignment and formation (16.5 km from Power House to Poonamallee bypass), 18 Elevated stations structural civil cost, General Consultancy.
- New Development Bank (NDB): P. way, station building components VAC and TVS, E&M, Lifts and Escalators, Architectural finishes and MMI.

2 PROJECT DEATAILS

Figure below shows the alignment and station plan of Corridor 5.

Figure 2-1: Corridor 5 Map

The first phase of the Chennai Metro Rail covers 54 km in two corridors, with 45 km currently already in operations since 2015 and another 9 km to be operational in 2020. GoI, GoTN, and the Japan International Cooperation Agency (JICA) funded the first phase that provides direct connection between northern and southern parts of Chennai.

The Chennai Metro Corridor 5 from Lighthouse to Poonamallee Bypass has a length of 26.8 km, of which 16.5 km is elevated, and 10.3 km is underground, with 18 and 12 stations, respectively. Stations of Corridor 5 are depicted in Figure 3.1 and summarized in Table 3.1.

Table 2-1 List of stations is corridor 5

SN	STATION NAME	CHAINAGE (M)	ELEVATIO N DIFFEREN CE (M)	ELEVATED/UG
1	MADHAVARAM MILK COLONY	0	-15.27	UG
2	VENUGOPAL NAGAR	868	-0.07	At Grade
3	ASSISSI NAGAR	1789	14.49	Elevated
4	MANJAMBAKKAM	2691	14.34	Elevated
5	VELUMURUGAN NAGAR	3491	14.05	Elevated
6	MMBT	4307	15.61	Elevated
7	SHASTRI NAGAR	5168	14.49	Elevated
8	RETTERI JN.	6028	18.20	Elevated
9	KOLATHUR JN.	7186	-8.33	UG
10	SRINIVASA NAGAR	8518	-14.91	UG
11	VILLIVAKKAM METRO	9505	-21.46	UG
12	VILLIVAKKAM BUS TERMINUS	10254	-15.02	UG
13	NATHAMUNI	11106	-15.27	UG
14	ANNA NAGAR DEPOT	12349	14.72	Elevated
15	THIRUMANGALAM	13366	18.04	Elevated
16	KENDRIYA VIDYALAYA	14158	14.14	Elevated
17	KALIAMMANKOIL STREET JN.	14915	19.00	Elevated
18	CMBT	16007	18.49	Elevated
19	GRAIN MARKET	16855	14.63	Elevated
20	SAI NAGAR BUS STOP	17619	14.13	Elevated
21	ELANGO NAGAR BUS STOP	18517	14.05	Elevated
22	ALWARTIRUNAGAR	19472	23.55	Elevated
23	VALASARAVAKKAM	20407	23.63	Elevated
24	KARABAKKAM	21530	23.07	Elevated
25	ALAPAKKAM JUNCTION	22291	22.72	Elevated
26	PORUR JN.	23109	23.03	Elevated
27	MUGALIVAKKAM	24309	14.22	Elevated
28	DLF IT SEZ	25573	14.22	Elevated
29	SATHYA NAGAR	26611	14.76	Elevated
30	CTC	27809	14.33	Elevated
31	BUTT ROAD	28982	14.77	Elevated
32	ALANDUR	30262	20.73	Elevated
33	ST. THOMAS MOUNT	31435	18.57	Elevated
34	ADAMBAKKAM	32442	19.14	Elevated
35	VANUVAMPET	33159	19.78	Elevated
36	PUZHUTHIVAKKAM	34017	14.95	Elevated
37	MADIPAKKAM	34947	14.07	Elevated
38	KILKATTALAI	35846	14.49	Elevated
39	ECHANGADU	36774	18.20	Elevated
40	KOVILAMBAKKAM	37791	14.64	Elevated

SN	STATION NAME	CHAINAGE (M)	ELEVATIO N DIFFEREN CE (M)	ELEVATED/UG
41	VELLAKKAL	38863	14.30	Elevated
42	MEDAVAKKAM KOOT ROAD	40010	18.78	Elevated
43	KAMARAJ GARDEN STREET	41056	23.23	Elevated
44	MEDAVAKKAM JN.	41985	15.08	Elevated
45	PERUMBAKKAM	42661	14.76	Elevated
46	GLOBAL HOSPITAL	43635	13.99	Elevated
47	ELCOT	44850	13.96	Elevated
48	SHOLINGANALLUR	46272	24.03	Elevated

2.1 SALIENT FEATURES OF THE METRO RAIL

Table 2-2: Salient Features of the Chenai Metro Rail Corridor 5

Corridor 5 Gauge(Nominal):	**1435 MM**			
Route Length:	44.63 km (10.3 km Underground and 16.5 km Elevated)			
Number of Stations:	46 (12 Underground and 18 Elevated)			
Speed:				
1. Design Speed **2. Maximum Design Speed** **3. Schedule(Booked)Speed**	80 kmph 90 kmph 32 kmph			
Train Operation Plan:				
Particulars	2025	2035	2045	Design
Trains/hour (3 Car, 6 Car)	8 (7,1)	8 (3,5)	8 (0,8)	10 (0,10)
Head Way (Second)	450	450	450	360

Rolling Stock:

1. Rolling Stock with light weight Stainless Steel/Aluminum Body
2. Max. Axle Load 16 T
3. Dimensions L22.6 x W2.9m x H3.9m

The corridor starts with Madhavaram at 0.00m and terminates at Sholinganallur at 46272m. The corridor is summarised in **Table 5.23** and presented in **Figure 5.35**.

Table 2-3: ALIGNMENT DESCRIPTION OF CORRIDOR – 5

Alignment Type	From (m)	To (m)	Length (m)
Underground	-386	356	742
Switch over Ramp (-)8.0m to 0.0m	356	573	217
At-grade	573	1150	577
Elevated	1150	6653	5503
Switch over Ramp (+)7.5m to (-)8.0m	6653	7049	396
Underground	7049	11530	4481
Switch over Ramp (-)8.0m to (+)7.5m	11530	11920	390
Elevated	11920	46623	34703
Total			47009

Alignment of Corridor -5 is described in detail in following sub sections: -

Figure 2-2: Madhavaram Milk Colony to Retteri- STARTING POINT OF CORRIDOR 3 & 5

Figure 2-3: Switch Over Ramp from Elevated to Underground- ALIGNMENT CROSSING RAILWAY TRACKS AT VILIVAKKAM METRO

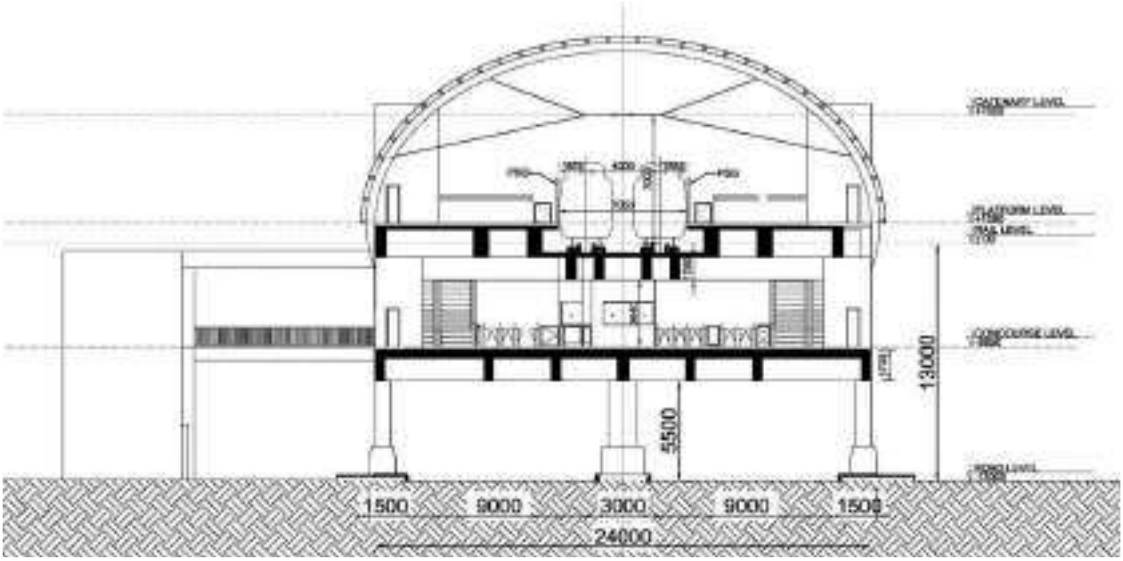
Figure 2-4: Kolathur Junction to Nathamuni- RAMP LOCATION AFTER NATHAMUNI STATION NEAR PADI CLOVER LEAF

Figure 2-5: Anna Nagar to Sholinganallur- ALIGNMENT NEAR KOYEMBEDU CLOVER LEAVES

2.1.1 STATION DESIGN

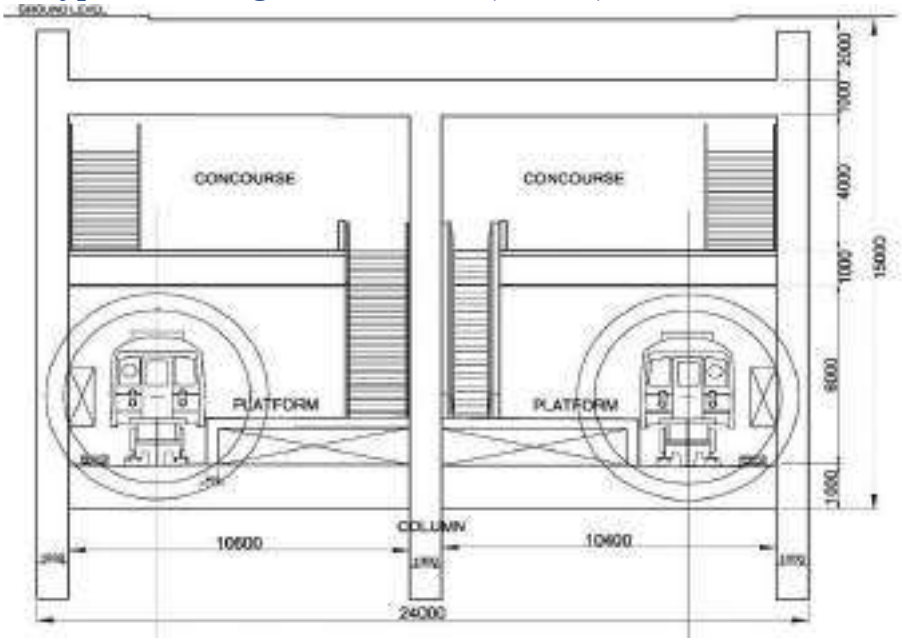
Elevated stations located at the median of existing roads will be 140 m long and 24 m wide. The stations will be constructed using the cantilever method. The typical elevated station consists of three levels: ground, concourse and platform. Passenger facilities, operational and commercial areas are provided at the concourse level. Platforms will be at a level of 13 m and concourse floor at about 7 m above the road, with a minimum of 5.5 m of vertical clearance under the concourse. To reduce physical and visual impact, stations will be transparent with minimum walls on the sides. Figure 3.2 shows the typical elevated station

Figure 2-6: Typical Elevated Station



The typical underground station is a two- or three-level station with entrances at ground level, a concourse with ticketing and passenger area, and platforms at the lowest level. Platforms will 140 m long and 12 m wide with easy accessibility features including escalators and elevators. Universal accessibility and green building features will be considered in the design. Two end concourses have been proposed, one at each end. The concourse is divided into paid and unpaid area. Since very limited space is available on the ground at station, all the over-ground structures are therefore, planned as and where space is available and are not necessarily grouped at ground level. The stations will be constructed using the cut and cover method. Figure 3.3 shows the typical underground station.

Figure 3-3: Typical Underground Station (2-level)



3 NATIONAL LAWS, REGULATIONS, AND GUIDELINES

3.1 INDIA - AMBIENT NOISE STANDARDS

The Noise Pollution (Regulation and Control) Rules, 2000 (Amended 2002) provides for the prevention, control and abatement of noise pollution. The national ambient noise standards are provided in the following Table. Day and Night-times cover the hours between 6:00 AM to 10:00 PM, and 10:00PM to 6:00PM, respectively. While silent zones include at least 100 meter perimeter around hospitals, educational institutions, courts, religious places and similar area.

Table 3-1: India National Ambient Noise Quality Standards

Area Code	Category of Area/Zone	Limits in dB(A)) Leq	
		Day Time	Night-time
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence	50	40

3.2 WORLD BANK GROUP'S ENVIRONMENTAL, HEALTH, AND SAFETY GUIDELINES ON NOISE MANAGEMENT

As part of the ADB's harmonization of safeguard policies with other multilateral financial institutions, it has adopted the World Bank's International Finance Corporation's general environmental, health, and safety guidelines (WBG EHS Guidelines 2007). Covered under the environmental guideline is the prevention and control of noise mainly though the noise level guideline as follows. The EHS Guidelines requires prevention and mitigation measures should the project related noise cause the exceedance of the guide values at the most sensitive point of reception. The WBG EHS Guidelines values are for noise levels measured out-of-doors or building façade and are based on Guidelines for Community Noise, World Health Organization (WHO), 1999. In addition, the IFC- EHS provides a 3 dB maximum increase from the background when the existing measure noise already exceeds the standards. A 3 dB noise increase represents a doubling of the existing noise level.

Table 3-2: WBG EHS (Noise Level) Guidelines

Receptor	One Hour Laq dB(A)	
	Daytime, 07:00-22:00	**Nighttime, 22:00-07:00**
Residential; institutional; educational	55	45
Industrial; commercial	70	70

Note that the GoI and WBG EHS noise guide values are similar for day and nighttime residential.

3.3 METRO RAIL POLICY 2017,

GoI's Union Cabinet approved a new Metro Rail Policy in 2017 that aims to enable the development and implementation of metro projects in a comprehensive and sustainable manner from the social, economic, and environmental perspectives. The Policy improves the integrated management of Metro development in three main aspects, (i) The new policy proposes that every city should setup a Unified Metropolitan Transport Authority for planning and developing multimodal transportation, which enable the overall planning and development of all modes of transport under the strong lead institutions; (ii) The need to carry out an alternative analysis is a welcome addition in the policy to help in better system selection; and (iii) The requirement to look at the 5-km catchment area for providing feeder services through walking, cycling and para-transit modes is promising.

3.4 VIBRATION IMPACT AND RISK TO EXISTING BUILDINGS

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

4 AMBIENT NOISE MONITORING

4.1 MONITORING

The baseline Noise data was recorded using **Tenma 72-947 sound level meter for sensitive receptors and Lutron Class 1 sound level meter for residential receptors.** The instrument was mounted in a tripod stand (height 1.5 m), so that the instrument remains stable for the entire study period. The photograph of the instrument mounted in a tripod stand is shown in **Figure 4-1.** Turnkey power portal is used to record the data without any interruptions. The instrument records the sound level every second in a SD memory card in "**.txt** " format. The sound levels are recorded in "**dbA**" units. The study was performed for 24 hr in the sensitory receptors such as schools, colleges, temples, and residential receptors along the proposed CMRL corridors.

The residential receptors of the FTA guideline and receptors selected by CMRL includes residential and sensitive structures located nearest to the edge of the tracks and structures that represent a cluster of receivers. During the site visit, all building heights were estimated by noting the number of structure floors/storeys assuming the ground and succeeding floor heights are 3.5m and 3.0m, respectively. The 24-hour monitoring was conducted in front of the building at a height of 1.5m and a minimum 7.5 m away from any obstacles to record unobstructed noise as per the noise monitoring standard ISO 9613-1.

LAeq,24h was used to measure continuing sounds such as road traffic noise, which includes individual events and also as a measurement of compliance to local standards. Supplementary shorter duration noise measurement was carried out at each of the floor of the building to based on the variation observed during the 24 hour reading. The shorter duration measurement spanning maximum of 30-minutes with 1-minute intervals was conducted. A shorter duration was made primarily to reduce cost, turnaround time and ability to represent one-hour Leq as required by the US Federal Highways Administration Noise Measurement Handbook. A 30-minute measurement duration was selected in anticipation of widest range of noise fluctuations during the day of more than 30 dB(A). Below is a guide to determine the duration of short-term measurement based on anticipated fluctuations during the worst noise hour of morning 9 am to 10:30 am:

- Range of 10 dB or less: 10 minutes.
- Range of 10–30 dB: 15–20 minutes.
- Range greater than 30 dB: 30 or more minutes

Figure 4-1 Photograph of instrument used for baseline Noise monitoring

The noise monitoring for the sensitive receptor was conducted separately compared to residential receptors. The noise data was collected at 12 noise monitoring stations at hourly interval during morning, afternoon and evening such that peak and off-peak hours are covered. Most of the stretch is along the existing road.

4.2 SELECTION OF SITE

The noise impact assessment methodology generally followed the guideline provided in the US Federal Transit Administration Guidance Manual (U.S. Department of Transportation, Federal Transportation Agency) following the steps outline below:

Identification of receivers. Noise receivers and land uses within the 300-meter corridor screening distance along the rail alignment were identified initially and sensitive receptors based on discussion with CMRL to ensure the most recent developments are accounted. Noise sensitive receivers were identified and consist of hospitals, and places of worship. The maximum height of the building were 2 floors and therefore all the monitoring were carried out at the ground level. Several non-sensitive receivers were also identified and marked for impacts assessment consistent in other phases of the study

The sensitive receptors along the alignment of Corridor 5 were chosen for noise study. The list of monitoring locations is summarized in **Table 4-1.**

Table 4-1 Details of the monitoring locations in Corridor 5

Sl.No	Name of the Sensitive Receptors	Location	Corridor	Type of Sensitive Receptor	Latitude	Longitude
1	MM hospital	Sai nagar bus stop to elango nagar bus stop	C5	Hospital	13°03'10.1"N	80°11'30.7"E
2	Government boys high school, porur	Porur to Mugalivakam	C5	School	13°02'01.8"N	80°09'36.0"E
3	St. joseph hospital	CTC to St. Wesley church	C5	Hospital	13°01'59.2"N	80°09'40.0"E
4	Kalpana hospital	Adambakkam MRTS to mevakkam main road	C5	Hospital	12°58'57.4"N	80°11'46.3"E
5	Cantonment board high	CTC to St.Wesley church	C5	School	13°00'46.5"N	80°11'43.3"E

	school					
6	Anjakha hospital	Medavakkam koot road bus stop to venkateswara nagar	C5	Hospital	12°57'50.1"N	80°11'16.5"E
7	St. joseph school	CTC to St.Wesley church	C5	School	13°00'48.9"N	80°11'37.2"E
8	Ravindra bharathi global school	Venkateswara nagar to echangadu bus stop	C5	School	12°57'06.1"N	80°11'08.5"E
9	National school	St. Wesley church to alandur	C5	School	13°00'32.3"N	80°12'14.7"E
10	Sri varasidhi vinayagar temple	Greenways road to Adayar junction	C5	College	12°55'52.27"N	80°10'54.2" E

4.3 MONITORING SCHEDULE

The schedule for recording the ambient noise levels along in the sensitive receptors along the alignment of corridors is summarized in **Table 4-5.** The field photographs are attached in **Figure 4-4.**

Table 4-2 Monitoring Schedule for Corridor 5

Sl. No	Name of the sensitive receptors	Monitoring date		Duration of the study	Location	Type of sensitive receptors	Latitude	Longitude
		From	To					
1	MM hospital	22/09/2020	23/09/2020	24 hrs	Sai nagar bus stop to elango nagar bus stop	Hospital	13°03'10.1"N	80°11'30.7"E
2	Government boys high school, porur	23/09/2020	24/09/2020	24 hrs	Porur to Mugalivakam	School	13°02'01.8"N	80°09'36.0"E
3	St. joseph hospital	23/09/2020	24/09/2020	24 hrs	CTC to St. Wesley church	Hospital	13°01'59.2"N	80°09'40.0"E
4	Kalpana hospital	24/09/2020	25/09/2020	24 hrs	Adambakkam MRTS to mevakkam main road	Hospital	12°58'57.4"N	80°11'46.3"E
5	Cantonment board high school	25/09/2020	26/09/2020	24 hrs	CTC to St.Wesley church	School	13°00'46.5"N	80°11'43.3"E
6	Anjakha hospital	25/09/2020	26/09/2020	24 hrs	Medavakkam koot road bus stop to venkateswara nagar	Hospital	12°57'50.1"N	80°11'16.5"E
7	St. joseph school	26/07/2020	27/09/2020	24 hrs	CTC to St.Wesley church	School	13°00'48.9"N	80°11'37.2"E
8	Ravindra bharathi global school	28/09/2020	29/09/2020	24 hrs	Venkateswara nagar to echangadu bus stop	School	12°57'06.1"N	80°11'08.5"E
9	National school	28/09/2020	29/09/2020	24 hrs	St. Wesley church to alandur	School	13°00'32.3"N	80°12'14.7"E
10	Sri varasidhi	29/09/	30/09/2	24 hrs	Greenways	College	12°55'52.27'	80°10'54.2

Sl. No	Name of the sensitive receptors	Monitoring date		Duration of the study	Location	Type of sensitive receptors	Latitude	Longitude
		From	To					
	vinayagar temple	2020	020		road to Adayar junction		'N	" E

Table 4-3: Residential receptors at Corridor 5 for 24h and spot reading

ID	Location	Building Name	Distance and Cardinal direction	UTM N	UTM E	No of Floors
HR1	Perumbakkam	Harmony Homes	6m N	414077	1426834	5
HR2	Perumbakkam	Malles Altius	34m S	413388	1427010	13
HR3	Medavakkam	Ragamalika phase-III	23m N	411489	1428532	4
HR4	Kovilambakkam	Navins Brookfield	41m NE	411361	1431298	5
HR5	Ramapuram	Police Quarters	15m N	413131	1438249	3
HR6	Manapakkam	Feathers - A Radha Hotel	94m NE	411138	1439656	2
HR7	Manapakkam	Vijay Ten Square	38m S	411368	1439610	8
HR8	Porur	Appaswamy Platina	32m N	409409	1440845	12
HR9	Old Kesavardhini Bus Stop	Pruva Jade	9m N	411170	1441990	3
HR10	Koyambedu	Arihanth Majestic Towers	47m NE	413600	1445265	15
HR11	Villivakkam	NPL Anjli Apartments	49m E	413048	1448561	3
HR12	Retteri Signal	Ganga Foundation	50m W	414820	1451858	9

Table 4-4: Measures Noise Level at Residential Receptors at Corridor 5

Location ID	Location	Building Name	Leq d	leq N
	National Ambient Noise Quality Standards (NAAQS)		55	45
HR-1	Perumbakkam	Harmony Homes	70.9	65.4
HR-2	Perumbakkam	Malles Altius	68.5	60.5
HR-3	Medavakkam	Ragamalika phase-III	66.1	59.7
HR-4	Kovilambakkam	Navins Brookfield	63.2	56.3
HR-5	Ramapuram	Police Quarters	66.3	60.5
HR-6	Manapakkam	Feathers - A Radha Hotel	67.1	63.8
HR-7	Manapakkam	Vijay Ten Square	69.4	62.8
HR-8	Porur	Appaswamy Platina	64.6	60.7
HR9	Old Kesavardhini Bus Stop	Pruva Jade	67.6	62.8
HR10	Koyambedu	Arihanth Majestic Towers	68.2	59.8
HR11	Villivakkam	NPL Anjli Apartments	60.6	54.6
HR12	Retteri Signal	Ganga Foundation	66.5	60.8

Figure 4-2: Ambient Noise compared to NAAQS at the receptors

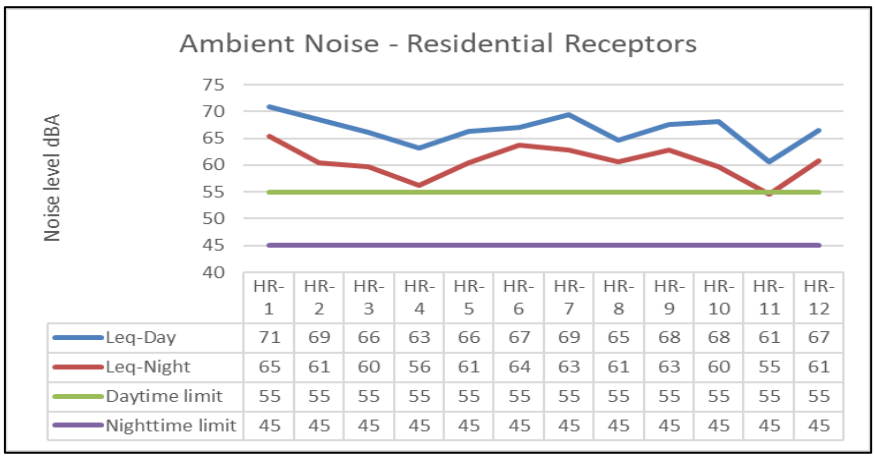


Figure 4-3: Noise Monitoring Locations- residential receptors

		
MM Hospital	**Government boys high school, porur**	**St. joseph hospital**
		
Kalpana hospital	**Cantonment board high school**	**Anjakha hospital**
		
St. joseph school	**Ravindra bharathi global school**	**National school**
		
Sri varasidhi vinayagar temple		

Figure 4-4 Field photographs of Baseline noise monitoring for Corridor 5

4.3.1 NOISE MONITORING LOCATIONS- RESIDENTIAL RECEPTORS

Figure 4-5: Noise monitoring at HR-1

Figure 4-6: Noise monitoring at HR-2

7

Figure 4-7: Noise monitoring at HR -3

Figure 4-8: Noise monitoring at hr-4

Figure 4-9: Noise monitoring at hr-5

Figure 4-10: Noise monitoring at HR-6


Figure 4-11: Noise monitoring at HR-7




Figure 4-12: Noise monitoring at HR-8

Figure 4-13: Noise monitoring at HR-9

Figure 4-14: Noise monitoring at HR-10

Figure 4-15: Noise monitoring at HR-11

Figure 4-16: Noise monitoring at HR-12

4.3.2 NOISE MONOITORING GRAPHS – RESIDENTIAL RECEPTORS

Figure 4-17: Hourly Noise Monitoring at HR-1

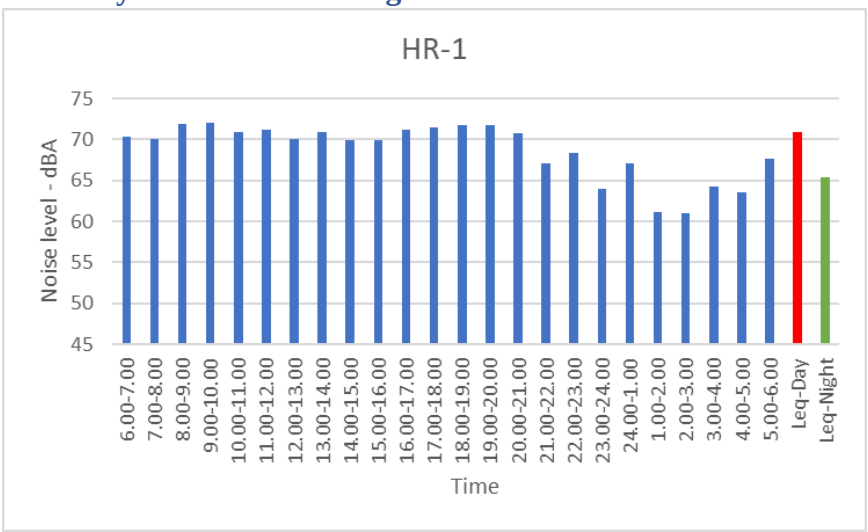


Figure 4-18: Hourly Noise Monitoring at HR-2

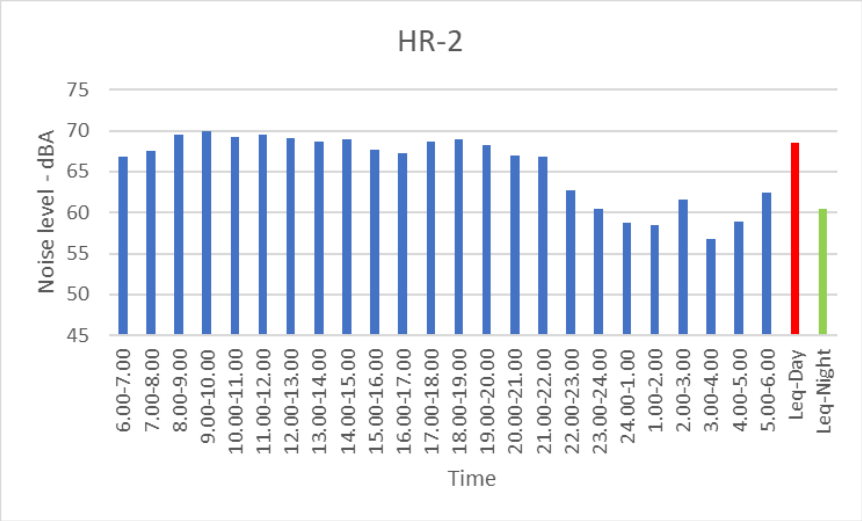


Figure 4-19: Hourly Noise Monitoring at HR-3

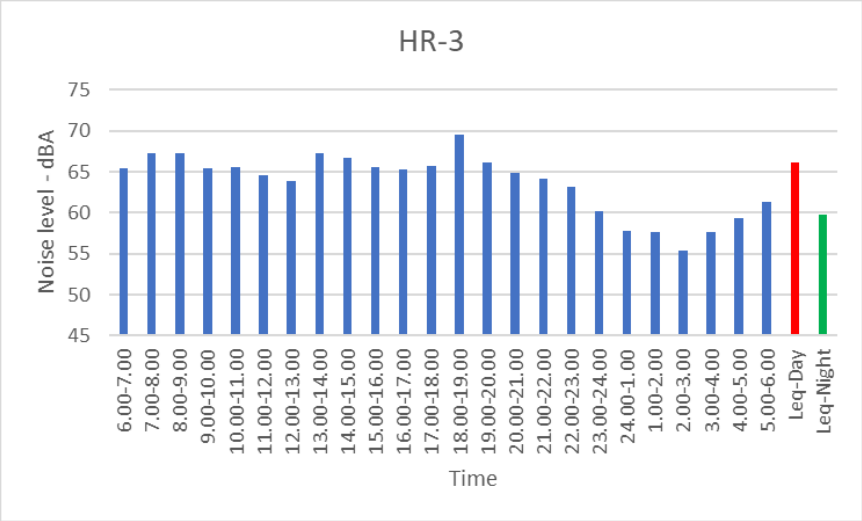


Figure 4-20: Hourly Noise Monitoring at HR-4

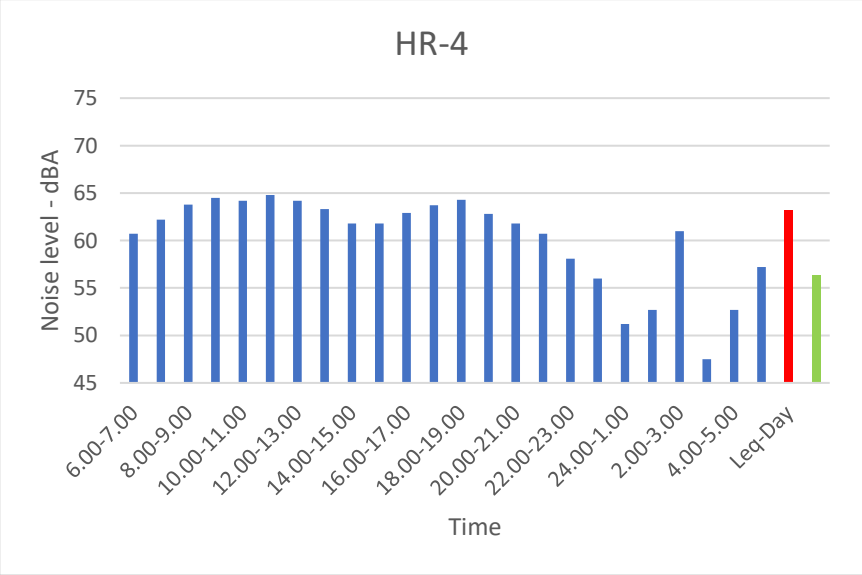


Figure 4-21: Hourly Noise Monitoring at HR-5

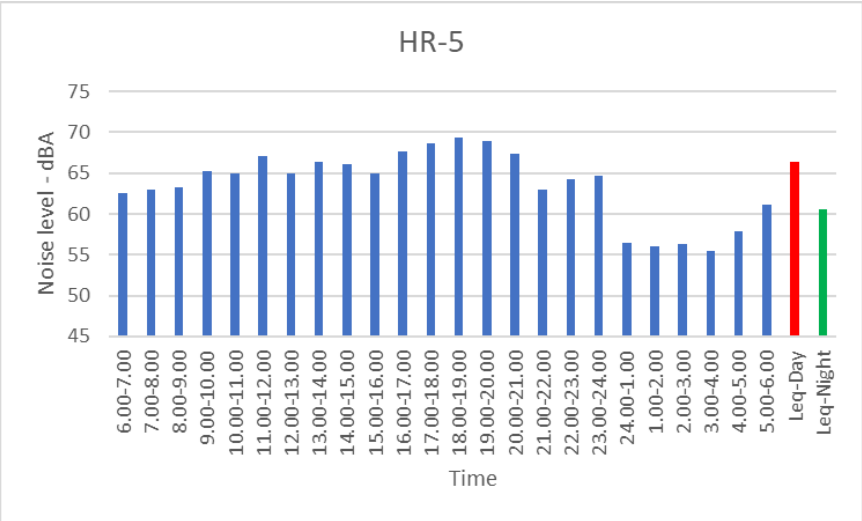


Figure 4-22: Hourly Noise Monitoring at HR-6

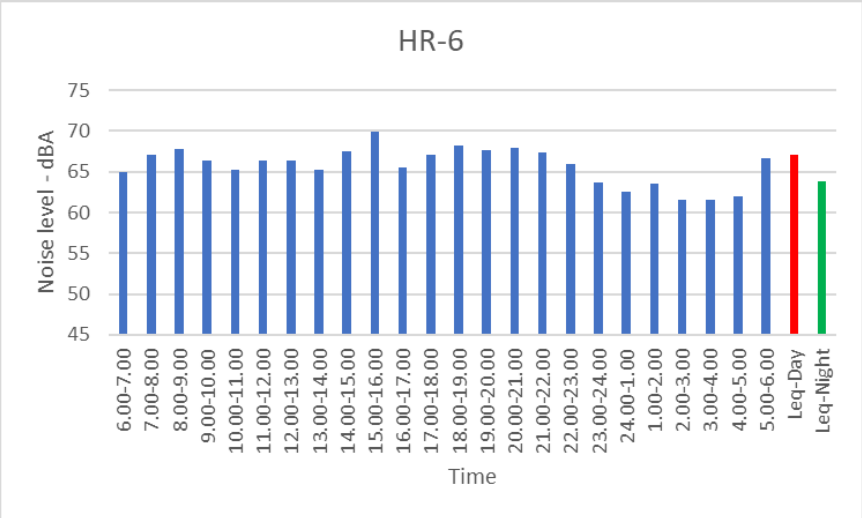


Figure 4-23: Hourly Noise Monitoring at HR-7

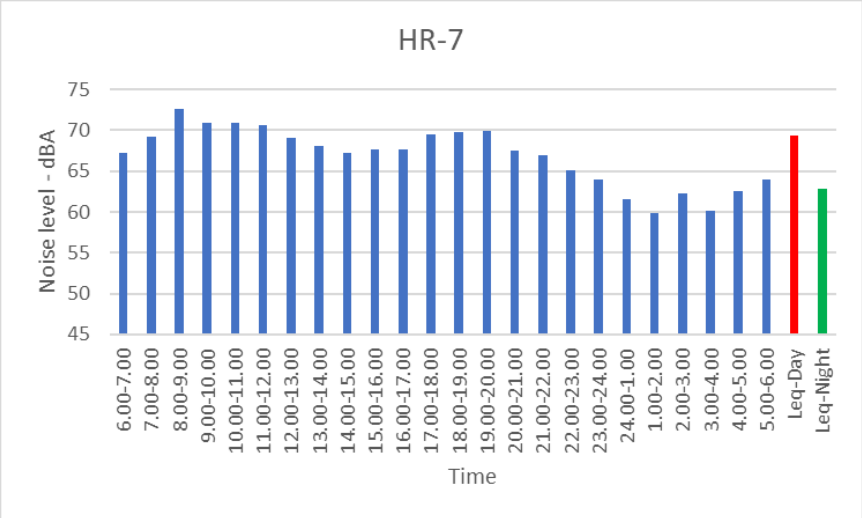


Figure 4-24: Hourly Noise Monitoring at HR-8

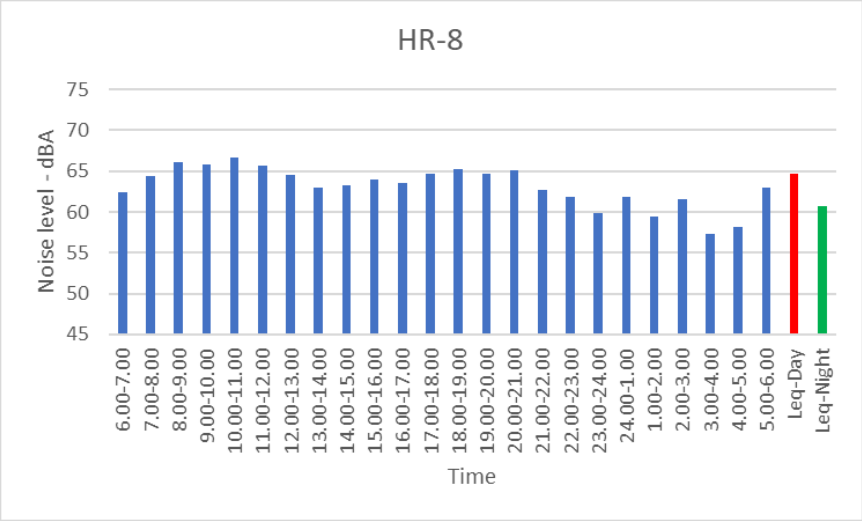


Figure 4-25: Hourly Noise Monitoring at HR-9

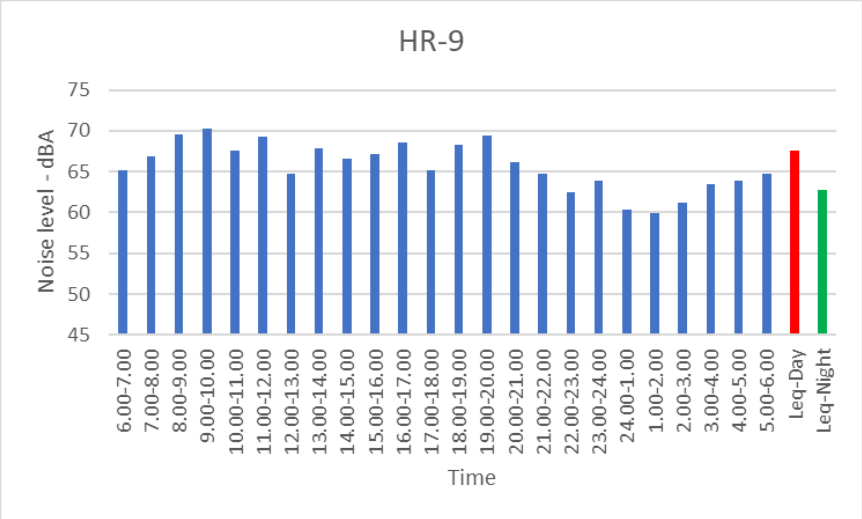


Figure 4-26: Hourly Noise Monitoring at HR-10

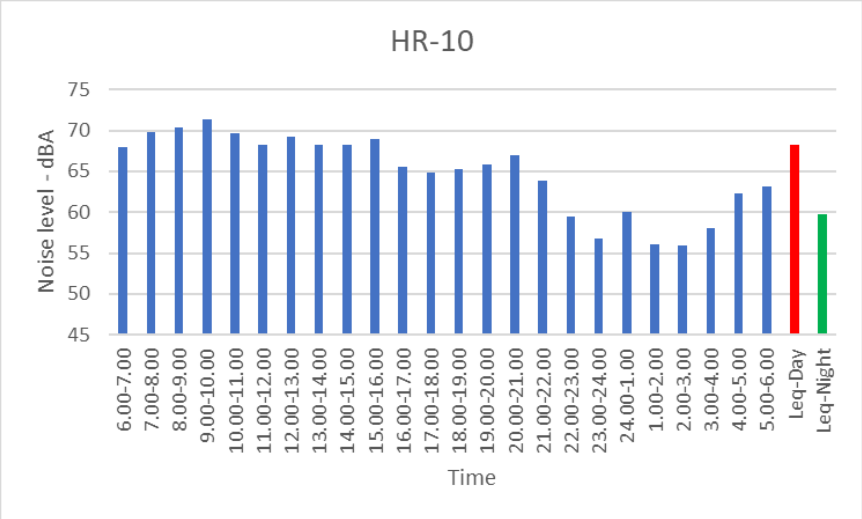


Figure 4-27: Hourly Noise Monitoring at HR-11

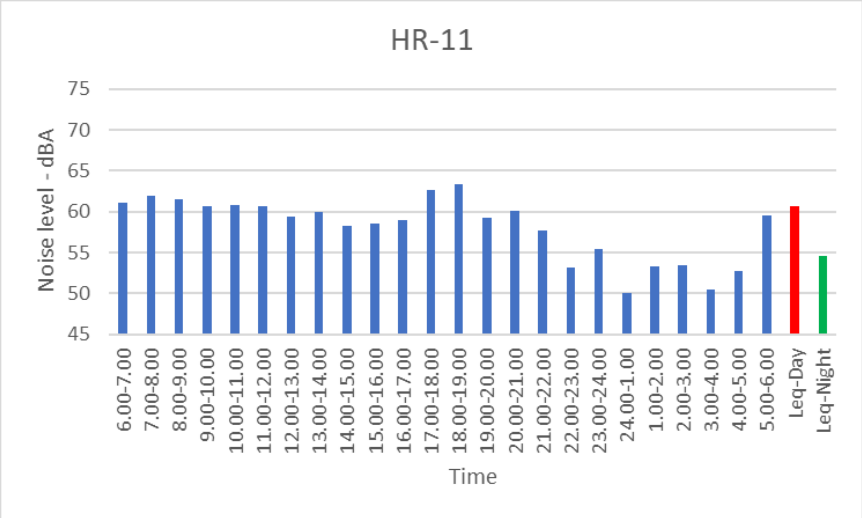
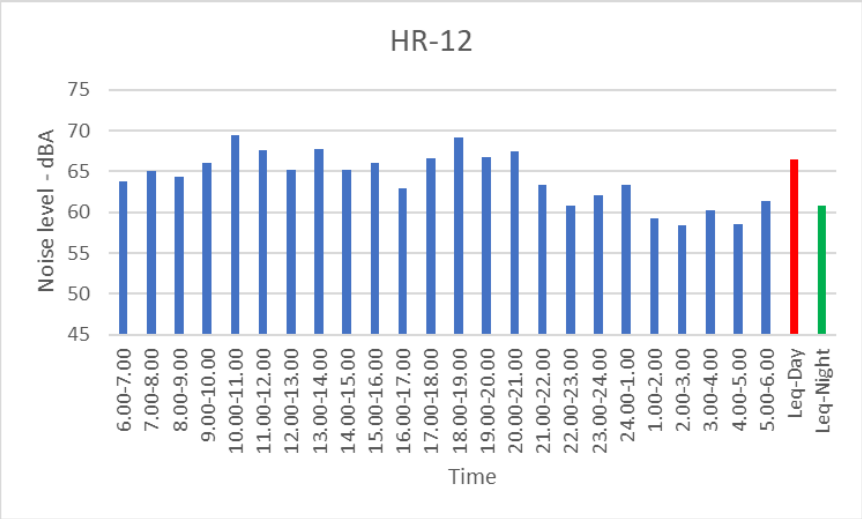


Figure 4-28: Hourly Noise Monitoring at HR-12



4.3.3 NOISE MONITORING GRAPHS AT SENSITIVE RECEPTOROS

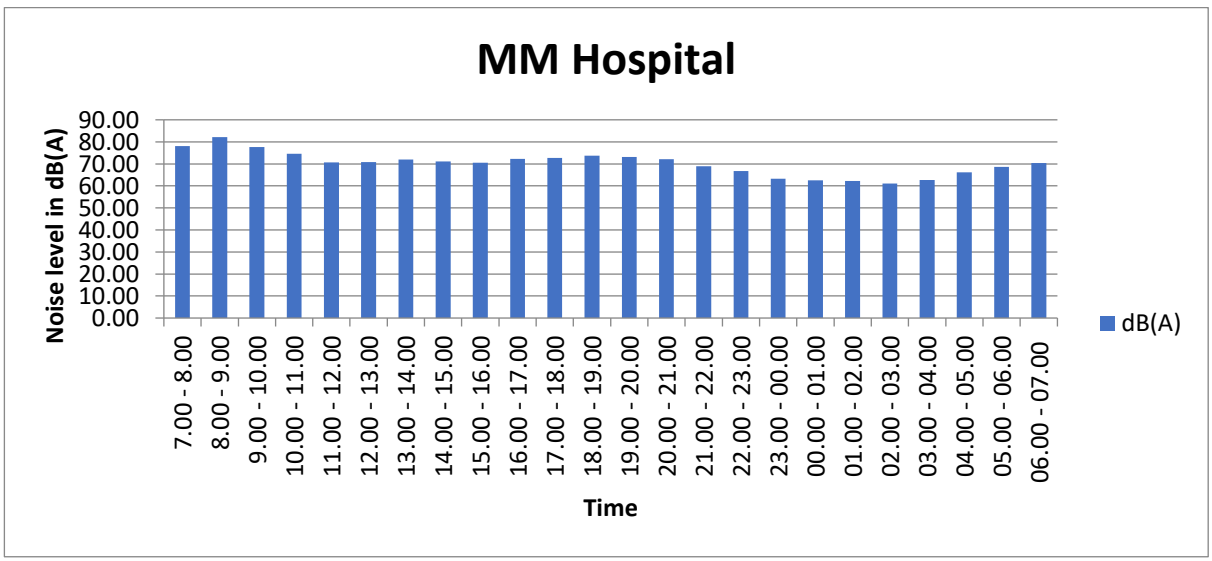


Figure 4-29 Hourly noise graph for MM hospital

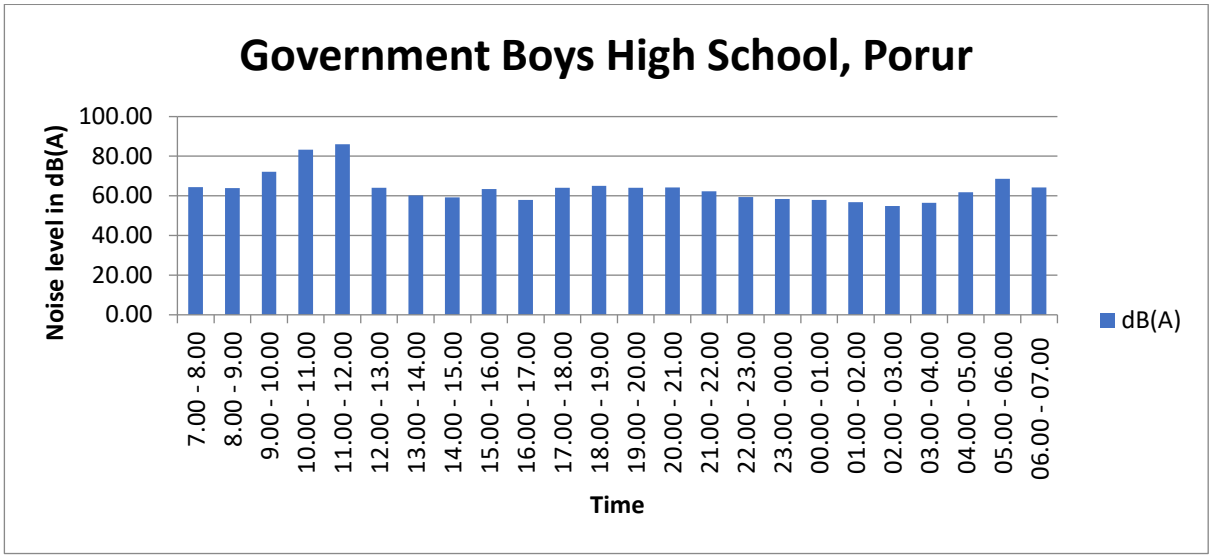


Figure 4-30 Hourly noise graph for Government Boys High School, Porur

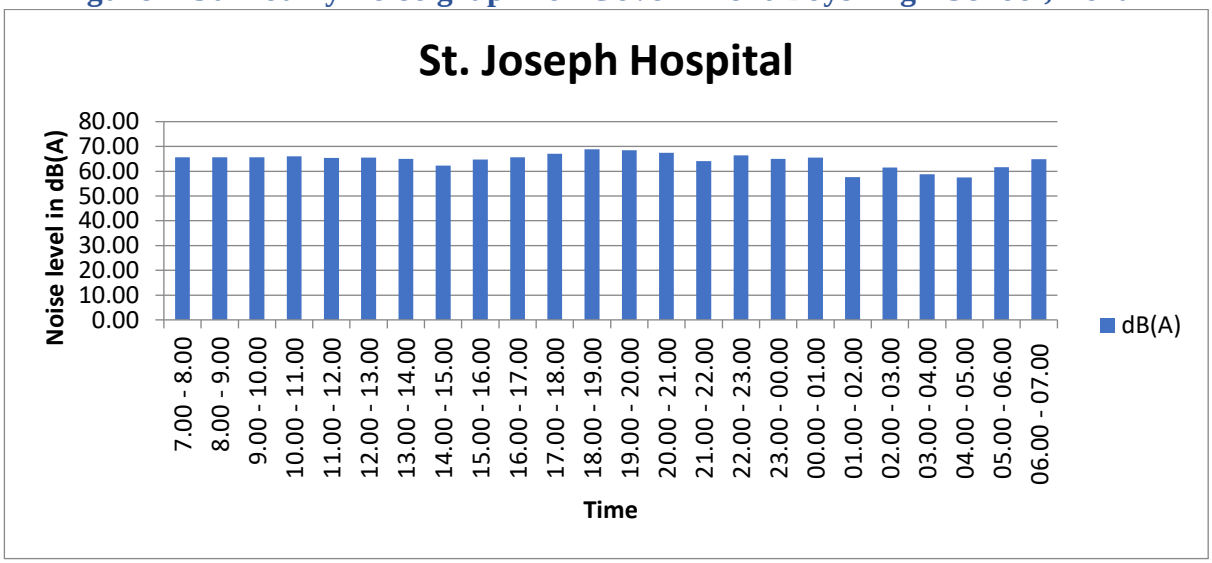


Figure 4-31 Hourly noise graph for St. Josephs Hospital

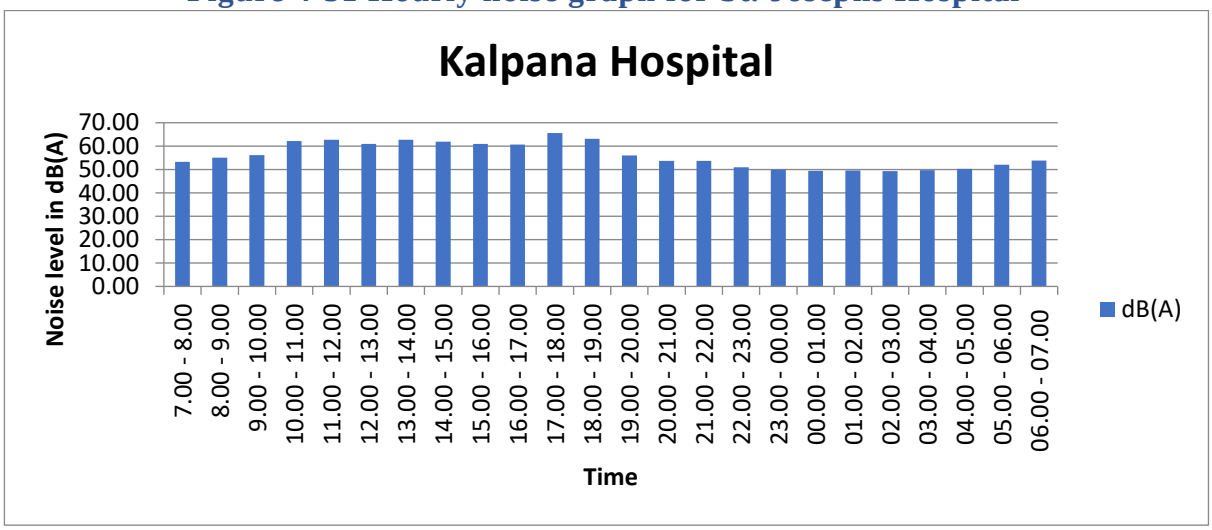


Figure 4-32 Hourly noise graph for Kalpana hospital

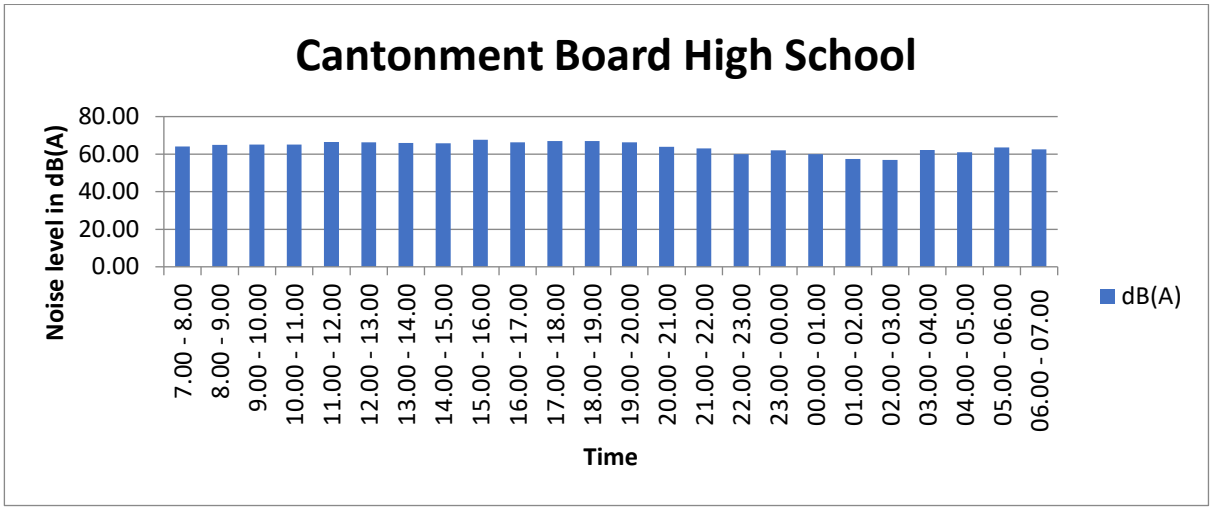


Figure 4-33 Hourly noise graph for Cantonment Board High School

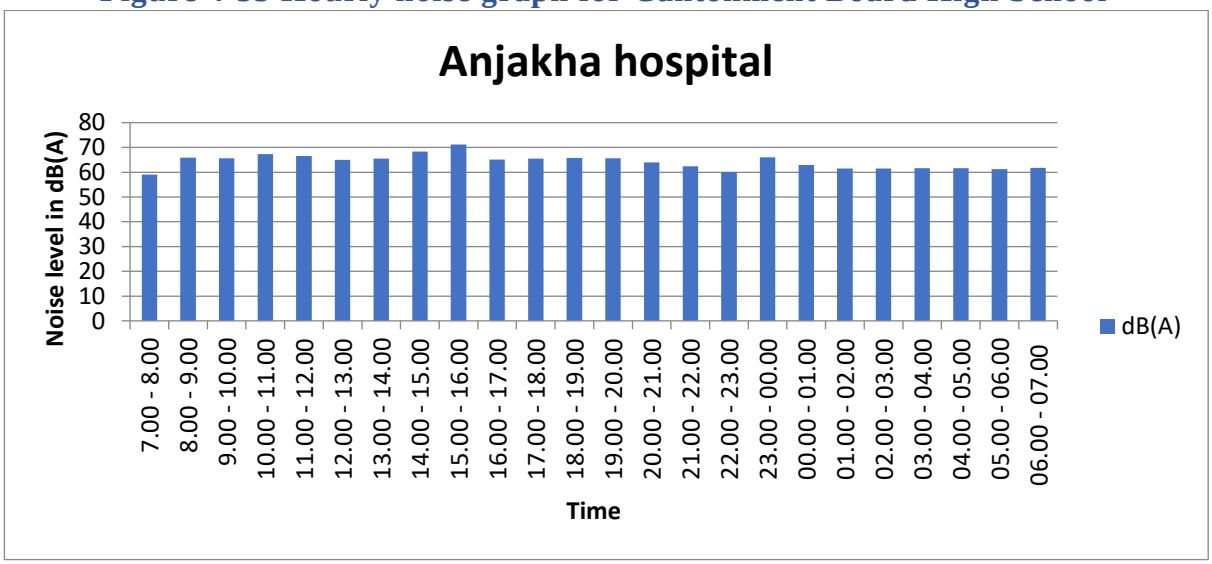


Figure 4-34 Hourly noise graph for Anjakha Hospital

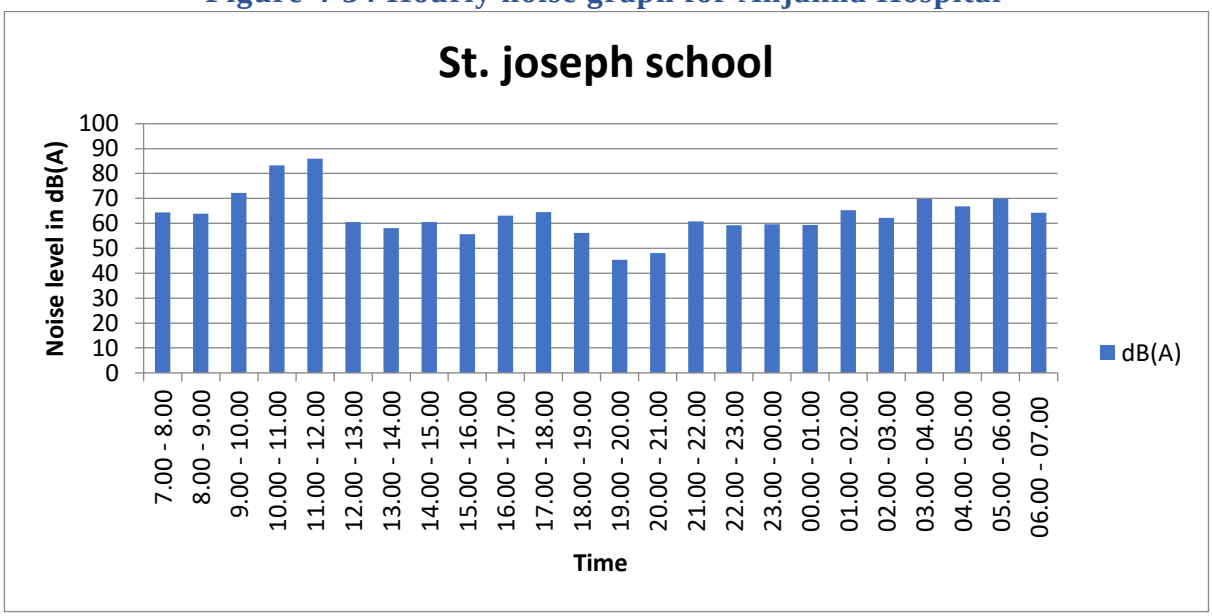


Figure 4-35 Hourly noise graph for St. Joseph School

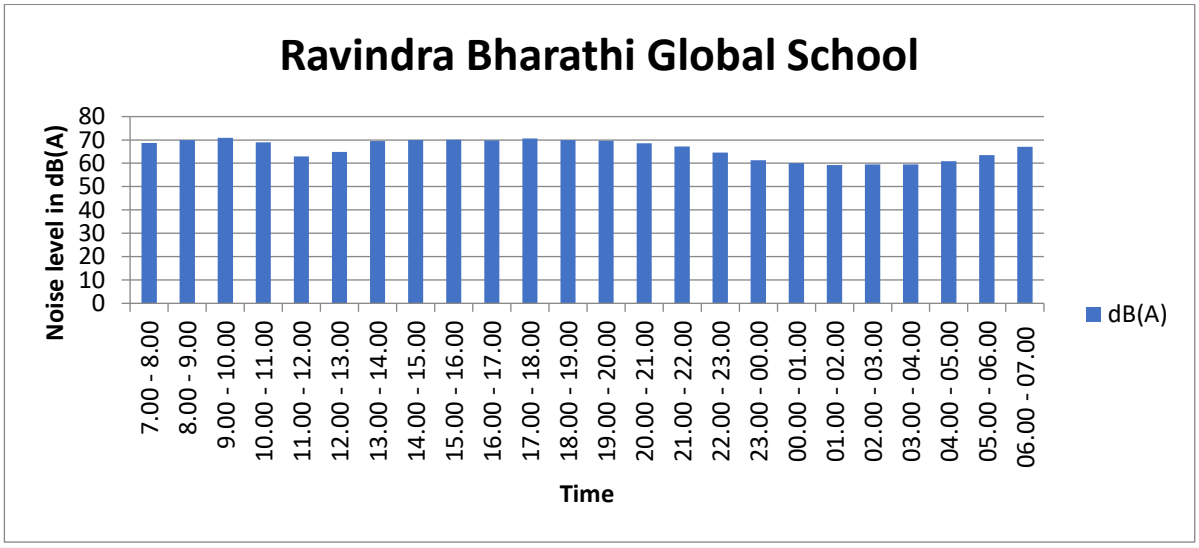


Figure 4-36 Hourly noise graph for Ravindra Bharathi Global School

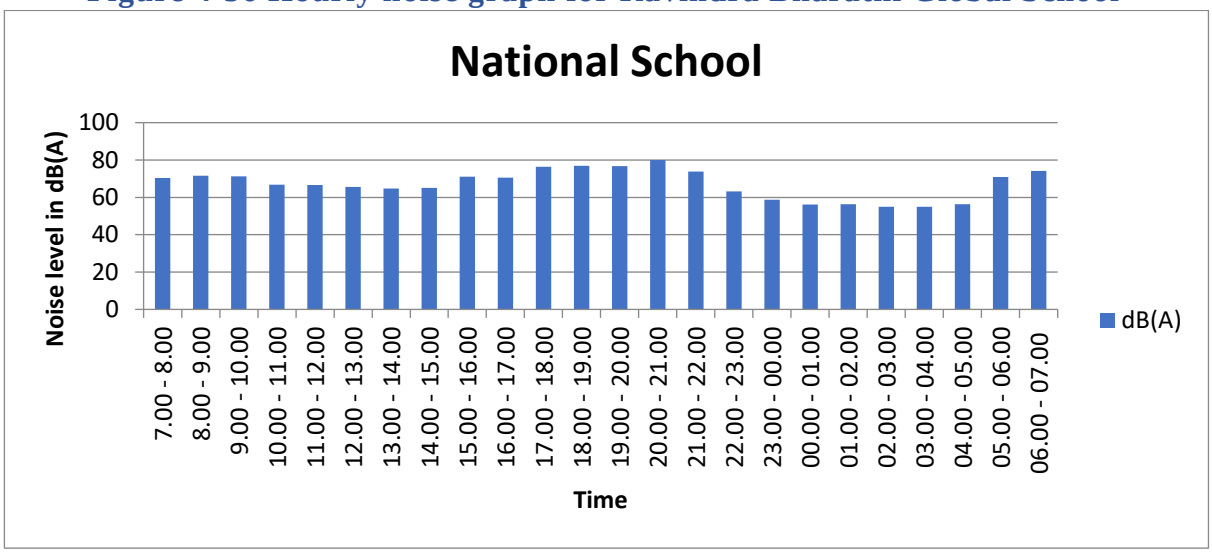


Figure 4-37 Hourly noise graph for National School

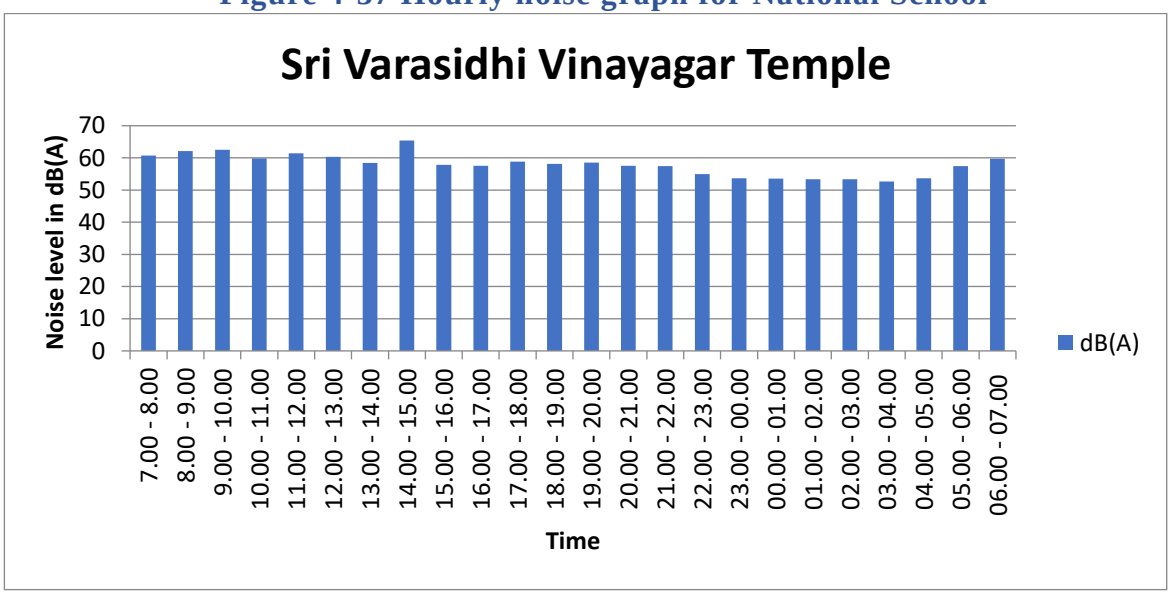


Figure 4-38 Hourly noise graph for Sri Varasidhi vinayagar Temple

1.1 MONITORING SUMMARY

The prevailing ambient noise level at a particular location is nothing but the resultant (total) of all kinds of noise sources existing at various distances around that location. The ambient noise level at a location varies continuously depending on the type of surrounding activities.

The noise data was collected over 24 hrs in September 2020. . The noise monitoring schedule was based on the operation criteria of metro rail, which is from 7 am to 10 pm

Based on the recorded hourly noise levels at each monitoring location, the day equivalent (Ld) and night equivalent (Ln) were calculated,

- Ld: Average noise levels between 7:00 hours to 22.00 hours.
- Ln: Average noise levels between 22:00 hours to 7.00 hours.

The comparison of day equivalent noise levels (Ld) and night equivalent noise levels (Ln) with the respective CPCB stipulated noise standards for various land use categories are shown in **Table 4-5.**

Table 4-5 Ambient Noise level monitoring results (Sensitive Receptors)

Sl. No	**Name of the sensitive receptors**	**Corridor**	**Noise level in dB(A) Leq**		**CPCB Standard**		**Environmental setting**
			Day	Night	L day (Ld)	L Night (Ln)	
1	MM hospital	C5	75.1	65.9	50	40	Silence zone
2	Government boys high school, porur	C5	76.3	62.2	50	40	Silence zone
3	St. joseph hospital	C5	66.1	63.2	50	40	Silence zone
4	Kalpana hospital	C5	60.8	50.8	50	40	Silence zone
5	Cantonment board high school	C5	65.9	61.1	50	40	Silence zone
6	Anjakha hospital	C5	66.2	62.3	50	40	Silence zone
7	St. joseph school	C5	76.3	65.7	50	40	Silence zone
8	Ravindra bharathi global school	C5	69.1	62.6	50	40	Silence zone
9	National school	C5	73.7	66.8	50	40	Silence zone
10	Sri varasidhi vinayagar temple	C5	60.4	55.4	50	40	Silence zone

Table 4-6: Ambient Noise Level at residential Receptors at Corridor 5 at each floor

Date of Monitoring:	12/Apr/21		12/Apr/21		14/Apr/21		14/Apr/21		21/Apr/21		19/Apr/21		19/Apr/21		16/Apr/21		16/Apr/21		21/Apr/21		23/Apr/21		23/Apr/21	
ID	HR1		HR2		HR3		HR4		HR5		HR-6		HR-7		HR8		HR9		HR10		HR11		HR12	
Ambient Noise Level	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N	Leq d	Leq N
NAAQS	55	45	55	45	55	45	55	45	55	45	55	45	55	45	55	45	55	45	55	45	55	45	55	45
Measured Noise Level	**70.9**	**65.4**	**68.5**	**60.5**	**66.1**	**59.7**	**63.2**	**56.3**	**66.3**	**60.5**	**67.1**	**63.8**	**69.4**	**62.8**	**64.6**	**60.7**	**67.6**	**62.8**	**68.2**	**59.8**	**60.6**	**54.6**	**66.5**	**60.8**
Floor wise Noise Monitoring (Spot reading during peak hours- between 9 am and 10:30 am																								
1st	64.8	56.8	63.5	54.1	67.8	57.8	60.1	49.7	63.5	57.1	63.1	54.9	60.7	53.6	60.5	56.5	68.5	57.9	67.1	56.4	62.2	55	64.1	56.7
2nd	60.9	56.5	65.7	55.6	64.2	58.4	62	51.7	64.1	58.3	66.6	57.1	59.1	53.1	61.7	57.1	67.1	59.5	65.7	54.9	62.5	55.8	63.5	55.8
3rd	59.7	52.6	62	53.9	65.8	58.2	62.5	52	63.8	57.7			62	52.9	61.2	60.5	68.4	59.9	66.8	55.1	62.7	57.4	63	55.5
4th	62.3	55.5	60.8	54.1	62	55.6	62.4	51.6					60.8	55.5	60.5	56.3	69.2	60.4	68.4	54.9			63.4	54
5th	64.2	58.5	63.3	57			63.1	53.1					65.6	57.8	60.8	57.6			68.4	55.8			64	56.8
6th			61.6	54.4									64.8	56.9	61.7	57.9			68	56.1			63.9	54.2
7th			63.4	54.4									65.3	57.7	63.4	58.9			69.2	54.9			65.5	59.7
8th			62.4	54.2									65.2	57.7	64.7	59.9			68.5	55.1			65.6	56.5
9th			64.3	54.4											64.3	61			67.9	55.5			64.5	59
10th			61.8	55.7											63.2	61.2			67	55				
11th			63.9	54											61.5	57.4			67.5	56.2				
12th			62.8	55.6											61.1	56.9			67	57.1				
13th			61.2	54.9															62.9	56.5				
14th																			66.1	55.8				
15th																			66.9	54.9				

Note:

1. Observance: high noise was perceived at higher floors could be due to less obstacles along the path of noise.
2. The Leq values for day and night are the average values recorded for the day and night, while the spot readings recorded at each floor are the 15 min average value during peak hours of 9 am and 10:30 am.

5 NOISE PREDICTION MODELLING

The noise impact assessment methodology generally followed the guideline provided in the US Federal Transit Administration Guidance Manual (U.S. Department of Transportation, Federal Transportation Agency) following the steps outline below:

1. Identification of receivers.
    a. Noise receivers and land uses within the 300-meter corridor screening distance along the rail alignment were identified initially from Open Street Map (OSM) – an open-source imagery and followed by site visits for confirmation to ensure the most recent developments are accounted. the noise receptors were provided by CMRL based on their experience in the area. For this assessment residential receptors were chosen. The building heights were estimated by noting the number of structure floors assuming the ground and succeeding floor heights are 2.8m and 3.0m, respectively.
2. Determine existing noise conditions.
    a. Existing noise levels were measured throughout the project alignment as detailed in the previous section.
3. Apply prediction models.
    a. In this study SoundPlan 8.2 following the TNM 2.5/30 and FRA standards as detailed in the FTA Guidance Manual was used to predict the noise levels at the identified sensitive receivers from train operation. The prediction model takes into account the planned daily number of train operations both up and down bound tracks, train distribution operating throughout the day (daytime 7AM-10PM, and evening or 10PM-7AM), the distance of sensitive receivers from the tracks, operating speeds, and the presence of noise protection walls that provide acoustic shielding to the receivers.
    b. The construction model was modelled using ISO 9613.
4. Evaluate receivers for predicted impact.
    a. Predicted noise levels from the train operation were compared to the existing measured noise levels and evaluated based on the allowable 3 dB(A) increase as provided the IFC EHS Guidelines and referred to in the ADB SPS (2009). The predicted noise levels during the Project construction phase were compared to the FTA impact thresholds while the operational noise was assessed based on the 3 dB(A) IFC threshold.
5. Evaluate mitigation options.
    a. Mitigation options, principally limited to the dimension, location, and shape of the noise protection walls were evaluated on sections where the predicted noise levels exceeded the 3dB(A) increase. Other mitigation measures were discussed but the quantitative impacts on noise reduction was limited to the noise protection walls.

5.1 METHODOLOGY

As per the FTA manual, The transit project category includes projects where the project noise is exclusively due to new transit sources, no changes are made to the highway or to existing noise barriers, and the existing noise levels generated by sources will not change because of the project.

As a part of the project a general screening assessment was performed by CMRL. The General Noise Assessment is used to examine potentially impacted areas identified in the screening step by examining the location and estimated severity of noise impacts. This procedure considers noise source and land use information likely to be available at an early stage in the project development process. Estimates are made of project noise levels and of existing noise conditions to model the location of a noise impact contour that defines the outer limit of an impact corridor or area. This modelling method uses transit-specific noise and adjustment data (in tabular and graphical form) for the noise computations.

Major steps in the General Noise Assessment procedure and recommended workflow are shown in Figure 4-5 and listed below.

1. **Step 1: Identify Noise-Sensitive Receivers –** Identify noise-sensitive receivers and their proximity to the project and major noise sources.
2. **Step 2: Determine Project Noise Source Reference Levels –** Determine the project noise sources and reference levels. Then, estimate the project noise exposure at the reference distance of 50 ft considering operational characteristics with preliminary estimations of the effect of mitigation.
3. **Step 3: Estimate Project Noise Exposure by Distance –** Estimate project noise exposure at distances beyond 50 ft considering propagation characteristics using a simplified procedure.
4. **Step 4: Combine Noise Exposure from All Sources –** Combine all sources associated with the project to predict the total project noise at the receivers.
5. **Step 5: Measure Existing Noise Exposure –** Measure the existing noise or estimate the existing noise exposure using a simplified procedure.
6. **Step 6: Inventory Impacts**
    b. **Option A:** Tabulate the change in noise (existing vs. estimated project noise) at each noise-sensitive receiver or cluster, identifying all moderate and severe impacts.
    c. **Option B:** Take inventory of noise-sensitive receivers that fall within the moderate and severe noise contours.
7. **Step 7: Determine Noise Mitigation Needs** – Evaluate the need for mitigation and repeat the General Noise Assessment with proposed mitigation.

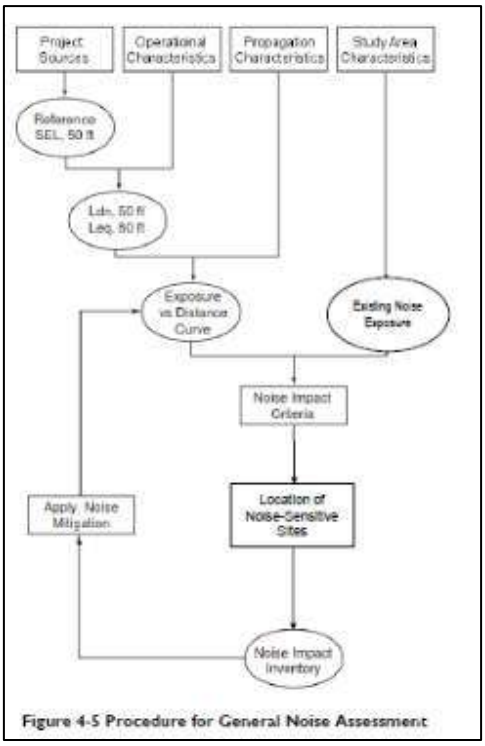


Figure 5-1: Procedure for General Noise Assessment as per FTA criteria

At an early project stage, the information available for a General Noise Assessment includes:

- Candidate transit mode
- Guideway options – design conditions
- Operational headways – will be single or double
- Design speed – maximum and average speed
- Alternative alignments

Conservative estimates (e.g., maximum (expected) design speeds and operations at design capacities) shall be used to estimate worst-case noise levels.

First choose the appropriate fixed-guideway transit source reference level and then predict the noise exposure at 15 m in terms of Leq(1hr) and Ldn.

Evaluate Path Treatments – When noise mitigation treatments cannot be applied at the noise source or additional mitigation is required after treating the source, the next preferred placement of noise mitigation is along the noise propagation path between the source and receiver

Noise Barriers – Noise barriers are effective in mitigating noise when they break the line-of-sight between source and receiver. The necessary height of a barrier depends on the source height and the distance from the source to the barrier.

- **Noise barriers close to vehicles** – Barriers located very close to a rapid transit train, for example, may only need to be approximately 2 to 3 m above the top of rail to be effective. Standard barriers close to vehicles can provide noise reductions of 6 to 10 dB.
- **Noise barriers at ROW line** – Barriers on the ROW line or for trains on the far track, the height must be increased to provide equivalent effectiveness to barriers located close to the vehicles. Otherwise, the effectiveness can drop to 3 dB or less, even if the barrier breaks the line-of-sight.

All barrier effectiveness can be increased by as much as 5 dB by applying sound-absorbing material to the inner surface of the barrier. The length of the barrier wall is also important to its effectiveness. The barrier must be long enough to block noise from a moving train along most of its visible path. This is necessary so that train noise from beyond the ends of the barrier will not severely compromise noise-barrier performance at noise-sensitive locations. The barrier length can be refined in the engineering phase, closely examining the predicted sound level exceedances at specific receivers, site geometries, and the contribution of barrier flanking noise, then adjusting the length as appropriate.

The noise modelling simulation of the project requires noise input data for all significantly noisy equipment in the project area with following input

- Sound Pressure Level (SPL) of noise source at a distance of 1 m from the edge of the source·
- Source type estimation of the wave-front of the source, modelled as either a point, line or area source.
- Other data types which improve source accuracy include operational duty cycles (as a conservative assessment, all equipment's are operating continuously at maximum operating conditions)

FTA criteria for noise impact were developed specifically for transit noise sources operating on fixed-guideways in urban areas. These criteria are based on well-documented research on human response to community noise and represent a reasonable balance between community benefit and project costs. These criteria do not reflect specific community attitudinal factors.

The levels of impact are described in Table 5-1: Levels of Impact. The criteria at which the levels of impact occur are presented in two ways depending on the relationship of project and existing noise sources.

If the project noise source is a new source of transit noise in the community, such as a new project in an area currently without transit, use the criteria as presented in analyzing the Project Noise Impact criteria presentation.

Table 5-1: Levels of Impact

Level of Impact	Description
No Impact	Project-generated noise is not likely to cause community annoyance. Noise projections in this range are considered acceptable by FTA and mitigation is not required.
Moderate Impact	Project-generated noise in this range is considered to cause impact at the threshold of measurable annoyance. Moderate impacts serve as an alert to project planners for potential adverse impacts and complaints from the community. Mitigation should be considered at this level of impact based on project specifics and details concerning the affected properties.
Severe Impact	Project-generated noise in this range is likely to cause a high level of community annoyance. The project sponsor should first evaluate alternative locations/alignments to determine whether it is feasible to avoid severe impacts altogether. In densely populated urban areas, evaluation of alternative locations may reveal a trade-off of affected groups, particularly for surface rail alignments. Projects that are characterized as point sources rather than line sources often present greater opportunity for selecting alternative sites. This guidance manual and FTA's environmental impact regulations both encourage project sites which are compatible with surrounding development when possible. If it is not practical to avoid severe impacts by changing the location of the project, mitigation measures must be considered.

Option A: Project Noise Impact Criteria Presentation – The impact criteria presentation for evaluating existing noise independently to project noise is presented in this option.

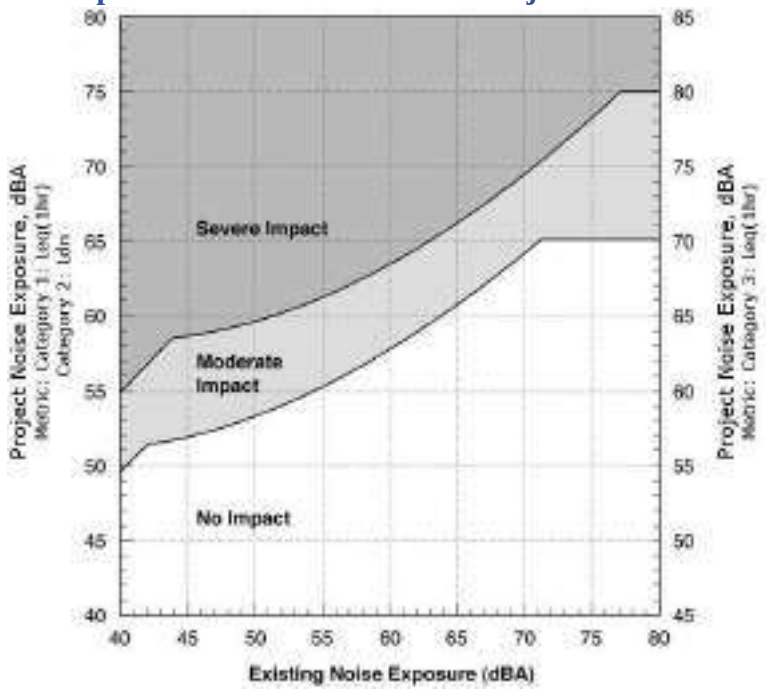
The noise levels at which impacts occur are presented in Figure 5-2: Noise Impact Criteria for Transit Projects and Table 5-1: Levels of Impact. If impact is determined, measures necessary to mitigate impacts are to be considered for incorporation into the project.

Figure 5-2 presents the existing noise exposure on the horizontal axis and project noise on the vertical axis. Category 1 and 2 land uses have the same criteria for project noise and are on the primary vertical axis. Category 3 land use criteria are presented on the secondary vertical axis. Note that project noise for category 1 and 3 land uses is expressed as Leq(1hr), whereas project noise for category 2 land use is expressed as Ldn. Also, note that project noise criteria are 5 dB higher for category 3 land uses in Figure 5-2 since these types of land use are less noise-sensitive than those in categories 1 and 2.

Note that for projects in locations with existing noise levels below 55 dBA, the project noise exposure is allowed some increase over the existing noise exposure before it is considered to cause impact. For category 1 and 2 land uses, the maximum project noise level to be considered to cause no impact is 65 dBA (Leq(1hr) or Ldn) regardless of the existing noise. Note that no impact at 65 dBA aligns with other Federal agencies in that a Ldn of 65 dBA is a standard limit for an acceptable living environment among some Federal agencies. Project noise levels above the top curve are considered to cause severe impact. The upper limit of the severe impact range is 75 dBA for category 1 and 2 land uses. The upper limit of 75 dBA is associated with an unacceptable living environment. Project noise between the two curves is considered to have moderate impact on the community.

The criteria are also tabulated in Table 5-1: Levels of Impact. The values in Table 5-1: Levels of Impact can be used for illustrative purposes and should only be used if all numbers are rounded up to the nearest decibel.

Figure 5-2: Noise Impact Criteria for Transit Projects



To estimate the operational noise level, the internationally recognized noise modelling software 'SoundPLAN' version 8.2 has been utilized. The Environmental noise propagation

methodology adopted, and the equations used within the SoundPLAN model are based on the ISO 9613 'Acoustics – Attenuation of Sound during Propagation Outdoors' (ISO, 1996) and Railway noise is using FTA/FRA- HSGT:2005 .

SoundPLAN has been developed by Braunstein & Berndt GmbH in Germany, and belongs to the class of sophisticated provisional models, based the technique of the Ray Tracing Inverted (from the receivers), that allow to simulate the propagation of the noise in complex source situations and orography.

The model allows calculating the sound levels due to various types of industrial sources and introduces its own algorithms for the calculation of the ground effect, the absorption and the other phenomena involved.

The equations used to estimate the propagation of the sound waves, for sources of industrial type, are those described in the International Standard ISO 9613.

The sound pressure level at the receiver is the sum of all contributing frequencies, and the fundamental equation is the following:

$$SPL = PWL + D_I - \left(A_d + A_a + A_g + A_b + A_n + A_v\right)$$

where:

- SPL=Sound Pressure Level at the receiver
- PWL=Sound Power Level of noise source
- Di=directivity of the source
- Ad=attenuation of sound wave due to geometric divergence
- Aa=attenuation of sound wave due to air absorption
- Ag=attenuation of sound wave due to ground absorption and reflection
- Ab=attenuation of sound wave due to diffraction
- An=attenuation of sound wave due to variations of the vertical gradient of the temperature, of
- the wind speed and of the atmospheric turbulence
- Av=attenuation of sound wave due to vegetation

- The directivity correction Di describes the extent by which the equivalent continuous Sound Pressure Level deviates from the point source in a specified direction from the level of an Omni directional point source.
- The geometrical divergence Av accounts for spherical spreading in the free field from a point sound source, making an attenuation in decibels.
- The law of spreading is different for point, line, and area sources.
- The attenuation due to atmospheric absorption Aa, in decibels, during the propagation through a distance "d", in meters, is equal to Aa = □d/1000, where □ is the atmospheric attenuation coefficient for each octave band. It depends strongly on the frequency of the sound, the ambient temperature, and the relative humidity.
- The attenuation of sound wave due to ground absorption and reflection "Ag" and that one due to the meteorological conditions "An" depend on the average height of the line of sight above the terrain and the distance from source to receiver. The absorption of sound waves by terrain is expressed by the model using a coefficient G (dimensionless), between 0 (hard ground, such as paving, water, ice and other surface having a low porosity) and 1 (porous ground, such as ground covered by grass, trees or other

vegetation); for intermediate terrains (0<G<1), G represents the percentage of porous terrain.

Table 5-2: Noise Levels Defining Impact for Transit Projects

Existing Noise Exposure, dBA	Project Noise Impact Exposure, dBA					
	Category 1 (Leq(1hr)) or 2 (Ldn) Sites			Category 3 Sites (Leq(1hr))		
Leq(1hr) or Ldn	No Impact	Moderate Impact	Severe Impact	No Impact	Moderate Impact	Severe Impact
<43	< Ambient+10	Ambient +10 to 15	> Ambient+15	< Ambient+15	Ambient +15 to 20	> Ambient+20
55	<56	56-61	>61	<61	61-66	>66
56	<56	56-62	>62	<61	61-67	>67
57	<57	57-62	>62	<62	62-67	>67
58	<57	57-62	>62	<62	62-67	>67
59	<58	58-63	>63	<63	63-68	>68
60	<58	58-63	>63	<63	63-68	>68
61	<59	59-64	>64	<64	64-69	>69
62	<59	59-64	>64	<64	64-69	>69
63	<60	60-65	>65	<65	65-70	>70
64	<61	61-65	>65	<66	66-70	>70
65[1]	<61	61-66	>66	<66	66-71	>71
66	<62	62-67	>67	<67	67-72	>72
67	<63	63-67	>67	<68	68-72	>72
68	<63	63-68	>68	<68	68-73	>73
69	<64	64-69	>69	<69	69-74	>74
70	<65	65-69	>69	<70	70-74	>74
71	<66	66-70	>70	<71	71-75	>75
72	<66	66-71	>71	<71	71-76	>76
73	<66	66-71	>71	<71	71-76	>76
74	<66	66-72	>72	<71	71-77	>77
75	<66	66-73	>73	<71	71-78	>78
76	<66	66-74	>74	<71	71-79	>79
77	<66	66-74	>74	<71	71-79	>79
>77	<66	66-75	>75	<71	71-80	>80

Table 5-3: Land use Category and Metrics for Transit Noise Impact Criteria

Land Use Category	Land Use Type	Noise Metric, dBA	Description of Land Use Category
1	High Sensitivity	Outdoor Leq(1hr)*	Land where quiet is an essential element of its intended purpose. Example land uses include preserved land for serenity and quiet, outdoor amphitheaters and concert pavilions, and national historic landmarks with considerable outdoor use. Recording studios and concert halls are also included in this category.
2	Residential	Outdoor	This category is applicable all residential land use and buildings where people normally sleep, such as hotels and

[1] As per CPCB Criteria **Error! Reference source not found.**, daytime noise levels were assumed to be 65 dBA a nd below

Land Use Category	Land Use Type	Noise Metric, dBA	Description of Land Use Category
		Ldn	hospitals.
3	Institutional	Outdoor Leq(1hr)*	This category is applicable to institutional land uses with primarily daytime and evening use. Example land uses include schools, libraries, theaters, and places of worship where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds, and recreational facilities are also included in this category.

* Leq(1hr) for the loudest hour of project-related activity during hours of noise sensitivity.

5.1.1 METEOROLOGY

Meteorological factors, such as temperature, humidity, wind speed and direction, affect sound propagation. Effects of wind on outdoor sound propagation during various weather conditions can cause large variations in project-related sound levels measured at a residence. If the residence is upwind of the facility, the wind could cause greater than normal outdoor sound attenuation and lower sound levels at the residence than would occur with no wind. However, if the residence is downwind of the facility, the opposite effect could occur, resulting in higher sound levels than normal at the residence. Crosswinds do not affect outdoor sound propagation and would result in sound levels at the residence that are essentially the same as those during calm conditions. The ISO 9613 algorithms used in this assessment simulate downwind propagation under a mildly developed temperature inversion (both of which enhance sound propagation) and provide a reasonable conservative assessment of potential effects.

The following meteorological parameters consistent with ISO 9613 requirements were applied in the noise model:

• Max Temperature = 34°C
• Average Relative humidity = 45%
• wind direction = downwind (i.e., wind blowing from the facility to the receptor)

Based on the predicted wind class frequency distribution for the Project site, a wind speed of 3 m/s typical of representative prevailing site condition was assumed in the noise model. These meteorological parameters and modelling approach are considered conservative assumptions during the month of Feb- march when the boiler blowing scenario is expected to occur.

6 CONSTRUCTION PHASE- NOISE ASSESSMENT

The assessment criteria adopted for this project is the maximum allowable 3 dB(A) increase provided in the IFC World Bank Group's Environment, Health, and Safety Guidelines.

The assessment of construction noise was confined on a selected corridor of impact based on the following:

a. construction period for each construction stage or activity on a specific stretch is short-term,
b. the types of equipment used for the entire stretch of the corridor would be identical, and

c. similar mitigation measure will be used by the contractor with slight variations based on noise monitoring and complaints received.

As per the CMRL SHE manual and Detailed Project report, there would be no construction activity that would take place during night.

6.1.1 CONSTRUCTION METHODOLOGY

Main construction activities include demolition of structures and ground clearing; Excavation and fill; Tunneling; Transport of construction materials, muck and waste; Casting of concrete elements and preparation of concrete and their transportation; Pile driving where cast-in-situ is not feasible, blasting in rock etc.

Elevated Sections. Substructure - open foundation, pile, pile caps, columns; station structure; earth retaining structures shall be cast-in-situ. The structural elements for superstructure i.e. box segments, I-Girders, U-girders and sometimes pile caps are pre-cast. Pre-cast construction may be segmental or non-segmental type. In case of segmental method, structural segments are pre-casted in casting yards, pre-stressed and then transported to the location of use and launched by means of suitable launching arrangement. The construction yard has arrangement for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 3 ha is required for each construction yard.

Underground Sections. Usually sections between underground stations are constructed by tunneling using Tunnel Boring Machine (TBM) while underground stations are built by cut-and-cover method. In the latter method, sidewalls of excavation at stations are supported in various ways. Between two stations tunnel is constructed by TBM. It will be launched from launching shaft. It is dragged in station area and continues from other side of station. Ground settlement analysis and monitoring is required during tunneling by TBM. Two separate tunnels are constructed by two different TBM. The initial plan is one to enter at Lighthouse Station, exit at Bharathidasan Road and the other one to enter at Natesan Park and exit at Bharathidasan Road and Meenakshi College. Depending upon the soil/rock strata, suitable type of TBM shall be used for tunneling. Locations where deployment of TBM is not possible (tunneling of short length, cross passages, underground stations which are not possible by cut and cover method etc.) are tackled by New Austrian Tunneling Method (NATM).

Construction of elevated, underground alignment involves following type of constructions: -

- Sub-structure - Columns on Open/Pile foundations with pier cap at top of columns. Alternatively, Portal arrangement is provided at certain locations.
- Superstructure by segmental construction of whole unit construction. Box segments are most common type of segmental construction. I-Girder and U- girder are most common type of non-segmental construction methods where the structural element for whole span length is pre-cast and launched in position.
- Underground alignment by means of tunnels made through Tunnel Boring Machine / open cut and cover method/ NATM method.
- Underground stations by means of cut and cover method or NATM method.
- Earth retaining structures like diaphragm walls, sheet piles, secant piles etc.

6.1.1.1 CAST IN-SITU AND PRE-CAST CONSTRUCTION

A) Cast in-situ construction

In cast in-situ construction method, structure is cast at its final location of use. This involves erection of temporary shuttering, scaffolding and support system for casting the structure. The temporary supports and shuttering is removed when the concrete is set and structure attains the strength to bear its dead weight and other loads. This method involves longer construction time and interference to road users for longer period. This method is restricted to casting of substructure - open foundation, pile, pile caps, columns; station structure; earth retaining structures.

B) Pre - cast construction

In this method, structural segments are pre-casted in casting yards, pre-stressed and then transported to the location of use and launched by means of suitable launching arrangement. The structural elements for superstructure i.e. box segments, I-Girders, U-girders and sometimes pile caps are casted by pre-cast technique. Pre-cast construction may be segmental or non-segmental type.

Casting yard is required for casting of precast structural segments and other precast units like U-girder, I-Girder etc. The construction depot has arrangement for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 2.5 Ha to 3 Ha is required for each construction depot.

Pre-cast construction has following advantages: -

- Reduction in construction period due to concurrent working for substructure and superstructure.
- For segmental, pre-cast element (of generally 3.0m length), transportation from construction depot to site is easy and economical. For other type of construction i.e. I-Girder, U Girder etc. longer trailer and straighter roads are required but erection can be done by using road cranes in comparatively less time.
- As the pre-cast elements are cast on production line in a construction depot, better and uniform quality control can be exercised.
- This method reduces the interference to road users to minimum. For casting of segments, both long line and short line method can be adopted. However, the long line method is more suitable for spans curved in plan while short line method is good for straight spans. A high degree of accuracy is required for setting out the curves on long line method for which pre-calculation of offsets is necessary. Match casting of segments is required in either method. The cast segments are cured on the bed as well as in stacking yard. Ends of the segments are to be made rough through sand blasting so that gluing of segments can be effective.

The segmental construction has following advantages.

- Segmental construction is an efficient and economical method for a large range of span lengths and types of structures. Structures with sharp curves and variable super elevation can be easily accommodated.
- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.

- Segmental construction permits a reduction of construction time as segments are manufactured in a casting yard while substructure work is in progress, and erected rapidly thereafter.
- Better quality control is possible in the casting yard.
- It is easier to transport smaller segments by road trailers on city roads.
- Interference to the traffic during construction is significantly reduced.

The entire construction stage of metro rail projects can be divided into several sub- activities that includes piling, footing, and piers construction, erection of box girder segment, and station building. This section describes these sub-activities by defining the individual equipment that will be used and their respective sound power levels and acoustical usage factor..

Table 6-1: List of Cast-In-Situ Pile Construction Equipment

Construction Equipment	Impact Device	Acoustical Usage Factor (%)	Sound Power Level, Lw dB(A)
Hydraulic Rig	N	20	92
Winch	N	20	81
Service Cranes	N	20	82.6
DG 125 KVA		50	113
DG 62.5 KVA	N	50	81
JCB	N	40	76
Displacement pump	N	50	69
Air compressor	N	40	74.9
		Overall	113
		50 & 40	**113**

Table 6-2: List of footing construction Equipment

Construction Equipment	Impact Device	Acoustical Usage Factor (%)	Sound Power Level, Lw dB(A)
Vibro Hammers (Hydraulic)	Y	20	132
Generators	N	50	81
Backhoe (breaker)	Y	40	92.5
Backhoe	N	40	62.2
Drainage Pump	N	50	68.9
Welding Machine	N	40	72.9
Cranes	N	16	82.6
Concrete Bucket	N	15	83
Air Compressor	N	40	80
		Overall Sound Level	132 dBA or 121 dBA
		50 & 40	**93.1**

Table 6-3: List of Box Girder Erection Equipment

Construction Equipment	Impact Device	Acoustical Usage Factor (%)	Sound Power Level, Lw dB(A)
Erection Girders 1/	N	16	82.6
Cranes	N	16	82.6
Tension Jack 2/	N	50	85
Air Compressors	N	40	80
Generators	N	50	81
Segment Carrier 1/	N	16	82.6
Overall			90.4
		50 & 40	87.3

Table 6-4: List of Pier Construction Equipment

Construction Equipment	Impact Device	Acoustical Usage Factor (%)	Sound Power Level, Lw dB(A)
Air Compressors	N	40	80
Concrete Bucket	N	15	83
Steel Formworks (column)	N	30	103.8
Steel Formworks (Pier Head)	N	30	103.8
Total			106.9

Table 6-5: List of Station Structure Construction Equipment

Construction Equipment	Impact Device	Acoustical Usage Factor (%)	Sound Power Level, Lw dB(A)
Crane	N	16	82.6
Truck (steel Materials	N	40	62.2
Air Compressors	N	40	80
Generators	N	50	81
Welding Machine	N	40	75.9

To assess the construction level noise, the maximum noise level was simulated as a line sources at the surface of the road. Based on the above data, the maximum noise level would be generated during the piling construction, with an approximate sound power level of 113 dBA. Therefore, an line source replicating piling construction was accounted for the entire stretch of the corridor.

The activities during the construction activities can be categorized based on the following:

6.1.2 IN-SITU PILING.

Piling construction starts with the survey works that involves the use of total stations and measuring tapes to establish pillars and coordinates for all pile points, foundations, including vertical controls. Bored cast in-situ piling starts with the initial boring for the installation of guide casing. Once the hydraulic rig is centered, a 4.0m bore is made to install a temporary guide casing. This guide casing will have a diameter equal to the pile and progressively driven to the desired depth by simultaneously boring and driving. Further boring done to hard rock

level using a Kelly bar inside the casing. Once the pile boring reaches the termination level, the reinforcement caged is lowered into the bored hole using piling rigs and cranes with double sling ropes. Tremmie pipes with hoppers are thenlowered ready for concreting.

6.1.3 FOOTING.

Footing works includes excavation, pile head treatment and concrete work. The excavation requires placing sheet piles and temporary retaining walls. Pile head treatment is performed with a breaker attached to the backhoe and simultaneously handled by a manual breaker to prevent the rebar from being damaged. This operation creates the loudest noise during footing construction. Large steels formwork is used requiring a crane to stay in the work area. Concrete will be applied using bucket or concrete pump lorry.

6.1.4 PIER CONSTRUCTION.

Will be carried out using large steel formwork and reusable mobile scaffolding that will be used as a working platform for the rebar installation. There will be a resident crane for each construction gang. The formwork consists of two types, a column and pier head. The column formworks are fabricated in the different heights. Concrete is placed in the column and pier head through a bucket or pump lorry.

The noise levels during the construction phase during maximum noise generation stage of piling at each of the receiver was estimated. Noise mitigation is confined to the current practice by installing temporary 3-m noise enclosure around the active construction site to control, among others, noise impacts.

Also shown in the Tables are the existing noise measurements surround these receivers, identified as day and Night-times noise limits, which are the bases to assess if during the construction activities exceed the maximum allowable 3 dB(A).

Based on conservative estimate, during the operation, the maximum noise levels exceed the allowable 3 dBA allowance, while the footing operation the levels, where within the 3 dBA allowance most of the occasions. The exceedance was predominately felt at the higher floors rather than the ground level.

Figure 6-1: Construction – Piling operations – Overall- Without and with Mitigation

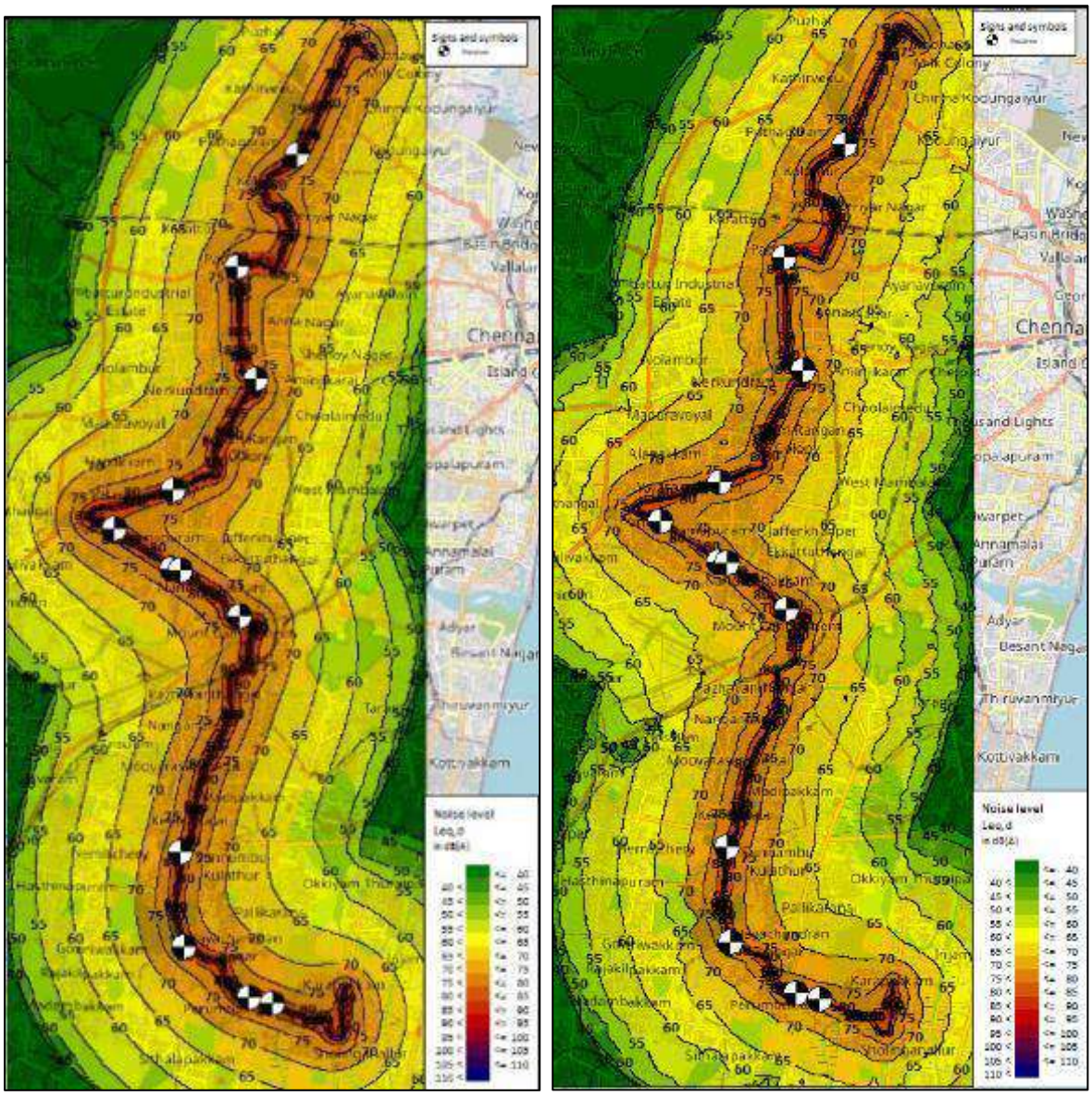
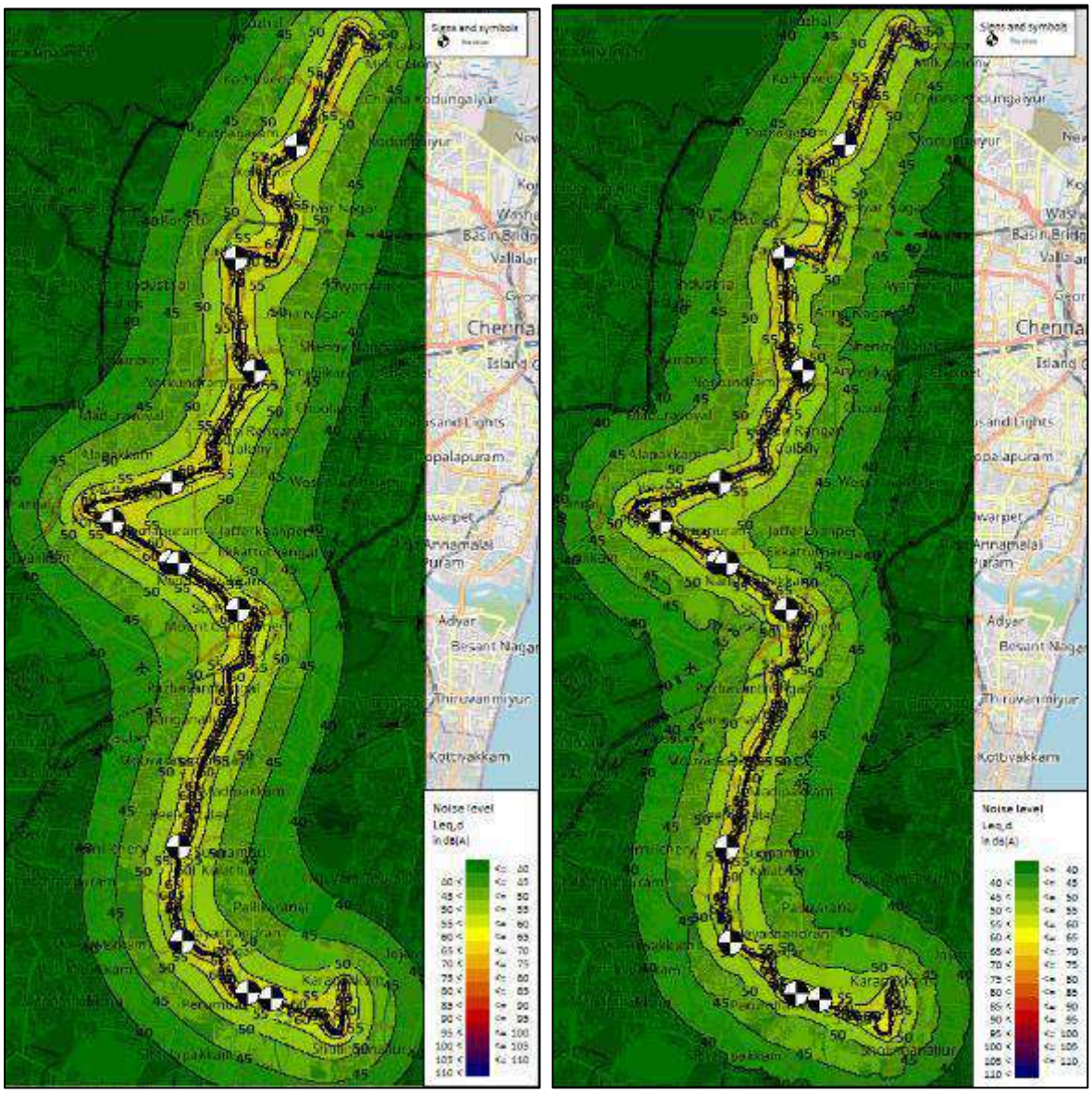


Figure 6-2: Construction – Footing operations – Overall- without and with Mitigation (wall)



6.1.5 MITIGATION MEASURES

In addition to the structural and engineer practice measures to control noise, good communication with affected communities is often the most effective way to manage potential construction noise impacts. Therefore, the Contractor should ensure the affected receivers well informed of the progress of the works, including when and where the noisiest activities will be taking place and how long they are expected to last. All noise complaints should be effectively recorded, investigated, and addressed. Account should be taken of the needs of residents near the project alignment in the choice of working hours and consider among others:

- Avoid nighttime and weekend working;
- Avoid working during prayer time; and to
- Carry out noisy works near offices during holiday periods

In addition, the Contractor will observe general good working practices including the following which are particularly relevant to road construction:

- Modern, silenced and well-maintained plant and construction equipment shouldbe used;
- All vehicles and plant should be fitted with effective exhaust silencers which should be maintained in good and efficient working order.
- Fitted acoustic covers should be kept in a good state of repair and should be kept closed when plant is in use.
- vehicles should not wait or queue on the road with engines running, shut down when not in use or where this is impracticable, throttled down to a minimum.
- Where activities, including delivery of material to site, cannot take place during normal working hours they should be carried out as close to normal working hours as is reasonably practicable.
- Concrete mixers should not be cleaned by hammering the drums.
- When handling materials, care should be taken not to drop materials from excessive heights
- Development of bypass roads to avoid road alignment
- Adoption of proper surface design and maintenance
- Provision of noise barriers. Specifications for installation of noise protection devices clearly indicating the location, design and material, and also provide for future maintenance requirements
- Provision of mandatory acoustic enclosure /acoustic treatment of room for stationary DG sets (5KVA and above). The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB (A) insertion loss for meeting the ambient noise standards, whichever is on the higher side. The DG set should be provided with proper exhaust muffler with insertion loss of minimum 25 dB (A)
- Building facade insulation, such as double window glazing, is an option usually adopted as a last resort in order to dampen noise in buildings. It is most likely to be needed in cases where noise impact result from an unforeseen expansion of traffic volume along existing roads
- Doubling the distance between the road and the receptor results in a decrease of 3 dB (A) in the noise level

- When traffic on road is doubled, the noise level increases 3 dB (A), all other factors being equal
- Doubling the speed results in an increase of 6 dB (A)
- Environmental specifications for contractors should cover the required safeguards during the design and construction stage

6.2 CONSTRUCTION PHASE NOISE ASSESSMENT AT SENSITIVE RECEPTORS

The results of Noise modelling (Contour map) for construction phase at various locations along the alignment of corridor 5 are enclosed below.

The assessment criteria adopted for this project is the maximum allowable 3 dB(A) increase provided in the IFC World Bank Group's Environment, Health, and Safety Guidelines.

Assessment Area

The assessment of construction noise was confined on a selected corridor of impact based on the following:

i) construction period for each construction stage or activity on a specific stretch is short-term,

ii) the same set or "gang" of equipment will be used and upon completion will be transferred to a new construction front, and

iii) similar mitigation measure will be used by the contractor with slight variations based on noise monitoring and complaints received. The selection of an assessment area also avoids the repetitive voluminous calculations required if the entire alignment was considered as what was done in the operational noise assessment.

The selected assessment area should represent the most sensitive stretch of the project area during the construction phase. Sensitivity is defined in terms of the density, variety, and nearness to the construction front (here taken as the centerline to coincide with the footing, pier, and box girder construction) of the receivers. The sensitive receptors were identified by the CMRL and the findings and recommendations, including limitations of noise controls on this particular stretch will be applicable to the rest of the project alignment.

In the assessment of construction noise impacts, a railway section was selected as a representative of the entire alignment in terms of train operation, topography, and location of receiver.

The entire construction stage of metro rail projects can be divided into several subactivities that includes piling, footing, and piers construction, erection of box girder segment, and station building. This section describes these sub-activities by defining the individual equipment that will be used and their respective sound power levels and acoustical usage factor. To focus the construction noise assessment on the activity that poses the highest risk to receivers, an inventory of all the equipment to be used for each of this construction activity was made with their noise power level and acoustic usage factors. The succeeding Tables present the typical set of equipment used on each of the construction sub-activities. The list of piling equipment was provided by the CMRL as per the DPR.

Table 6-6: List of Cast-In-Situ Pile Construction Equipment

Construction Equipment	Impact Device	Acoustical Usage Factor(%)1/[2]	Sound Power Level, LwdB(A)
Hydraulic Rig	N	20	92
Winch	N	20	81
Service Cranes	N	20	82.6
DG125 KVA		50	113
DG62.5 KVA	N	50	81
JCB (1)	N	40	76
Displacement pump	N	50	69
Air compressor	N	40	74.9
Overall Sound level			**102 dBA or 113 dB**

Table 6-7: List of Footing Construction Equipment

Construction Equipment	Impact Device	Acoustical Usage Factor(%)	Sound Power Level, LwdB(A)
VibroHammers(Hydraulic)	Y	20	132
Generators	N	50	81
Backhoe(breaker)	Y	40	92.5
Backhoe	N	40	62.2
Drainage Pump	N	50	68.9
Welding Machine	N	40	72.9
Cranes	N	16	82.6
Concrete Bucket	N	15	83
Air Compressor	N	40	80
Overall Sound Level			132 dBA or 121

6.2.1 ANJAKHA HOSPITAL

The Noise contour map for the construction phase of (Madipakkam Koot Road to Venkateswara nagar) is shown in **Figure 6-3.**

[2]Acoustical usage factor is the fraction of time that the equipment generates noise at the maximum level. The average (Leq) sound level at a receptor is calculated by accounting for the reduction in sound level with distance (that is, geometric divergence).

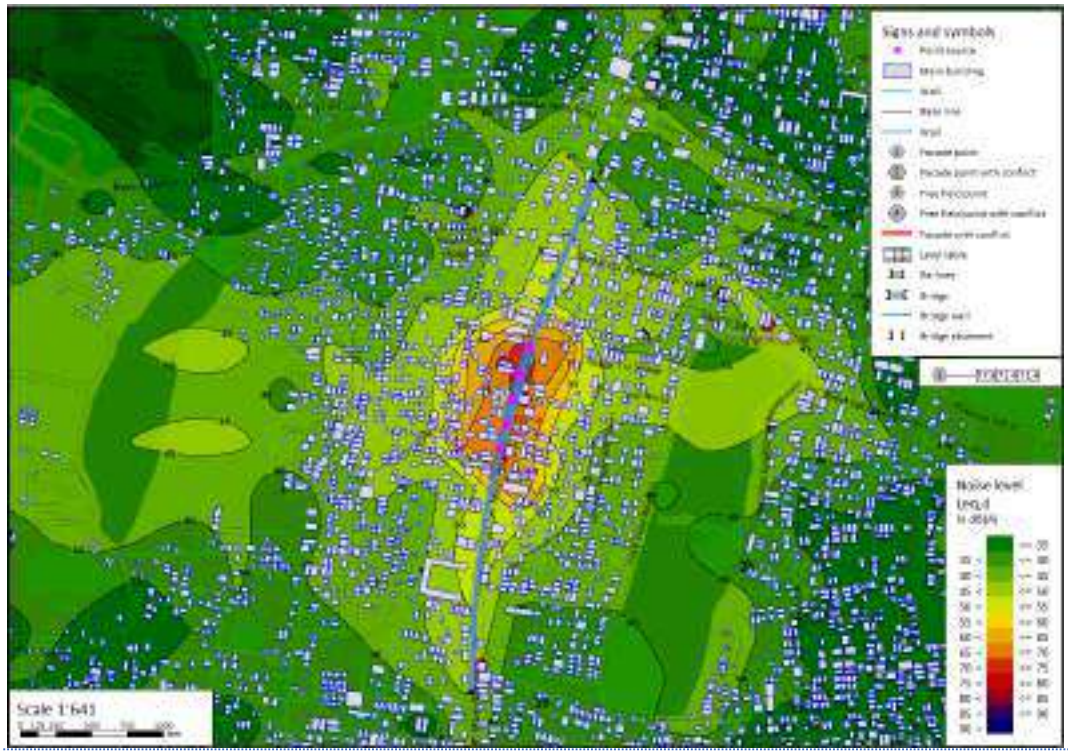


Figure 6-3: Noise contour maps for construction phase (Madipakkam Koot Road to Venkateswara nagar)

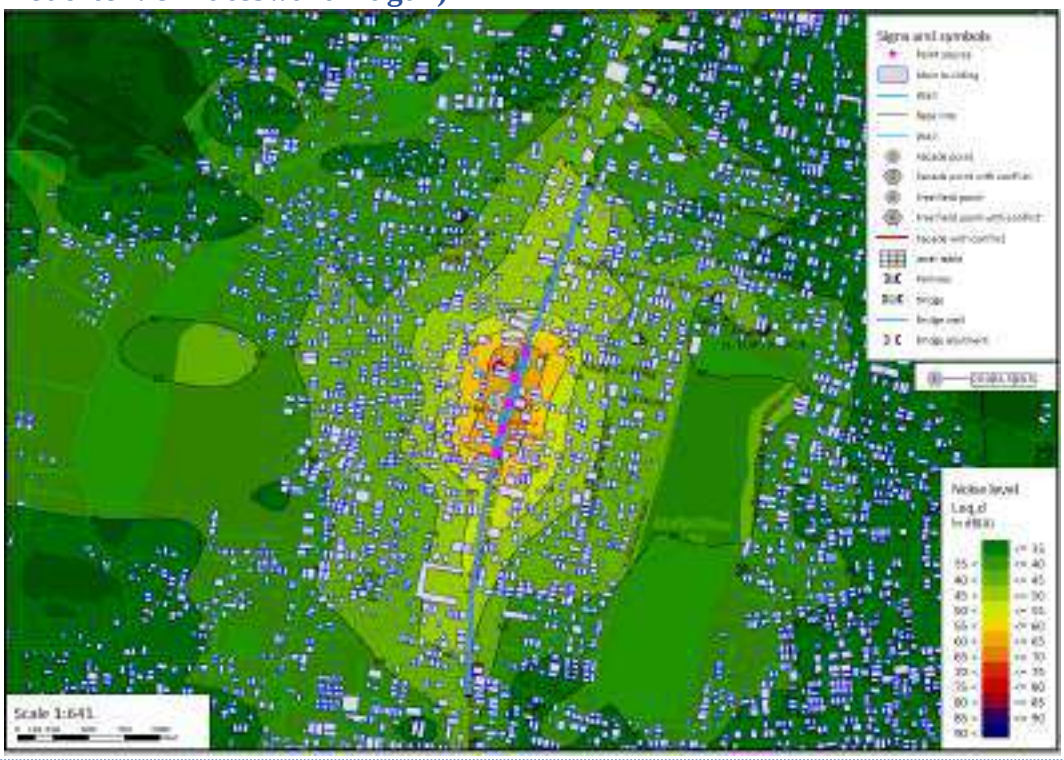


Figure 6-4: Anjiakha Hospital –Construction Noise contour map

6.2.2 CONTONEMENT BOARD SCHOOL

The Noise contour map for the construction phase of (CTC to St. Wesley Church) is shown in **Figure 6-5.**

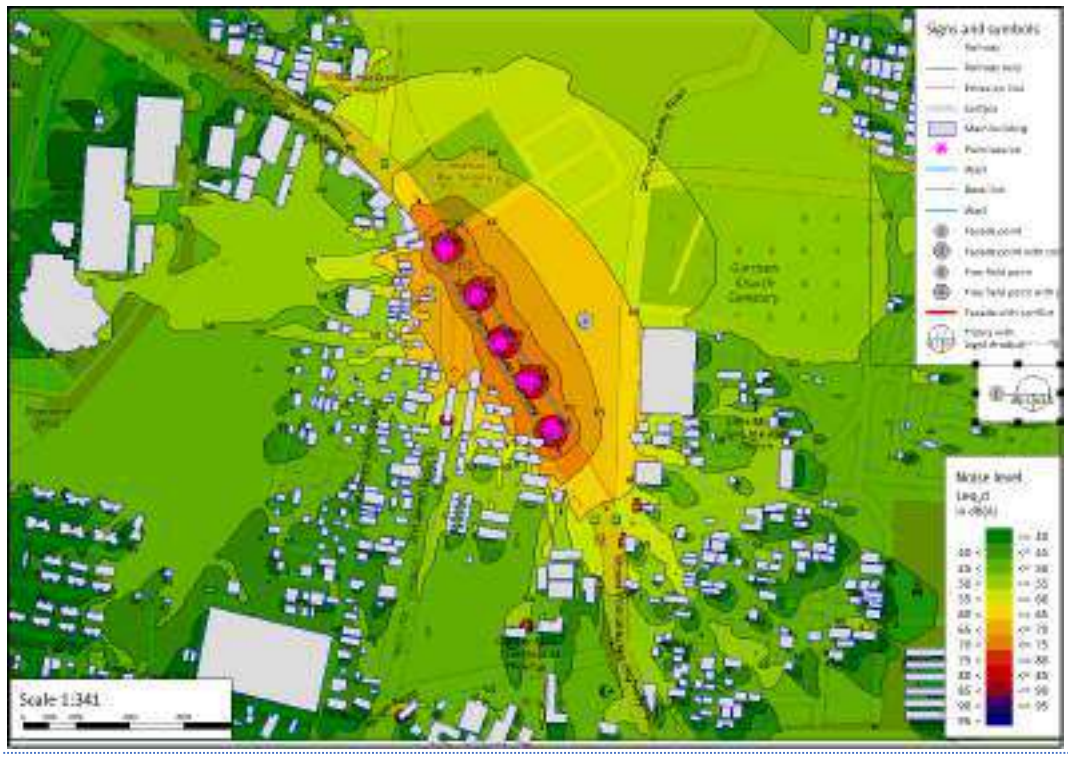


Figure 6-5: Noise contour maps for Construction phase (CTC to St. Wesley Church).

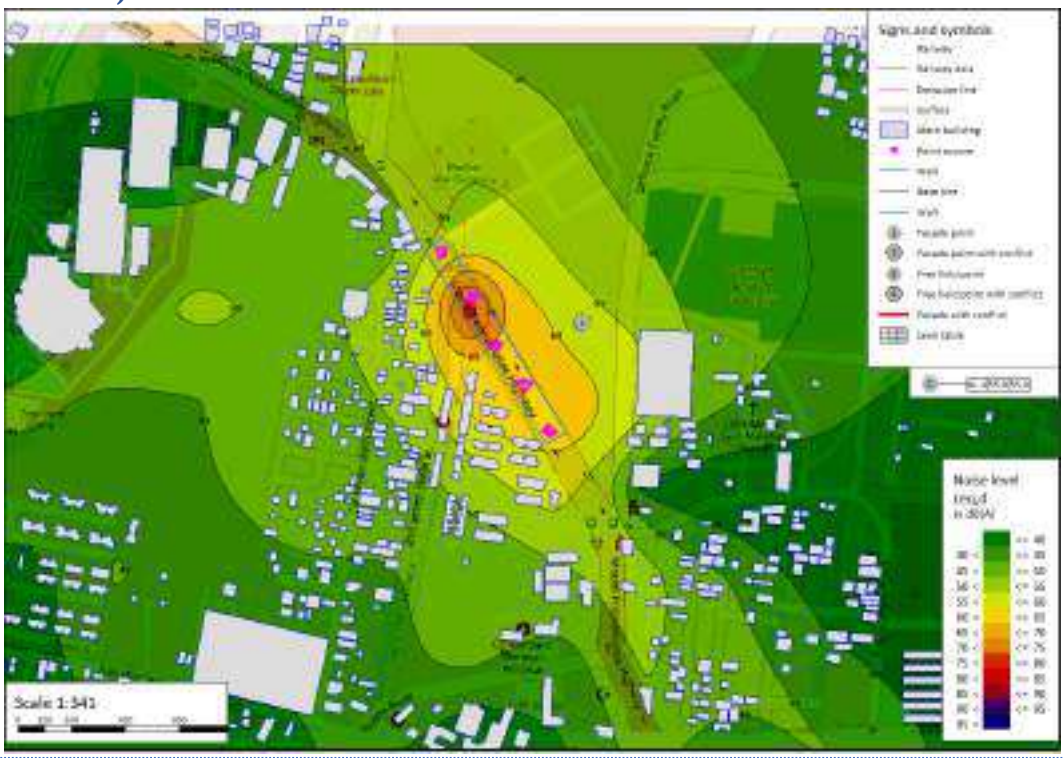


Figure 6-6: Contonement Board School - After Mitigation - Noise contour maps for Construction phase.

6.2.3 ST. JOSEPH HOSPITAL

The Noise contour map for the construction phase (Porur to Mugalivakkam) is shown in **Figure 6-7.**

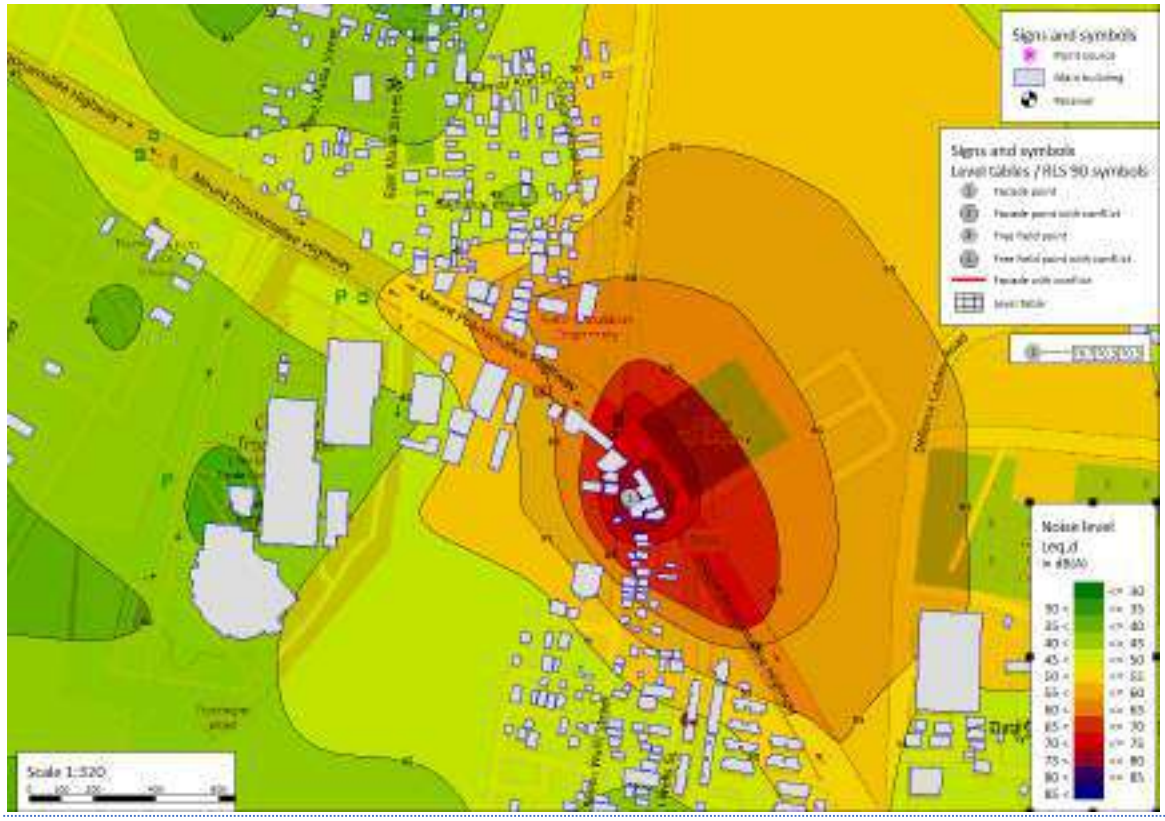


Figure 6-7: Noise contour maps for Construction phase (Porur to Mugalivakkam).

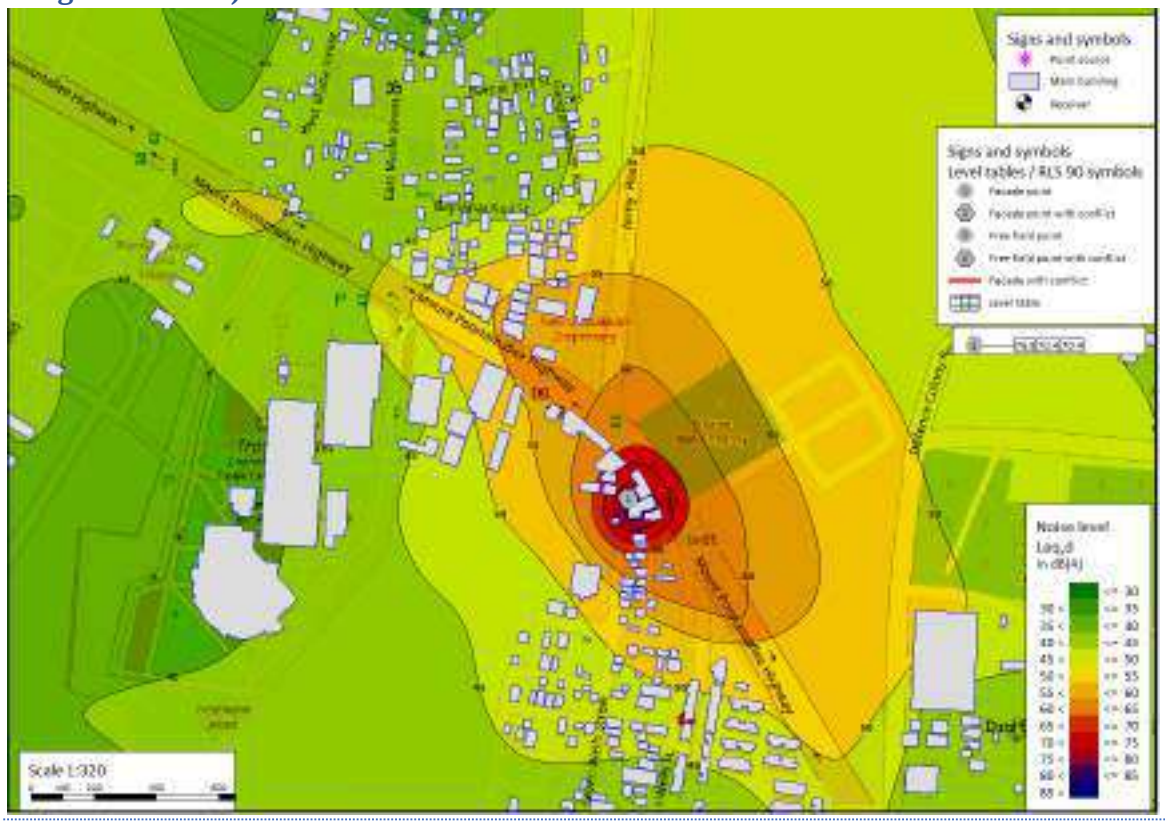


Figure 6-8: St. Joseph Hospital- After Mitigation - Noise contour maps for Construction phase.

6.2.4 GOVERNMENT BOYS SCHOOL PORUR

The Noise contour map for the construction phase (Porur to Mugalivakkam) is shown in **Figure 6-9.**

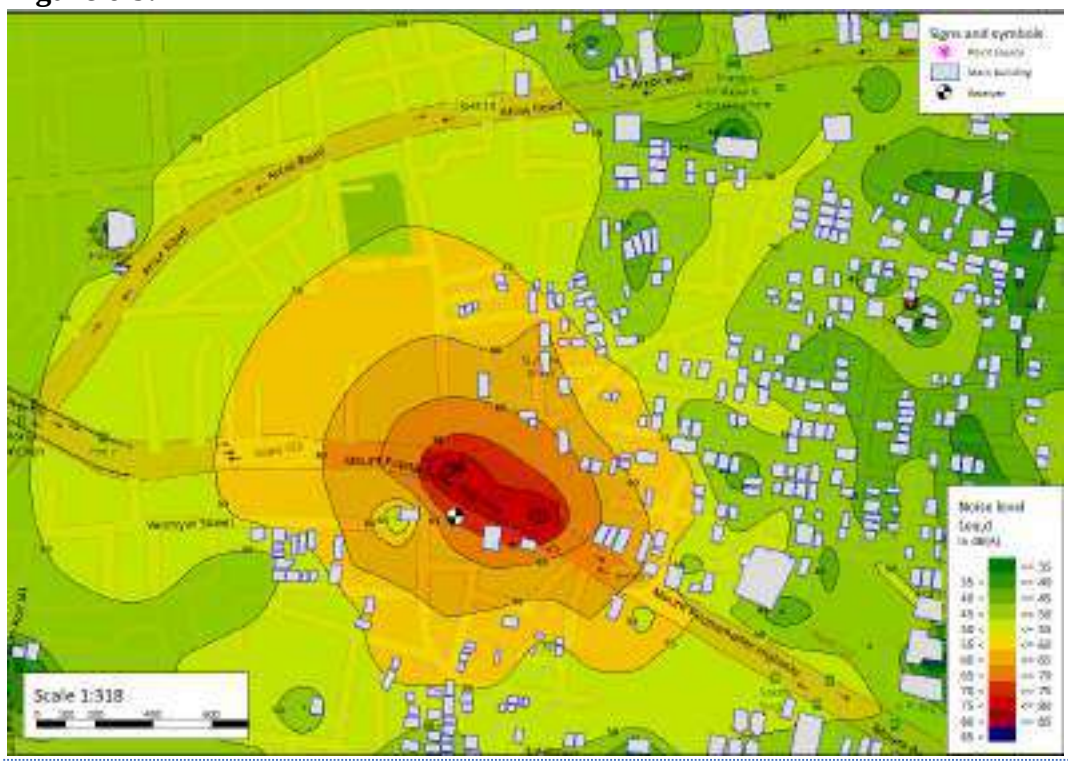


Figure *6-9*: Noise contour maps for Construction phase (Porur to Mugalivakkam).

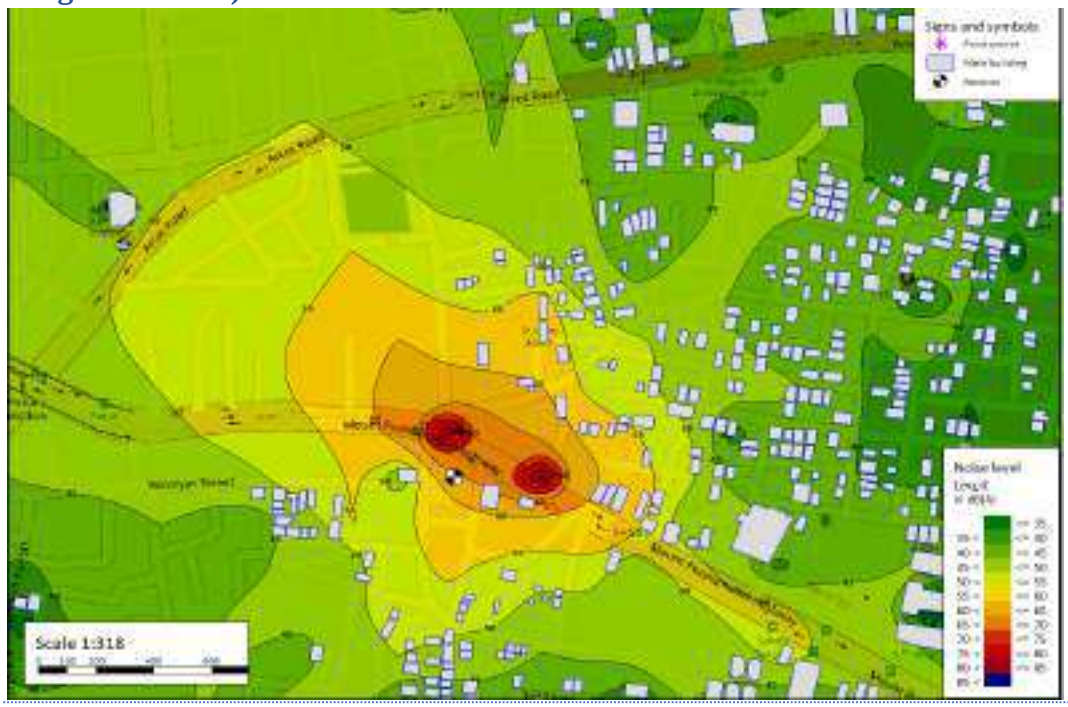


Figure 6-10: Government Boys High School Porur - After Mitigation - Noise contour maps for Construction phase.

6.2.5 KALAPANA HOSPITAL

The Noise contour map for the construction phase (Adambakkam MRTS to Medavakkam main road) is shown in **Figure 6-11.**

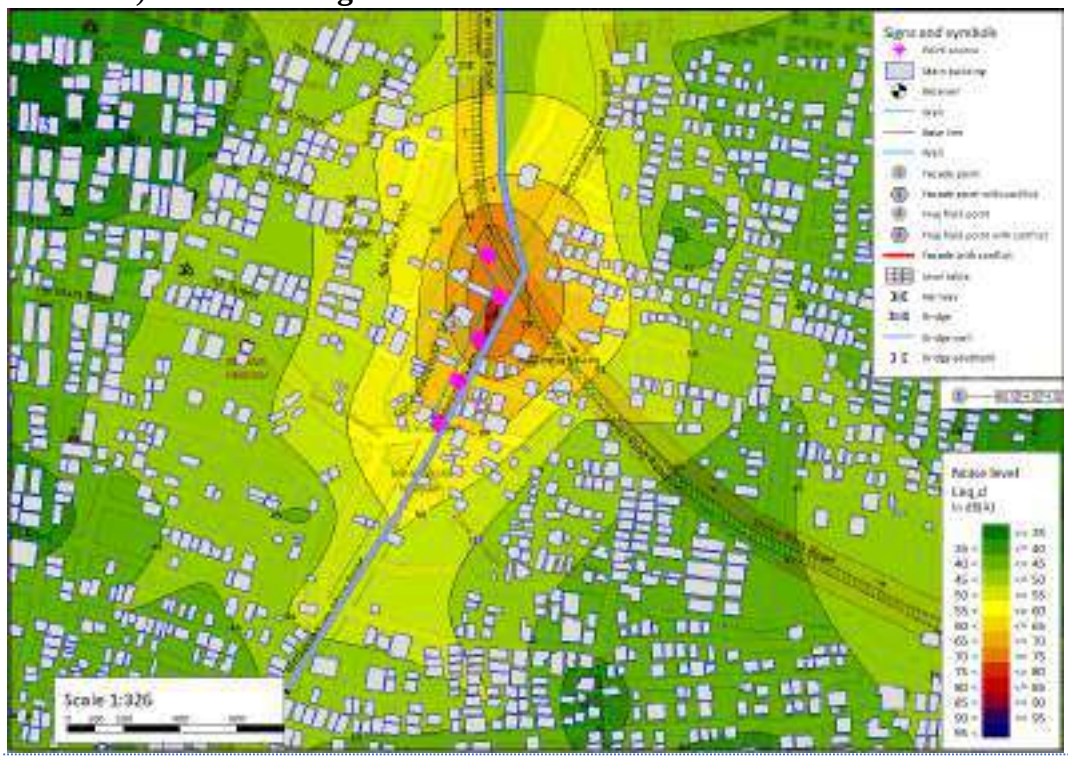


Figure 6-11: Noise contour maps for Construction phase (Adambakkam MRTS to Medavakkam main road).

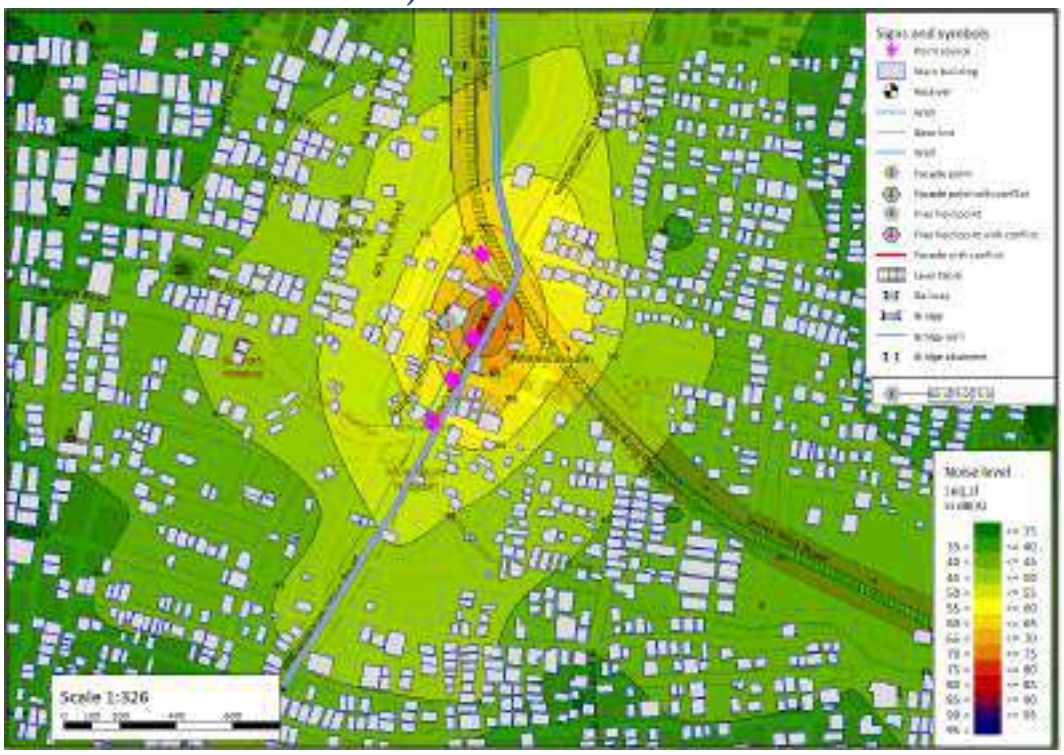


Figure 6-12: Kalapana Hospital - After Mitigation - Noise contour maps for Construction phase.

6.2.6 MM HOSPITAL

The Noise contour map for the construction phase (Sai nagar Bus Stop to Elango nagar Bus Stop) is shown in **Figure 6-13.**

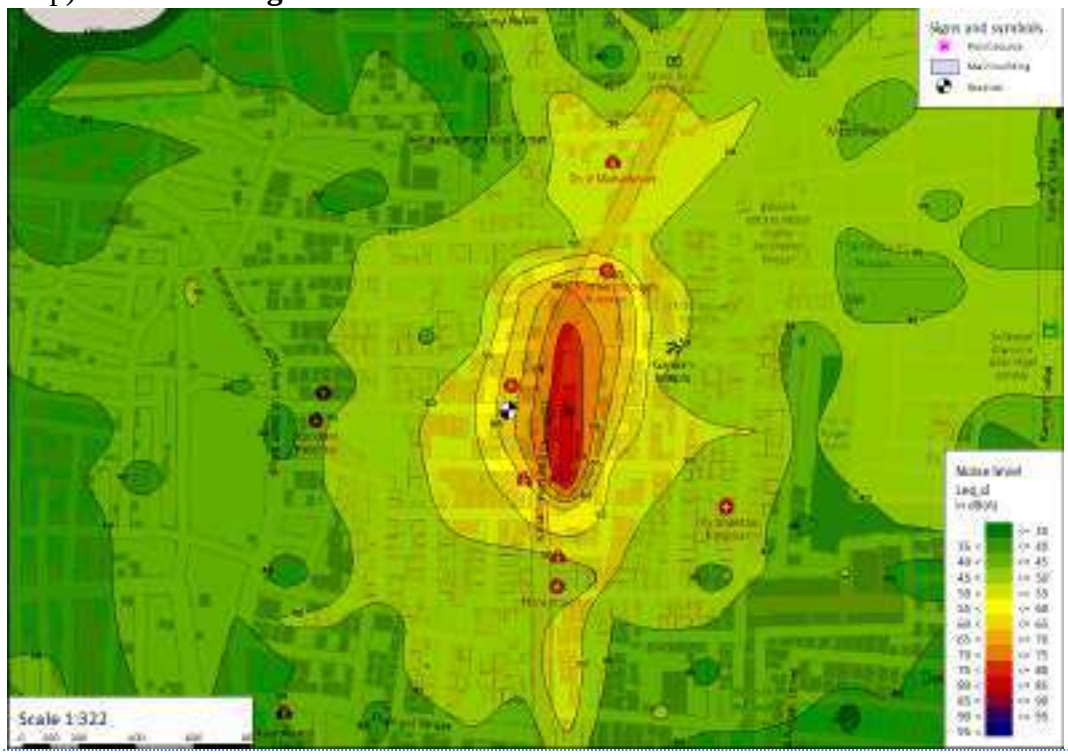


Figure 6-13: Noise contour map for construction phase (Sai nagar Bus Stop to Elango nagar Bus Stop).

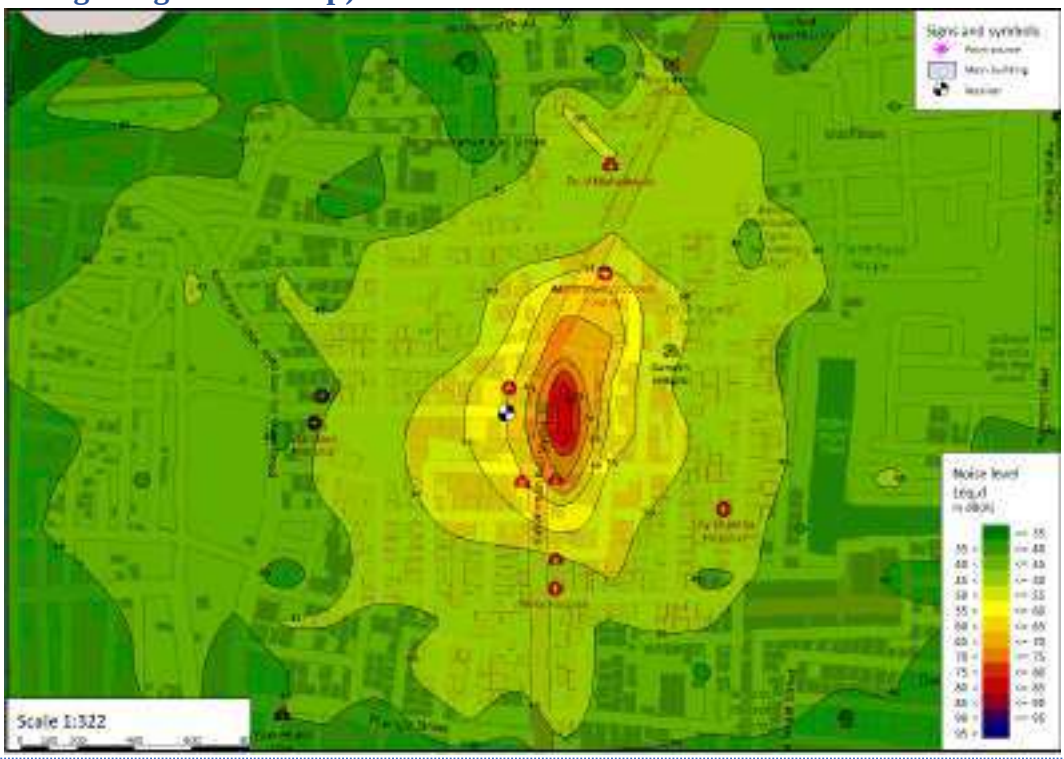


Figure 6-14: MM Hospital- After Mitigation - Noise contour maps for Construction phase.

6.2.7 NATIONAL SCHOOL

The Noise contour map for the construction phase (St. Wesley Church to Alandur) is shown in **Figure 6-15.**

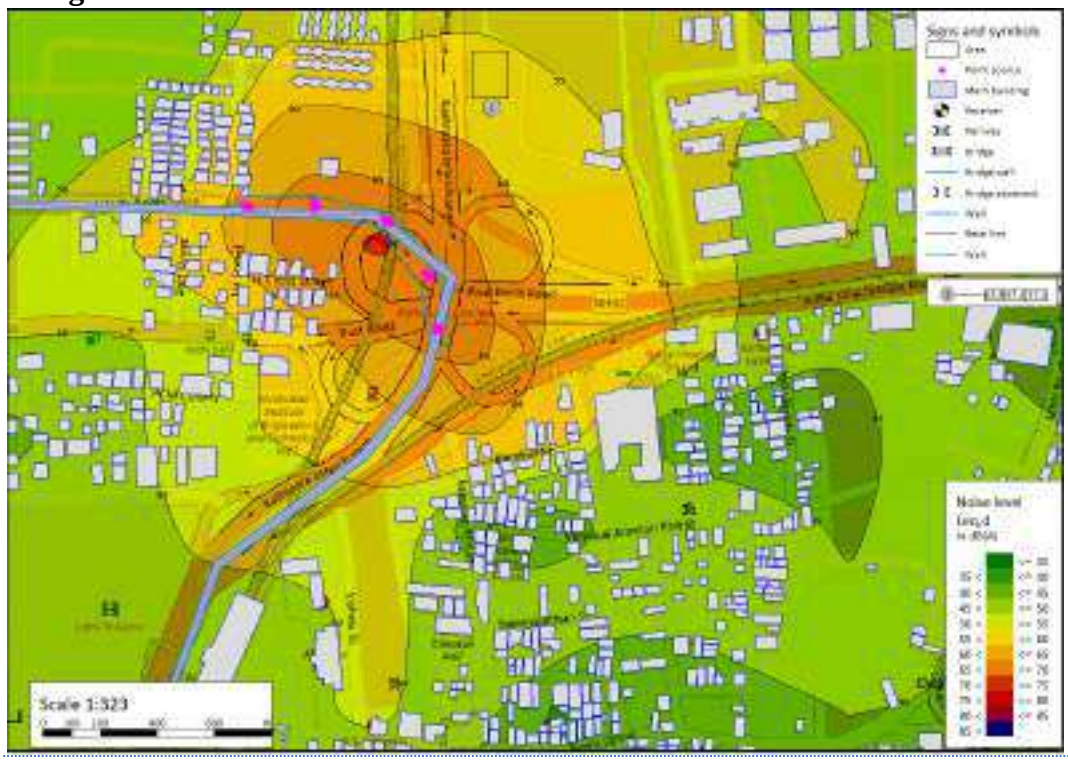


Figure 6-15: Noise contour maps for Construction phase (St. Wesley Church to Alandur).

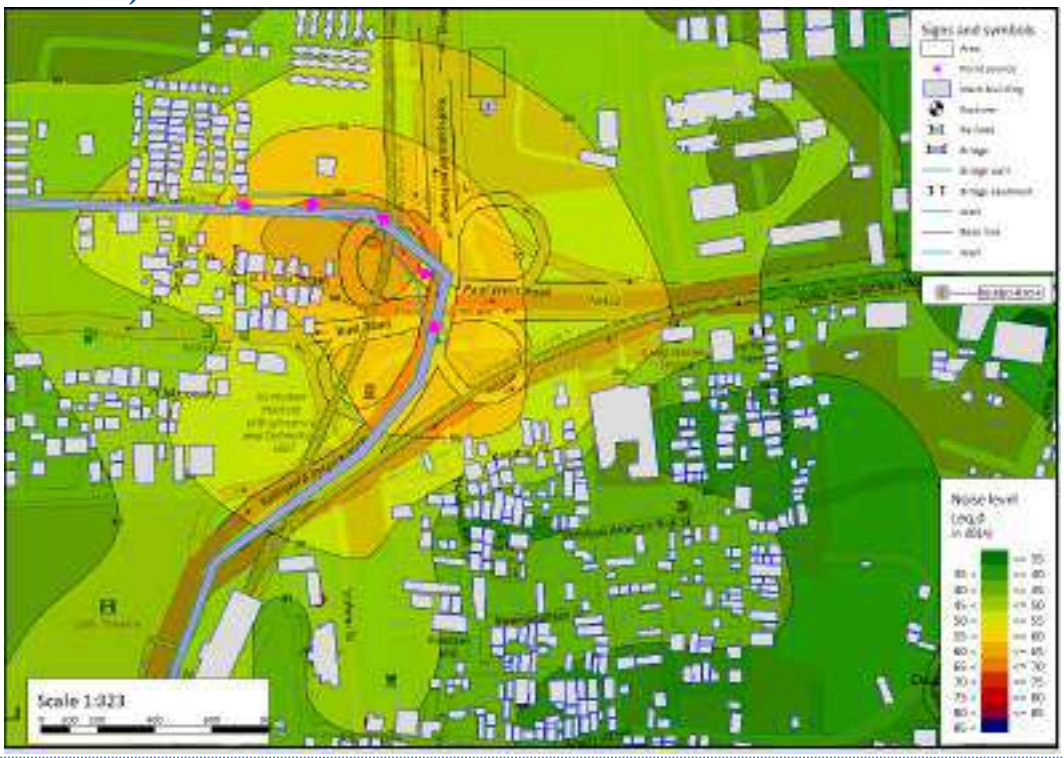


Figure 6-16: National School - After Mitigation - Noise contour maps for Construction phase

Ravindra Bharathi Global School

The Noise contour map for the construction phase (Venkateswara nagar to Echankadu Bus Stop) is shown in **Figure 6-17.**

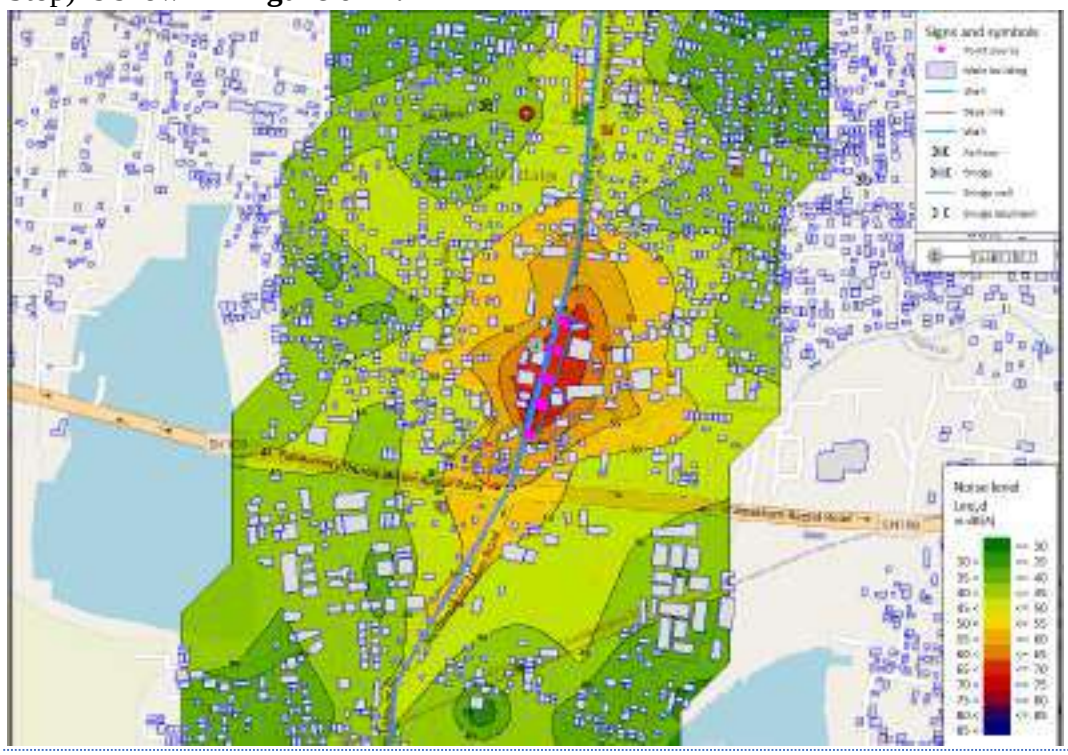


Figure *6-17*: Noise contour maps for Construction phase (Venkateswara nagar to Echankadu Bus Stop).

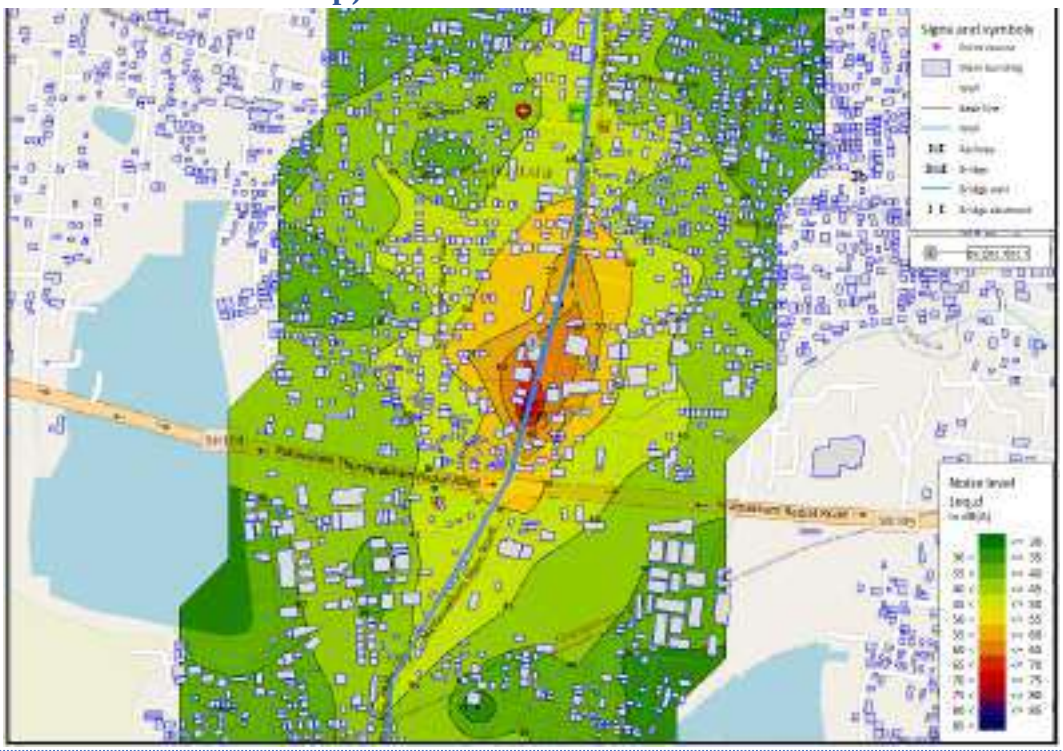


Figure 6-18: Ravindra Bharathi Global School - After Mitigation - Noise contour maps for Construction phase

6.2.8 SRI VARASIDHI VINAYAGAR TEMPLE

The Noise contour map for the construction phase (Velakallu Bus stop to Medavakkam Koot Road Bus Stop) is shown in **Figure 6-19.**

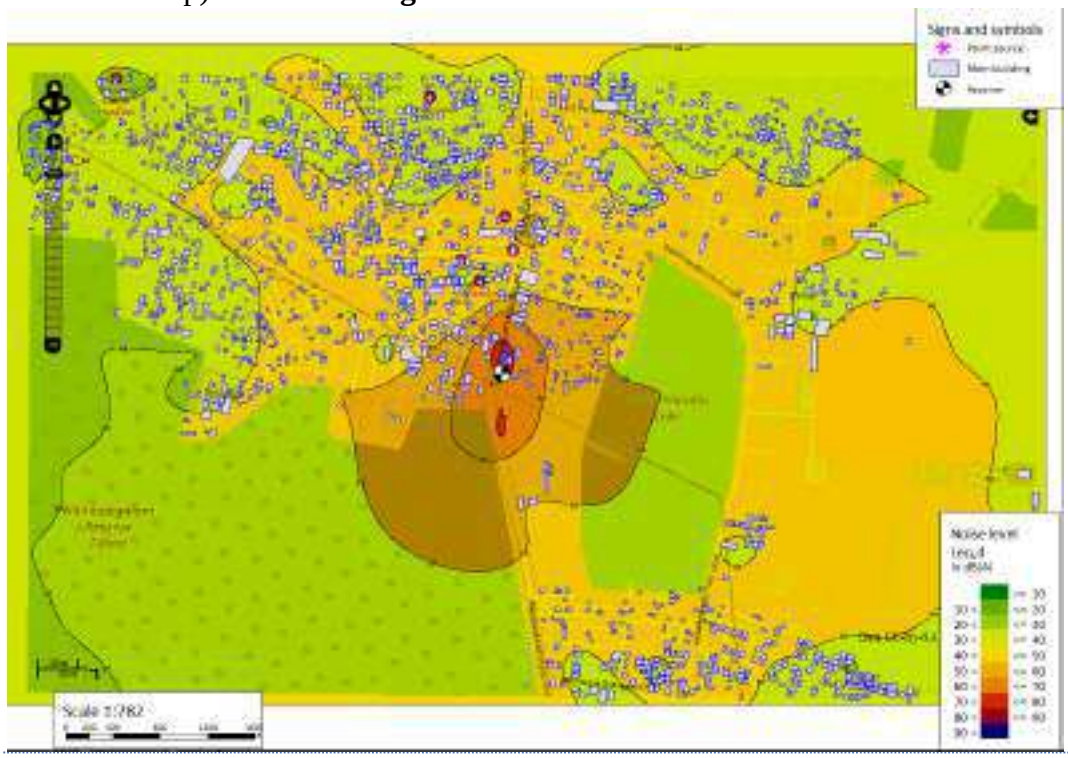


Figure 6-19: Noise contour maps for Construction phase (Velakallu Bus stop to Medavakkam Koot Road Bus Stop).

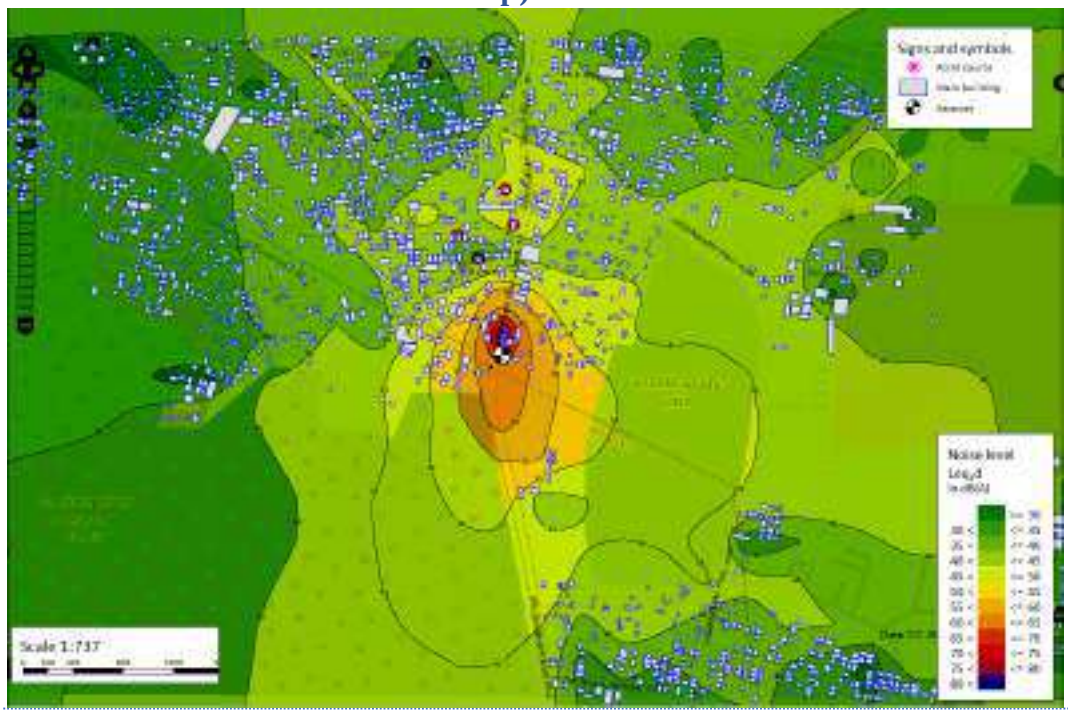


Figure 6-20: Sri Varasidhi Vinayagar Temple - After Mitigation - Noise contour maps for Construction phase

6.2.9 ST. JOSEPH SCHOOL

The Noise contour map for the construction phase (CTC to St. Wesley Church) is shown in **Figure 6-19.**

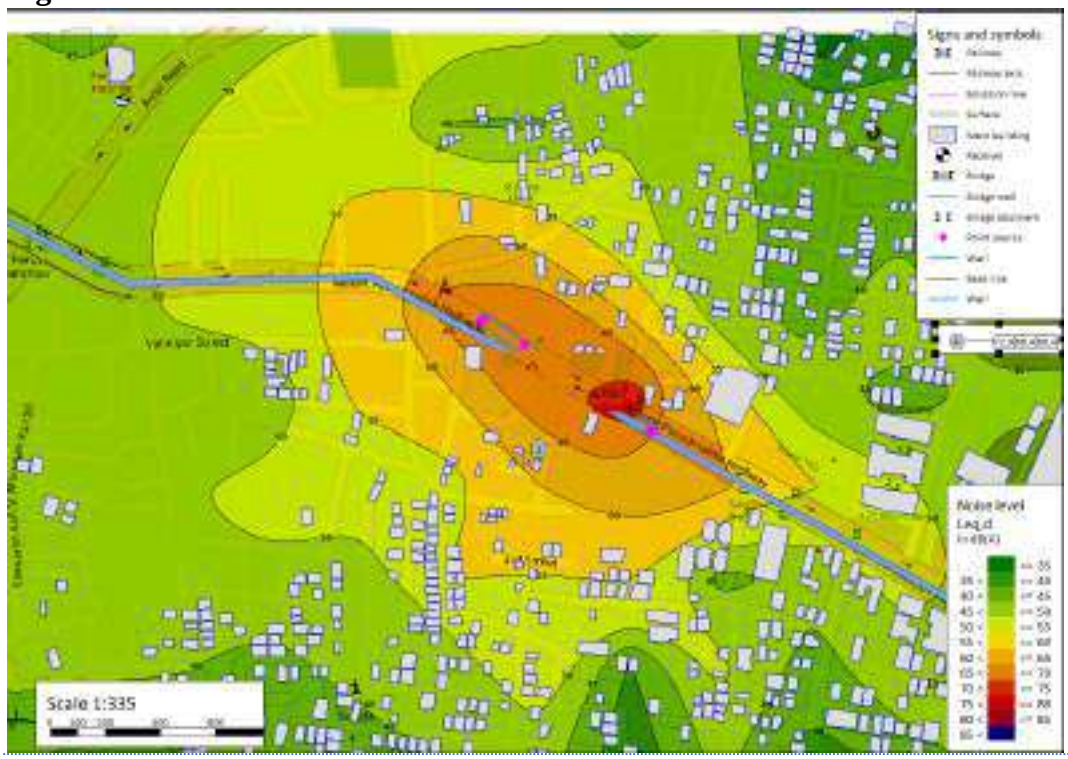


Figure 6-21: Noise contour maps for Construction phase (CTC to St. Wesley Church).

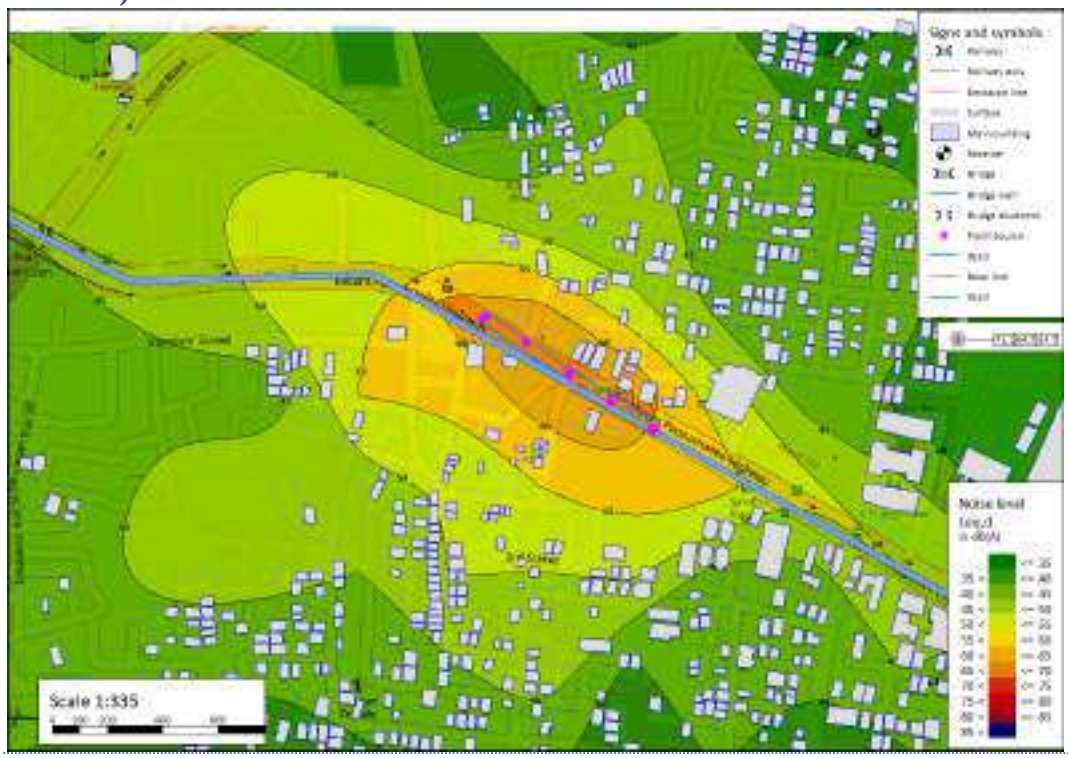


Figure 6-22: St. Joseph School - After Mitigation - Noise contour maps for Construction phase

6.3 CONSTRUCTION PHASE NOISE ASSESSMENT AT RESIDENTIAL RECEPTORS

6.3.1 CONSTRUCTION – PILING HR-1

Table 6-8: Construction Noise During Piling Operation- HR 1

ID	HR1							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	71	65	90	90	90	87	87	87
Floor								
1st	65	57	90	90	90	87	87	87
2nd	61	57	91	91	91	90	90	90
3rd	60	53	92	92	92	91	91	91
4th	62	56	93	93	93	93	93	93
5th	64	59	93	93	93	94	94	94

Table 6-9: Construction Noise During Piling Operation- HR 2

ID	HR2							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	69	61	92	92	92	85	85	85
Floor								
1st	64	54	92	92	92	85	85	85
2nd	66	56	94	94	94	87	87	87
3rd	62	54	94	94	94	90	90	90
4th	61	54	95	95	95	90	90	90
5th	63	57	95	95	95	93	93	93
6th	62	54	94	94	94	94	94	94
7th	63	54	94	94	94	94	94	94
8th	62	54	94	94	94	94	94	94
9th	64	54	94	94	94	94	94	94
10th	62	56	94	94	94	94	94	94
11th	64	54	93	93	93	93	93	93
12th	63	56	93	93	93	93	93	93
13th	61	55	93	93	93	93	93	93

Table 6-10: Construction Noise During footing Operation- HR-2

ID	HR1							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				No-Impact	Impact		No-Impact	No-Impact
Noise Level	71	65	68	73	70	65	72	68
Floor								
1st	65	57	68	70	68	65	68	66
2nd	61	57	69	70	70	68	69	68
3rd	60	53	71	71	71	69	70	69

4th	62	56	71	72	71	72	72	72
5th	64	59	71	72	71	73	73	73

Table 6-11: Construction Noise During footing Operation – HR -2

ID	**HR2**							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		No-Impact	Impact
Noise Level	69	61	70	72	70	64	70	65
Floor								
1st	64	54	70	71	70	64	67	64
2nd	66	56	72	73	72	66	69	66
3rd	62	54	73	73	73	68	69	68
4th	61	54	73	73	73	69	69	69
5th	63	57	73	73	73	71	72	71
6th	62	54	73	73	73	73	73	73
7th	63	54	73	73	73	73	73	73
8th	62	54	72	73	72	72	73	72
9th	64	54	72	73	72	72	73	72
10th	62	56	72	72	72	72	72	72
11th	64	54	72	72	72	72	72	72
12th	63	56	72	72	72	71	72	72
13th	61	55	71	72	71	71	72	71

There would be a significant increase during the construction Noise in particular to the piling operation. As per the DPR, the piling operation would be short term, few hours in a day and therefore the significant of the noise disturbance is not continuous. A conservative assessment of 110 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3 meter wall was able to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

Figure 6-23: Receiver Location HR-1 and HR-2

The succeeding Figures present the noise contour maps without and with the 3-meter - noise walls during in-situ piling and footing.

Figure 6-24: Construction Phase-Piling at HR-1 and HR-2- Day Time – No Mitigation

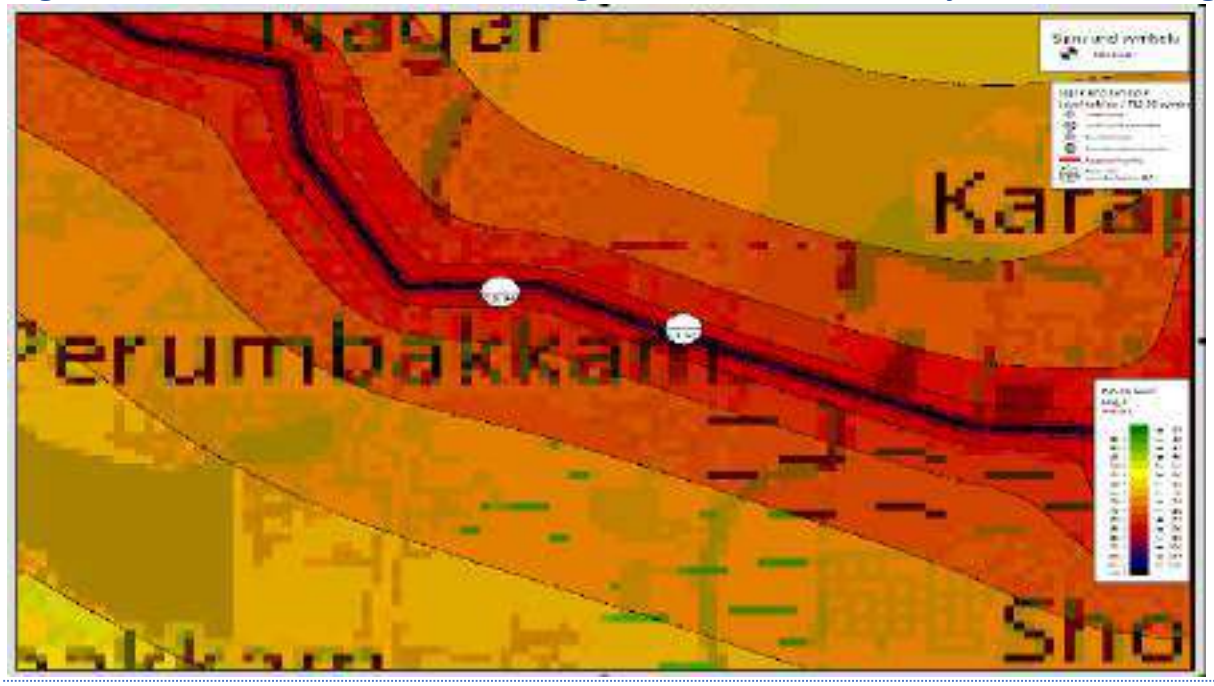
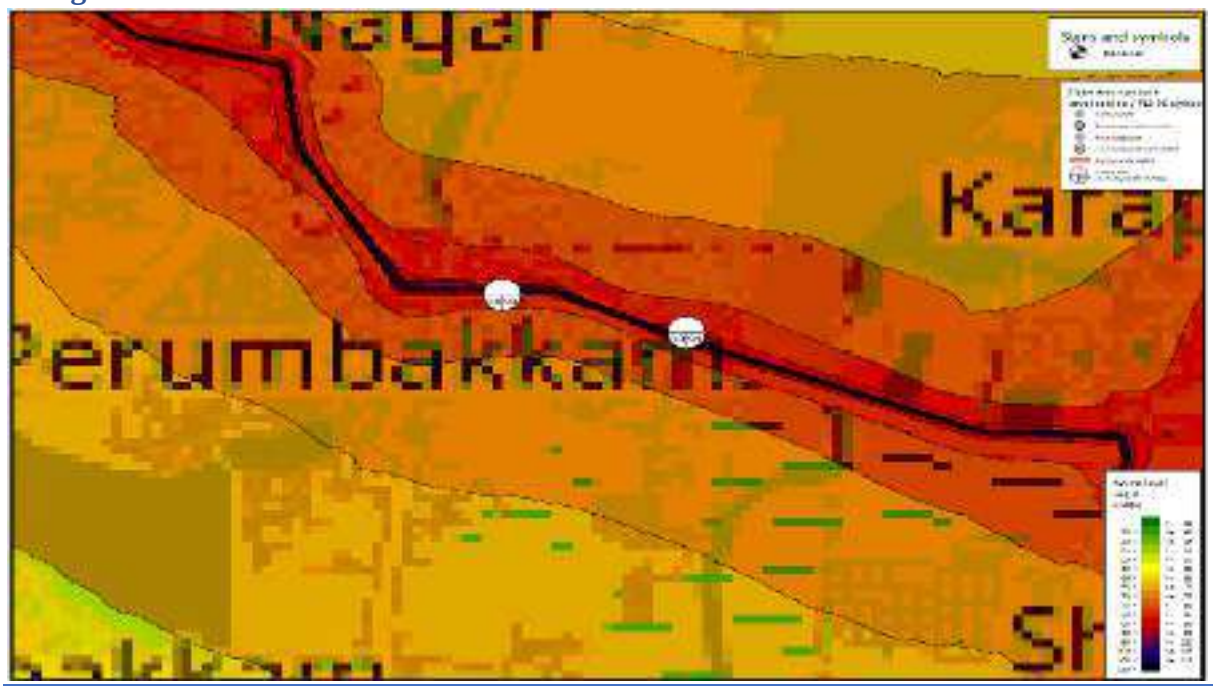


Figure 6-25: Construction Phase-Piling at HR-1 and HR-2- Day Time – With Mitigation



6.3.2 CONSTRUCTION – PILING HR-3

There would be a significant increase during the construction Noise in particular to the piling operation. As per the DPR, the piling operation would be short term, few hours in a day and therefore the significant of the noise disturbance is not continuous. A conservative assessment of 110 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3-meter wall was able to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

There would be a significant increase during the construction Noise in particular to the piling operation. As per the DPR, the piling operation would be short term, few hours in a day and therefore the significant of the noise disturbance is not continuous. A conservative assessment of 110 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3 meter wall was able to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

Table 6-12: Construction Noise During Piling Operation- HR 3

ID	HR3							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	66	60	103	103	103	91	91	91
Floor								
1st	68	58	103	103	103	91	91	91
2nd	64	58	102	102	102	100	100	100
3rd	66	58	101	101	101	101	101	101
4th	62	56	100	100	100	99	99	99

Table 6-13: Construction Noise During footing Operation- HR 3

ID	HR3							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	66	60	81	81	81	69	71	70
Floor								
1st	68	58	81	81	81	69	71	69
2nd	64	58	80	80	80	78	78	78
3rd	66	58	79	79	79	80	80	80
4th	62	56	78	78	78	78	78	78

Figure 6-26: Receiver Location HR-3

The succeeding Figures present the noise contour maps without and with the 3-meter noise walls during in-situ piling and footing.

Figure 6-27: Construction Phase-Piling at HR-3,– Day Time- No Mitigation

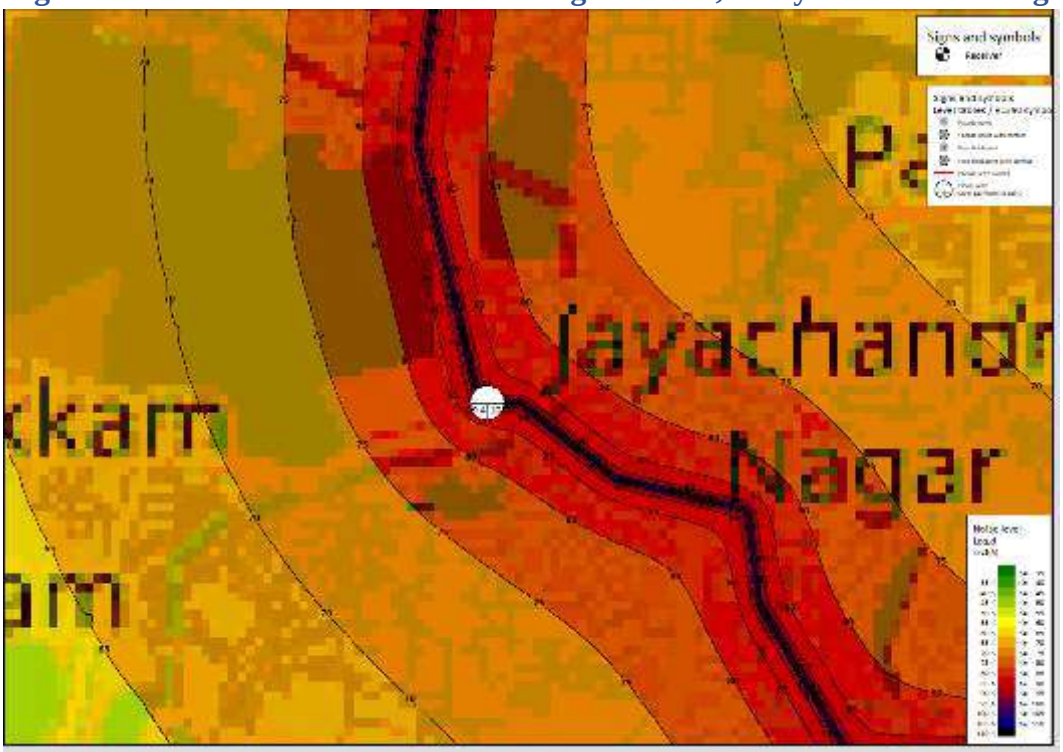


Figure 6-28: Construction Phase-Piling at HR-3– Day Time- with Mitigation

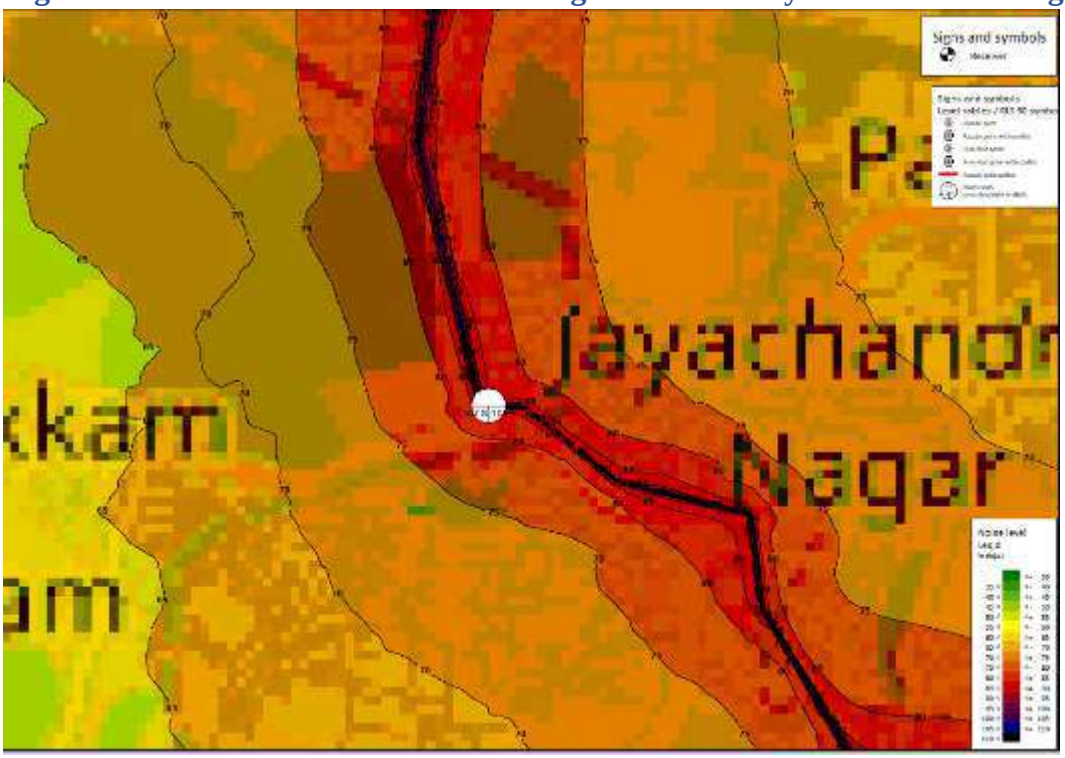


Figure 6-29: Construction Phase-Footing at HR-3– Day Time- No Mitigation

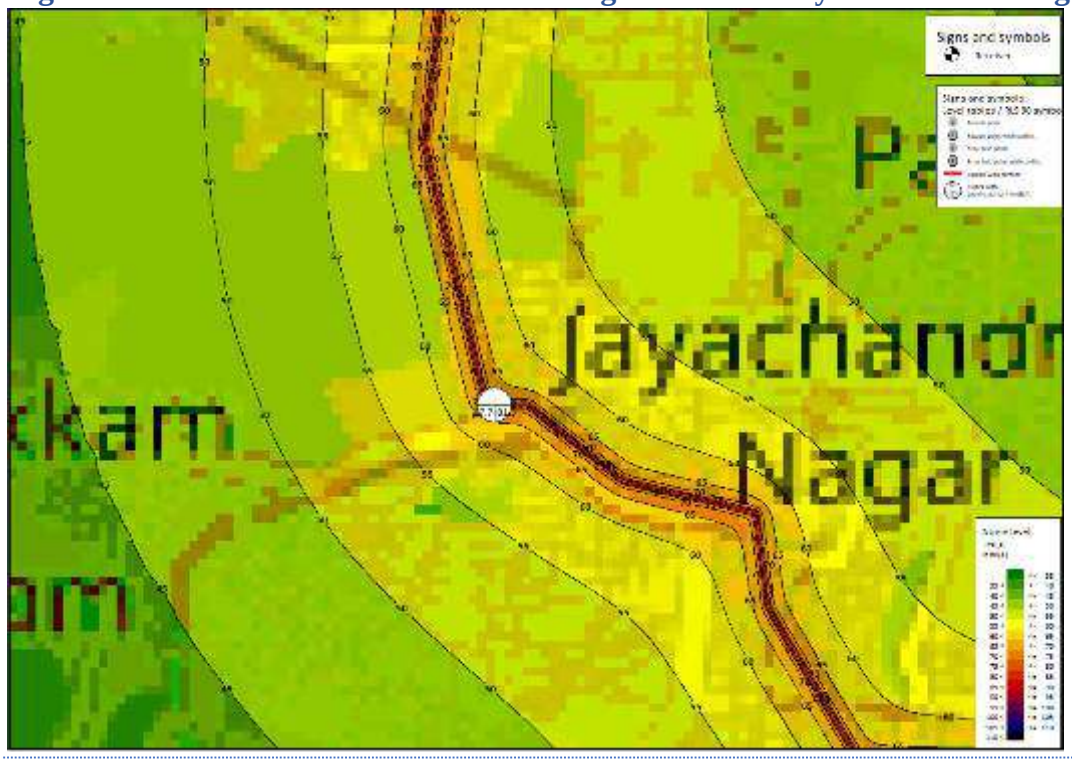
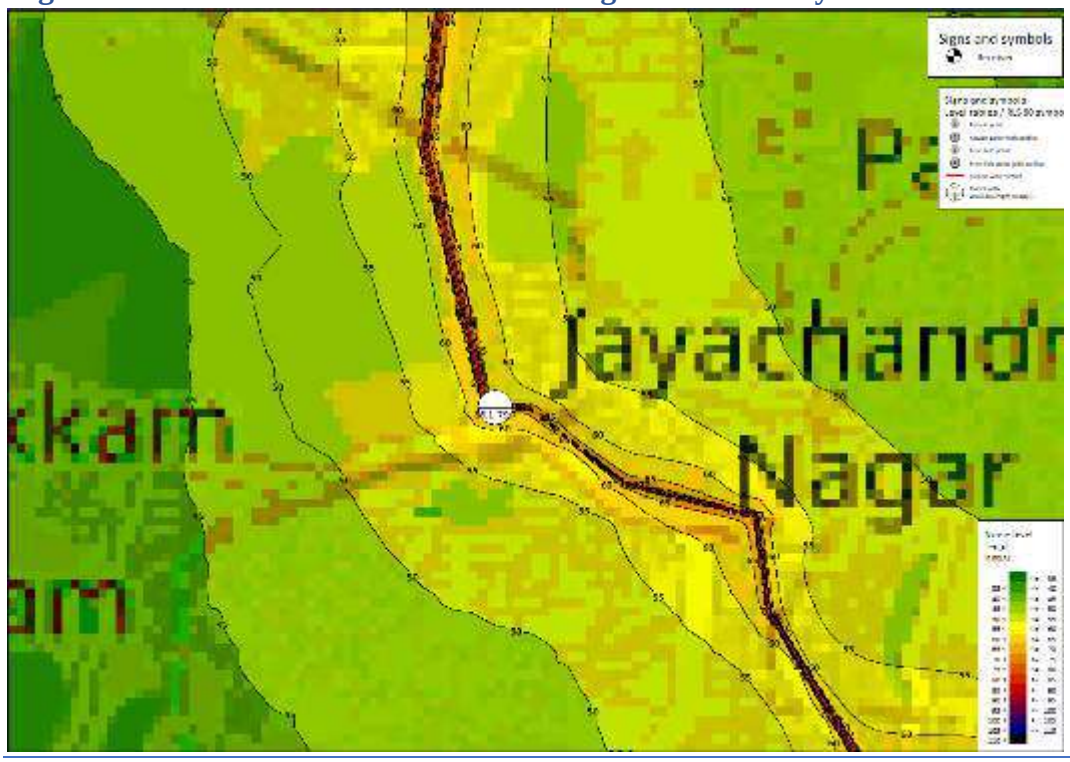


Figure 6-30: Construction Phase-Footing at HR-3– Day Time- with Mitigation



6.3.3 CONSTRUCTION – PILING HR-4

There would be a significant increase during the construction Noise in particular to the piling operation. As per the DPR, the piling operation would be short term, few hours in a day and therefore the significant of the noise disturbance is not continuous. A conservative assessment of 110 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3-meter wall was able

to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

There would be a significant increase during the construction Noise in particular to the piling operation. As per the DPR, the piling operation would be short term, few hours in a day and therefore the significant of the noise disturbance is not continuous. A conservative assessment of 110 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3 meter wall was able to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

Table 6-14: Construction Noise During Piling Operation- HR 4

ID	HR4							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		No-Impact	Impact
Noise Level	63	56	89	89	89		63	61
Floor								
1st	60	50	89	89	89	85	85	85
2nd	62	52	90	90	90	87	87	87
3rd	63	52	91	91	91	88	88	88
4th	62	52	92	92	92	89	89	89
5th	63	53	92	92	92	91	91	91

Table 6-15: Construction Noise During footing Operation- HR 4

ID	HR4							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	63	56	67	69	67	63	66	65
Floor								
1st	60	50	67	68	67	63	65	64
2nd	62	52	68	69	68	65	67	65
3rd	63	52	69	70	69	66	68	66
4th	62	52	70	71	70	67	68	67
5th	63	53	70	71	70	69	70	69

Figure 6-31: Receiver Location HR-4

The succeeding Figures present the noise contour maps without and with the 3-meter noise walls during in-situ piling and footing.

Figure 6-32: Construction Phase-Piling at HR-4– Day Time- No Mitigation

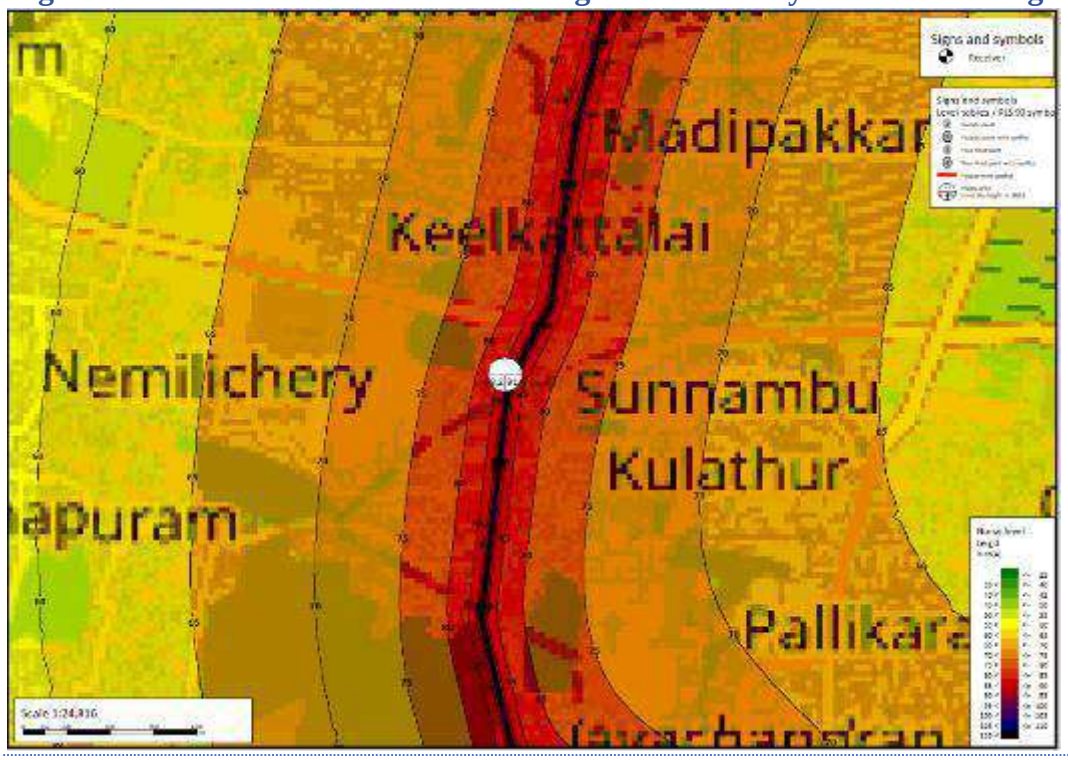


Figure 6-33: Construction Phase-Piling at HR-4– Day Time- with Mitigation

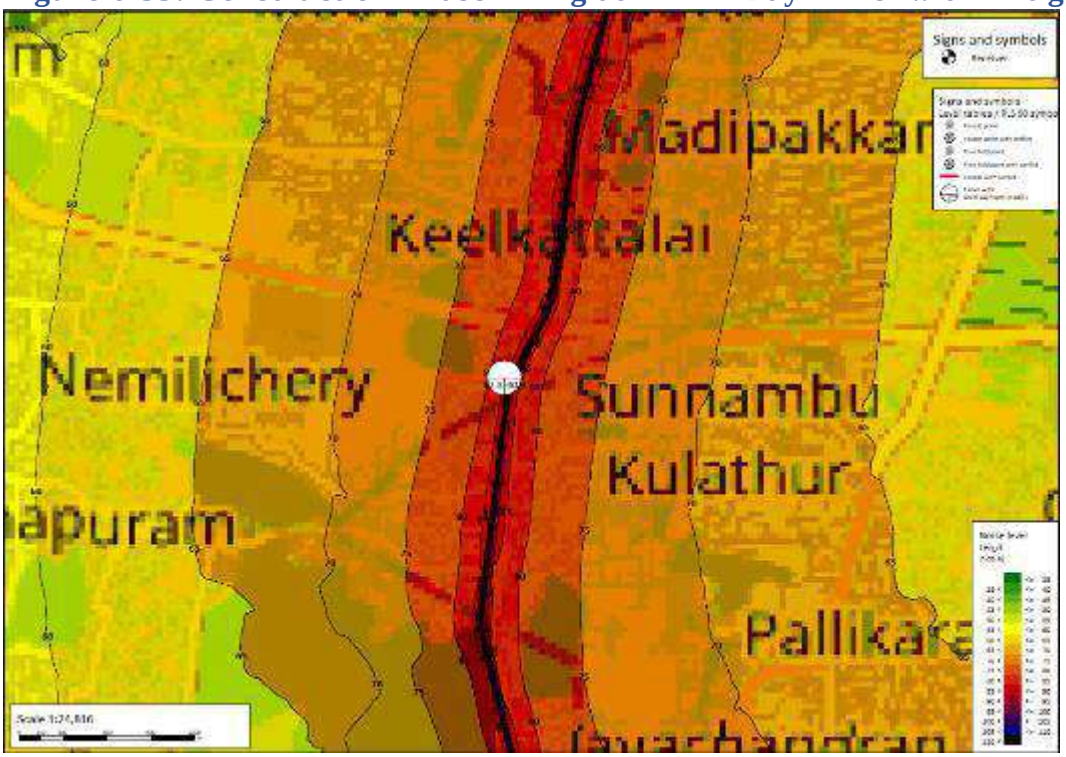


Figure 6-34: Construction Phase-Footing at HR-4– Day Time- No Mitigation

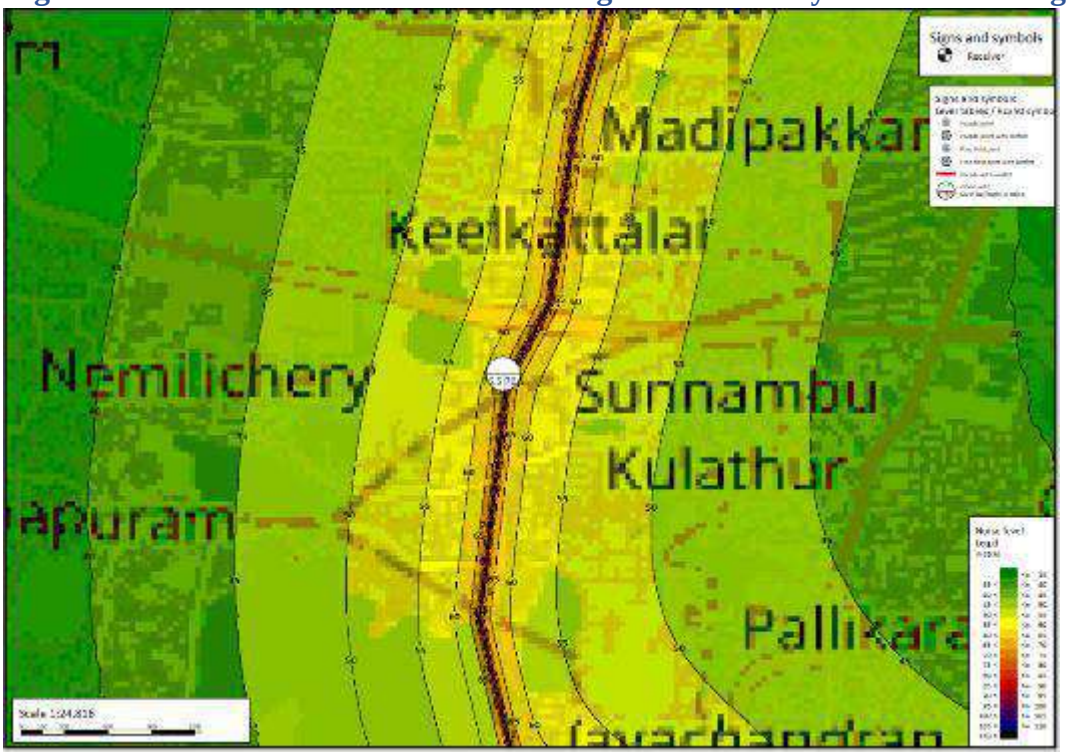
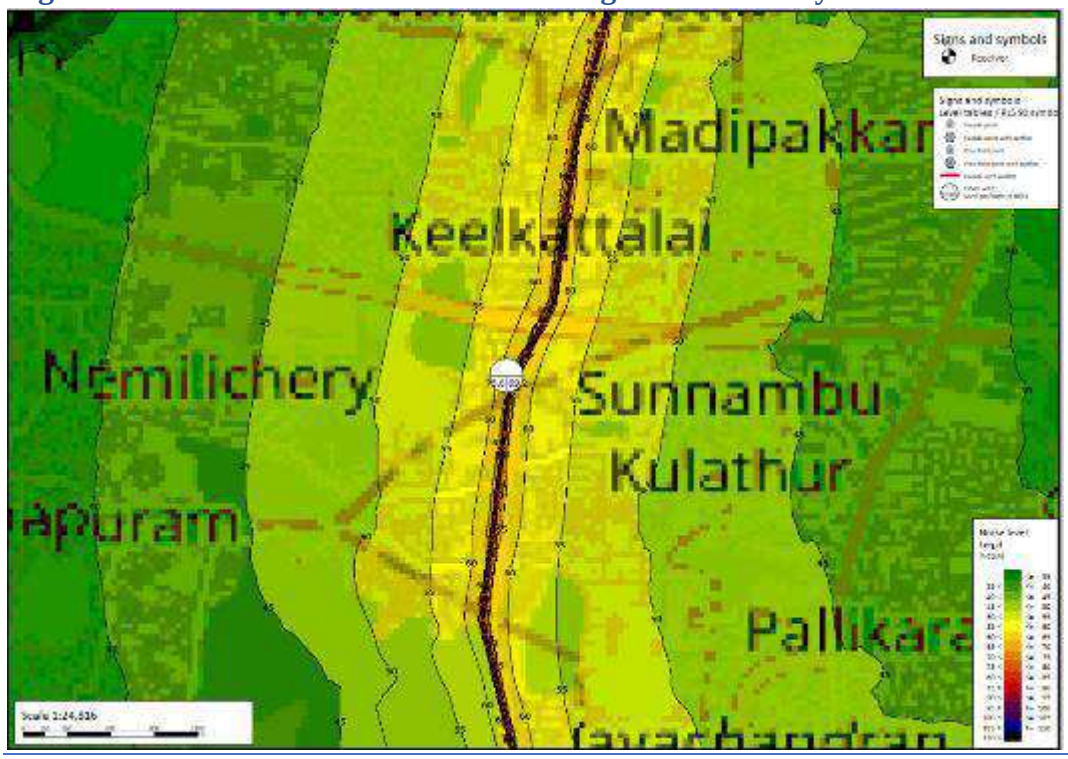


Figure 6-35: Construction Phase-Footing at HR-4– Day Time- with Mitigation



6.3.4 CONSTRUCTION – PILING HR-5, HR-6, HR-7, HR-8 AND HR-9

There would be a significant increase during the construction Noise in particular to the piling operation. As per the DPR, the piling operation would be short term, few hours in a day and therefore the significant of the noise disturbance is not continuous. A conservative assessment of 110 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3-meter wall was able

to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

There would be a significant increase during the construction Noise in particular to the piling operation. As per the DPR, the piling operation would be short term, few hours in a day and therefore the significant of the noise disturbance is not continuous. A conservative assessment of 110 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3 meter wall was able to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

Table 6-16: Construction Noise During Piling Operation- HR 5

ID	HR5							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	66	61	85	85	85	87	87	87
Floor								
1st	64	57	85	85	85	87	87	87
2nd	64	58	86	86	86	87	87	87
3rd	64	58	86	86	86	86	86	86

Table 6-17: Construction Noise During footing Operation- HR 5

ID	HR5							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		No-Impact	Impact
Noise Level	66	61	85	85	85	65	69	66
Floor								
1st	64	57	85	64	85	65	67	65
2nd	64	58	86	64	86	65	68	65
3rd	64	58	86	65	86	64	67	65

Table 6-18: Construction Noise During Piling Operation- HR 6

ID	HR-6							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	67	64	90	90	90	87	87	87
Floor								
1st	63	55	90	90	90	87	87	87
2nd	67	57	91	91	91	89	89	89

Table 6-19: Construction Noise During footing Operation- HR 6

ID	HR-6							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		No-Impact	No-Impact
Noise Level	67	64	68	71	70	65	69	66

Floor								
1st	63	55	68	69	68	65	67	65
2nd	67	57	70	71	70	67	70	67

Table 6-20: Construction Noise During Piling Operation- HR 7

ID	HR-7							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				No-Impact	No-Impact		Impact	Impact
Noise Level	69.4	62.8		69	63	69	72	70
Floor								
1st	60.7	53.6	88.5	89	89	84	84	84
2nd	59.1	53.1	89.3	89	89	86	86	86
3rd	62	52.9	90.2	90	90	87	87	87
4th	60.8	55.5	91	91	91	88	88	88
5th	65.6	57.8	91.5	92	92	89	89	89
6th	64.8	56.9	91.7	92	92	91.1	91	91
7th	65.3	57.7	91.8	92	92	91.7	92	92
8th	65.2	57.7	91.8	92	92	91.8	92	92

Table 6-21: Construction Noise During footing Operation- HR 7

ID	HR-7							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
Status				No-Impact	Impact		No-Impact	No-Impact
Noise Level	69	63	67	71	68	63	70	65
Floor								
1st	61	54	67	68	67	63	65	64
2nd	59	53	68	68	68	64	65	65
3rd	62	53	69	69	69	66	67	67
4th	61	56	69	70	69	66	67	67
5th	66	58	70	71	70	67	69	67
6th	65	57	70	71	70	69	71	70
7th	65	58	70	71	70	70	71	70
8th	65	58	70	71	70	70	71	70

Table 6-22: Construction Noise During Piling Operation- HR 8

ID	HR8							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	64.6	60.7	90.2	90	90	93	93	93
Floor								
1st	60.5	56.5	90.2	90	90	84	84	84
2nd	61.7	57.1	91.5	92	92	85	85	85
3rd	61.2	60.5	92.7	93	93	86	86	86
4th	60.5	56.3	93.1	93	93	87	87	87
5th	60.8	57.6	93.3	93	93	88	88	88

6th	61.7	57.9	93.3	93	93	89	89	89
7th	63.4	58.9	93.2	93	93	89.4	89	89
8th	64.7	59.9	93.1	93	93	90	90	90
9th	64.3	61	93	93	93	91.7	92	92
10th	63.2	61.2	92.9	93	93	92.8	93	93
11th	61.5	57.4	92.7	93	93	92.7	93	93
12th	61.1	56.9	92.6	93	93	92.6	93	93

Table 6-23: Construction Noise During footing Operation- HR 8

ID	**HR8**							
	Ambient Noise		**Construction - No Mitigation**			**Construction - With Wall**		
			Predicted	**Final Noise**		**Predicted**	**Final Noise**	
Status				**Impact**	**Impact**		**No-Impact**	**Impact**
Noise Level	65	61	69	70	69	63	67	65
Floor								
1st	61	57	69	69	69	63	65	63
2nd	62	57	70	70	70	63	66	64
3rd	61	61	71	71	71	64	66	66
4th	61	56	71	72	72	66	67	66
5th	61	58	72	72	72	67	68	67
6th	62	58	72	72	72	67	68	68
7th	63	59	72	72	72	68	69	68
8th	65	60	71	72	72	68	70	69
9th	64	61	71	72	72	70	71	71
10th	63	61	71	72	72	71	72	72
11th	62	57	71	71	71	71	71	71
12th	61	57	71	71	71	71	71	71

Table 6-24: Construction Noise During Piling Operation- HR 9

ID	**HR9**							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	67.6	62.8	91.9	92	92	88	88	88
Floor								
1st	68.5	57.9	91.9	92	92	88	88	88
2nd	67.1	59.5	93.8	94	94	90	90	90
3rd	68.4	59.9	94.5	95	95	91	91	91
4th	69.2	60.4	94.7	95	95	95	95	95

Table 6-25: Construction Noise During footing Operation- HR 9

ID	**HR9**							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
Status				Impact	Impact		No-Impact	Impact
Noise Level	68	63	70	72	71	66	70	67
Floor								
1st	69	58	70	72	70	66	70	66
2nd	67	60	72	73	72	68	71	69
3rd	68	60	73	74	73	69	72	70
4th	69	60	73	75	73	73	74	73

Figure 6-36: Receiver Location HR-5, HR-6, HR-7, HR-8 and HR-9

The succeeding Figures present the noise contour maps without and with the 3-meter noise walls during in-situ piling and footing.

Figure 6-37: Construction Phase-Piling at HR-5, HR-6, HR-7, HR-8 and HR-9– Day Time- No Mitigation

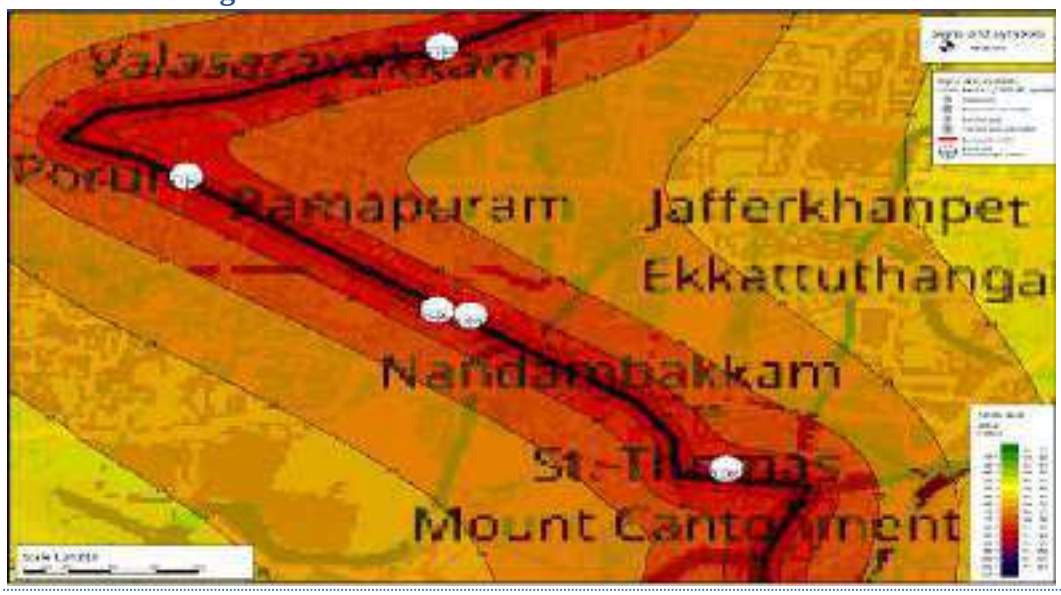


Figure 6-38: Construction Phase-Piling at HR-5– Day Time- with Mitigation

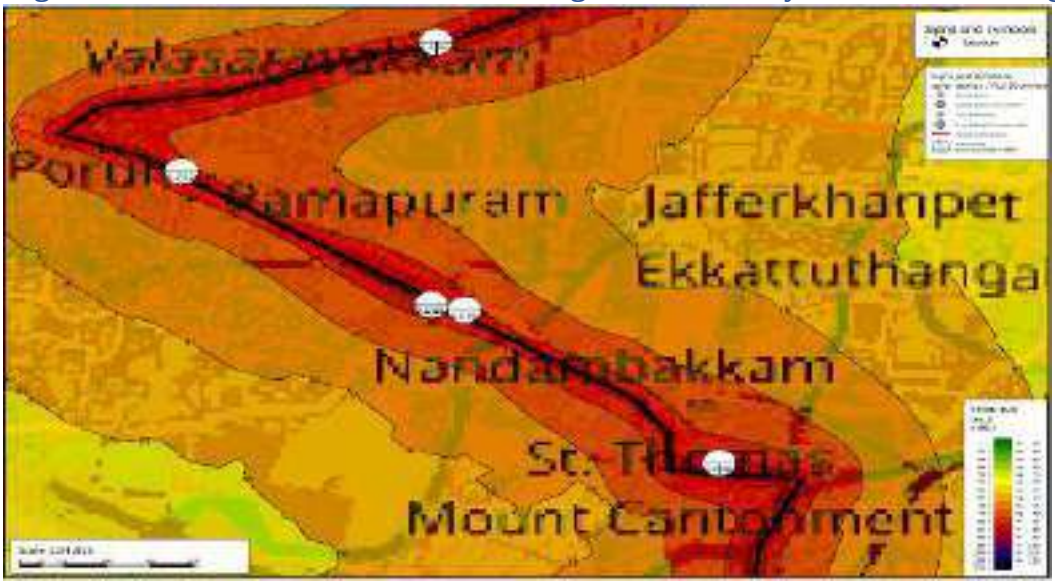


Figure 6-39: Construction Phase-Footing at HR-5, HR-6, HR-7, HR-8 and HR-9– Day Time- No Mitigation

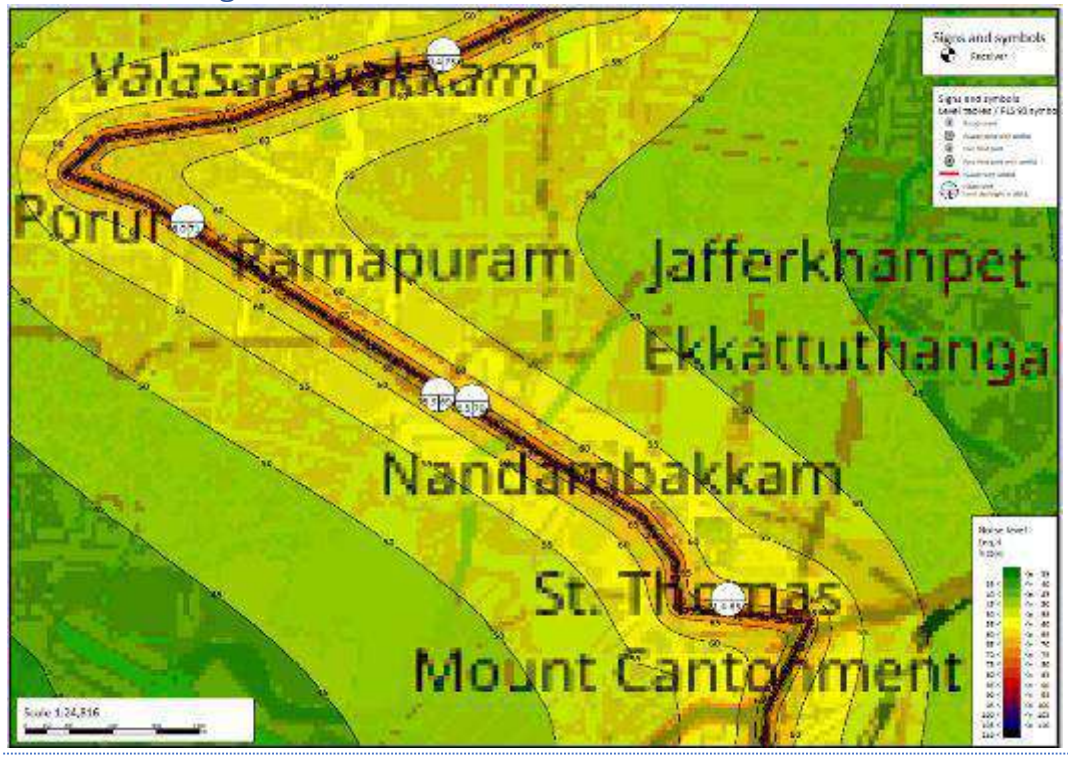
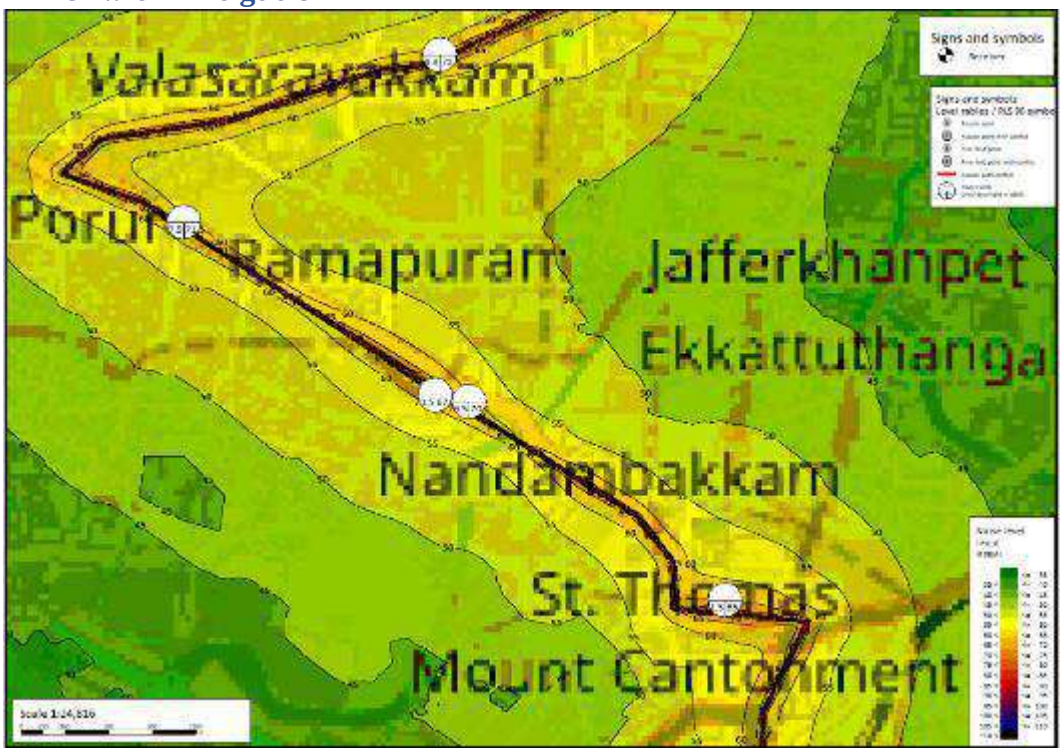


Figure 6-40: Construction Phase-Footing at HR-5, HR-6, HR-7, HR-8 and HR-9– Day Time- with Mitigation



6.3.5 CONSTRUCTION – PILING HR-10

There would be a significant increase during the construction Noise in particular to the piling operation. As per the DPR, the piling operation would be short term, few hours in a day and therefore the significant of the noise disturbance is not continuous. A conservative assessment of 110 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3-meter wall was able to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

There would be a significant increase during the construction Noise in particular to the piling operation. As per the DPR, the piling operation would be short term, few hours in a day and therefore the significant of the noise disturbance is not continuous. A conservative assessment of 110 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3 meter wall was able to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

Table 6-26: Construction Noise During Piling Operation- HR 10

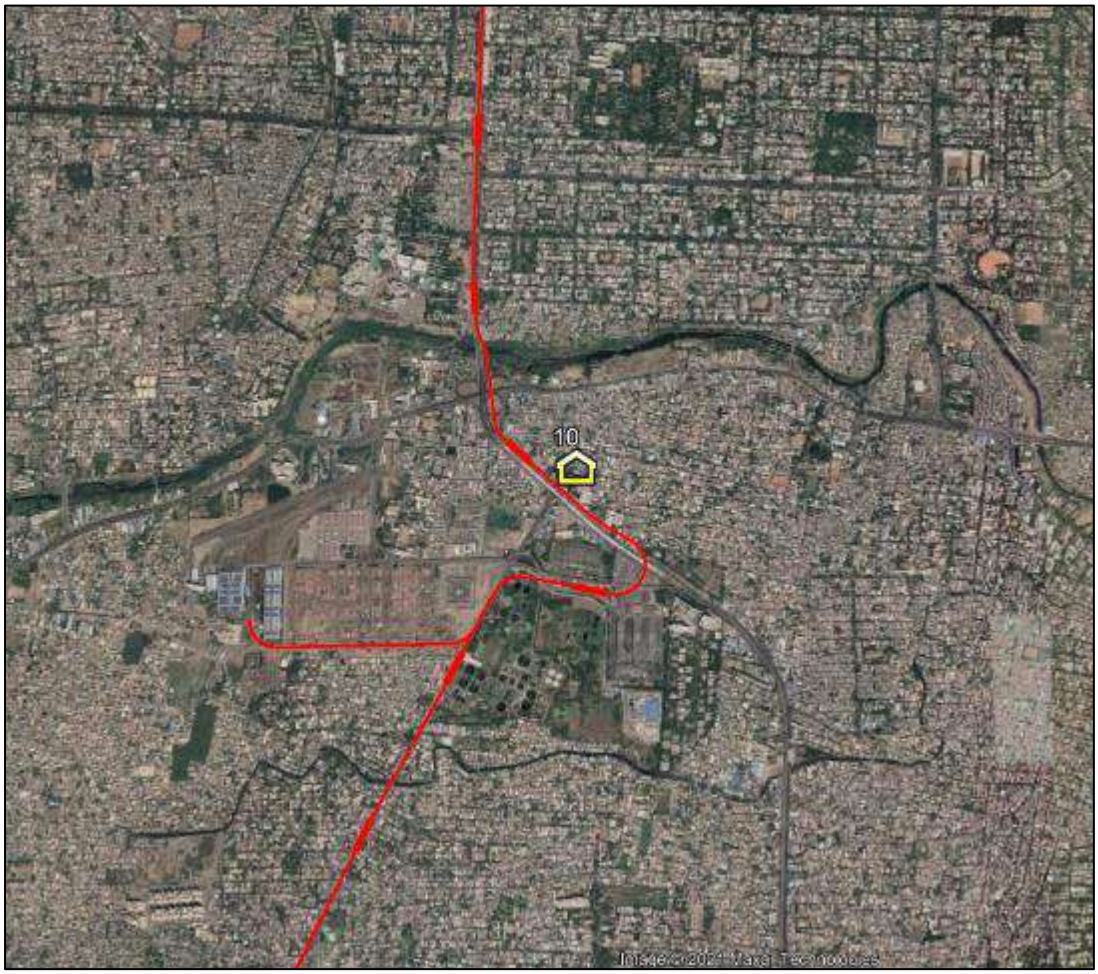
ID	HR10							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	68.2	59.8	86	86	86	89	89	89
Floor								
1st	67.1	56.4	86	86	86	81	82	81
2nd	65.7	54.9	86.4	86	86	82	82	82
3rd	66.8	55.1	86.9	87	87	83	83	83
4th	68.4	54.9	87.3	87	87	83	83	83
5th	68.4	55.8	87.8	88	88	84	84	84
6th	68	56.1	88.2	88	88	84.3	84	84
7th	69.2	54.9	88.7	89	89	84.8	85	85
8th	68.5	55.1	89	89	89	85.2	85	85
9th	67.9	55.5	89.2	89	89	85.6	86	86
10th	67	55	89.3	89	89	85.8	86	86
11th	67.5	56.2	89.4	89	89	85.9	86	86
12th	67	57.1	89.4	89	89	86.1	86	86
13th	62.9	56.5	89.4	89	89	86.6	87	87
14th	66.1	55.8	89.4	89	89	87.6	88	88
15th	66.9	54.9	89.4	89	89	88.6	89	89

Table 6-27: Construction Noise During footing Operation- HR 10

ID	HR10							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
Status				No-Impact	Impact		No-Impact	Impact
Noise Level	68	60	64	70	66	60	69	63
Floor								
1st	67	56	64	69	65	60	68	61
2nd	66	55	65	68	65	60	67	62
3rd	67	55	65	69	66	61	68	64
4th	68	55	66	70	66	62	69	63
5th	68	56	66	70	66	62	69	63

ID	HR10							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
Status				No-Impact	Impact		No-Impact	Impact
6th	68	56	67	70	67	63	69	64
7th	69	55	67	71	67	63	70	64
8th	69	55	67	71	68	64	70	65
9th	68	56	68	71	68	64	69	66
10th	67	55	68	70	68	64	69	66
11th	68	56	68	71	68	64	69	65
12th	67	57	68	70	68	64	69	65
13th	63	57	68	69	68	65	67	65
14th	66	56	68	70	68	66	69	66
15th	67	55	68	70	68	67	70	67

Figure 6-41: Receiver Location HR-10



The succeeding Figures present the noise contour maps without and with the 3-meter noise walls during in-situ piling and footing.

Figure 6-42: Construction Phase-Piling at HR-10– Day Time- No Mitigation

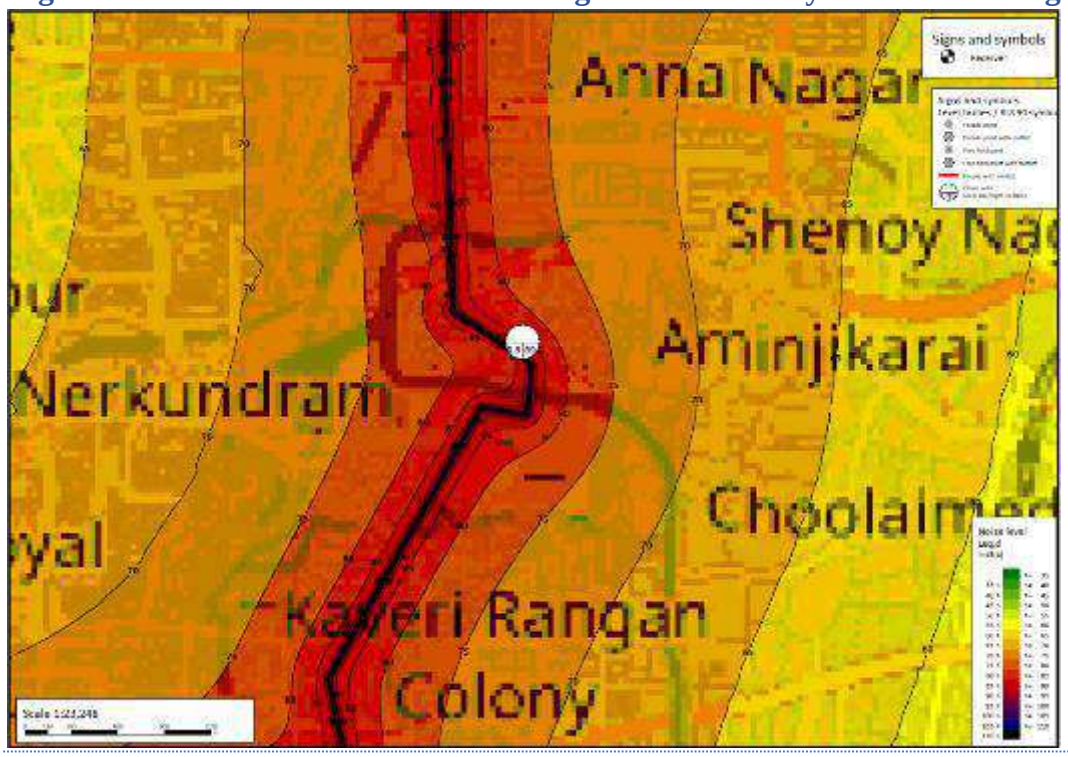


Figure 6-43: Construction Phase-Piling at HR-10– Day Time- with Mitigation

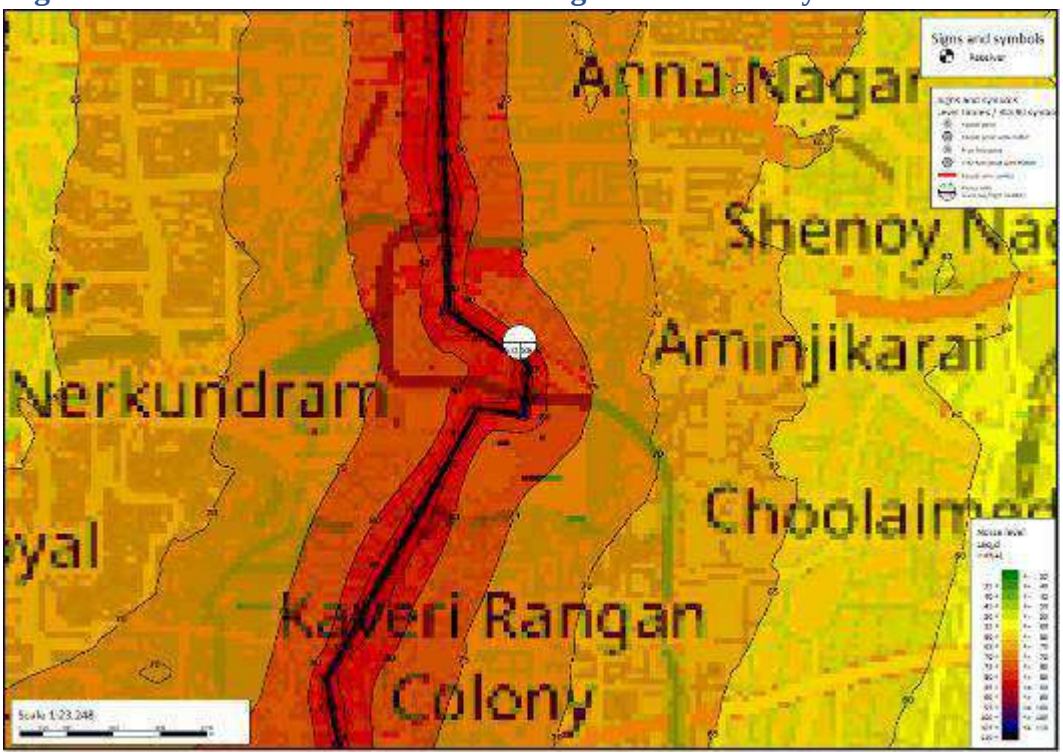


Figure 6-44: Construction Phase-Footing at HR-10– Day Time- No Mitigation

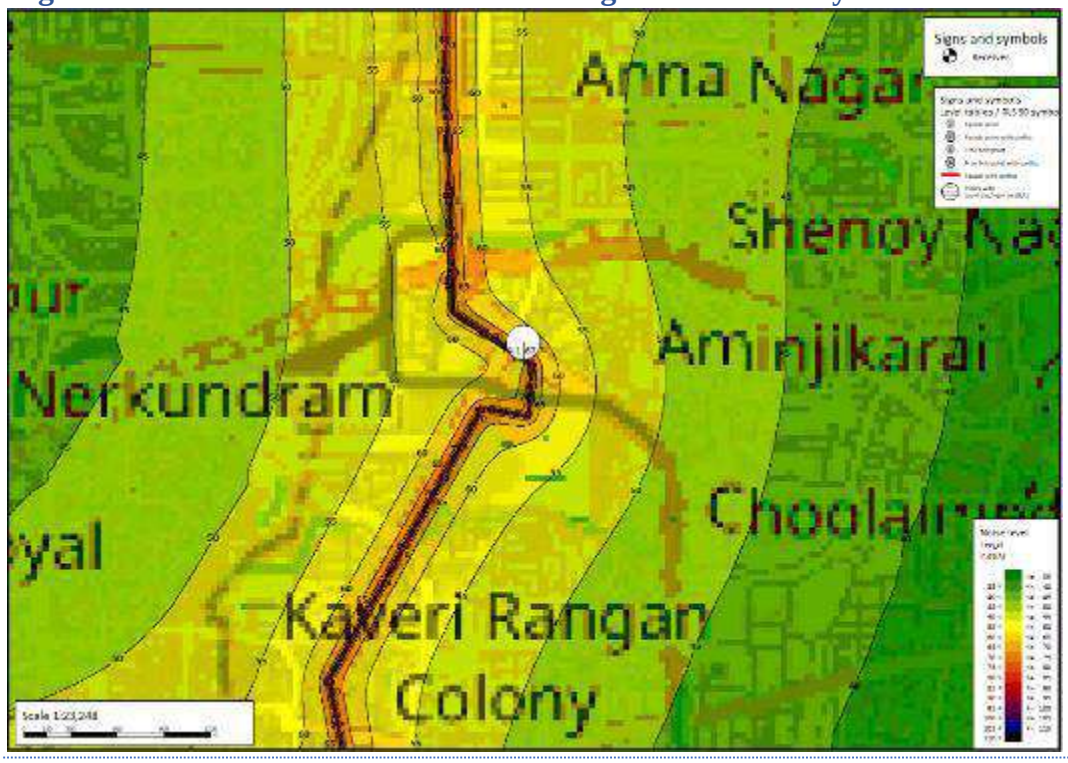
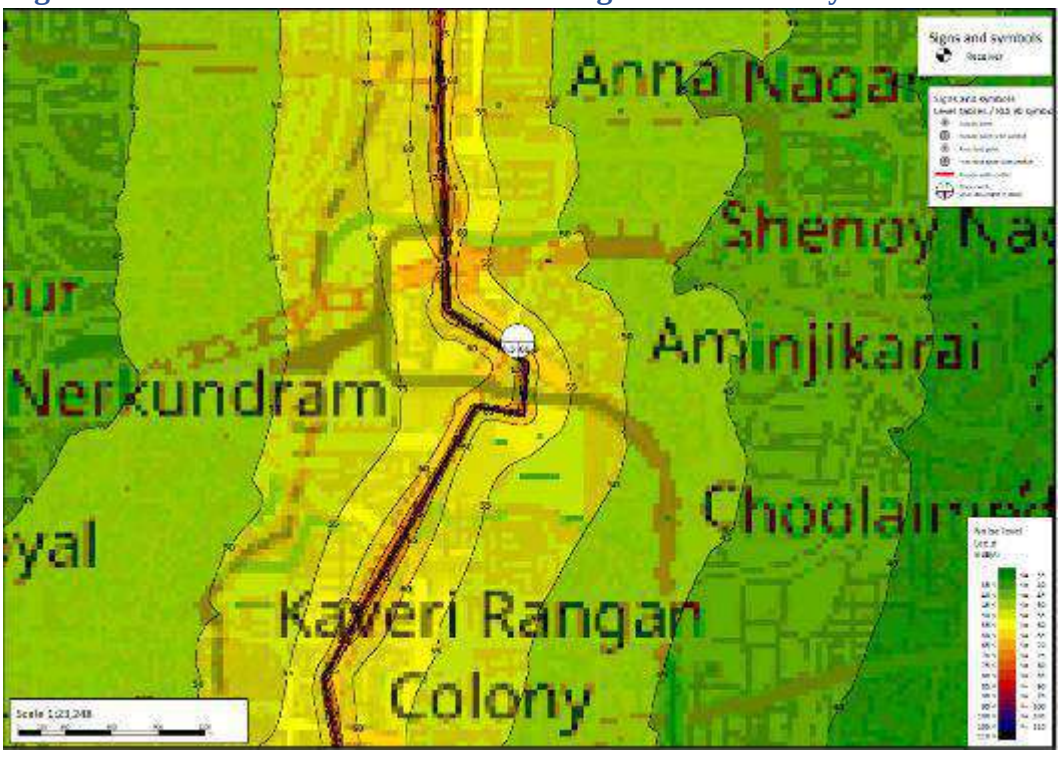


Figure 6-45: Construction Phase-Footing at HR-10– Day Time- with Mitigation



6.3.6 CONSTRUCTION – PILING HR-11

It is to be noted that piling operation would not be conducted near HR-7 and 8 as the metro line near the receivers are underground therefore only TBM would be conducted. If at all any operation would be conduction would be the regular construction operation. A conservative assessment of 90 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3-meter wall was able to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

Figure 6-46: Receiver Location HR-11

The succeeding Figures present the noise contour maps without and with the 3-meter noise walls during in-situ piling and footing.

Table 6-28: Construction Noise During Piling Operation- HR 11

ID	HR11							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	60.6	54.6	90.4	90	90	93	93	93
Floor								
1st	62.2	55	90.4	90	90	82	82	82
2nd	62.5	55.8	91.6	92	92	83	83	83
3rd	62.7	57.4	92.9	93	93	84	84	84

Table 6-29: Construction Noise During footing Operation- HR 11

ID	HR11							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
Status				Impact	Impact		Impact	Impact
Noise Level	61	55	69	69	69	61	64	64
Floor								
1st	62	55	69	70	69	61	65	62
2nd	63	56	70	71	70	62	65	63
3rd	63	57	71	72	71	62	66	65

Figure 6-47: Construction Phase-Piling at HR-11– Day Time- No Mitigation

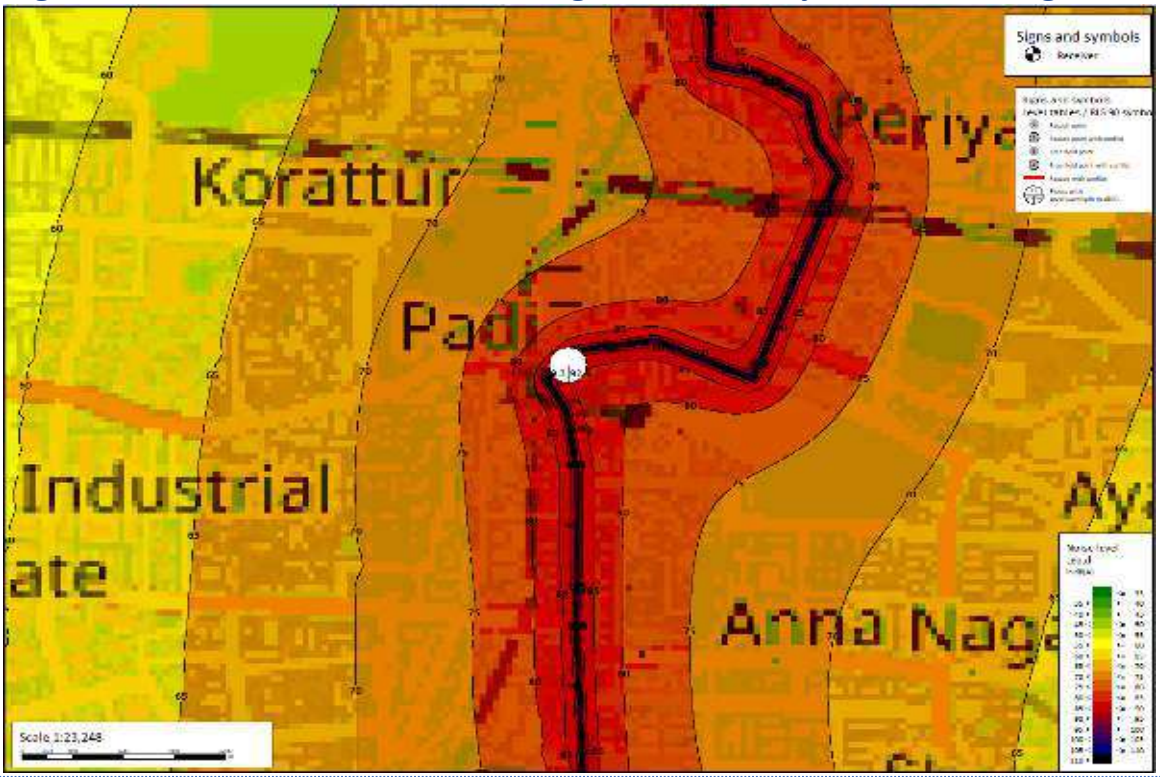


Figure 6-48: Construction Phase-Piling at HR-11– Day Time- with Mitigation

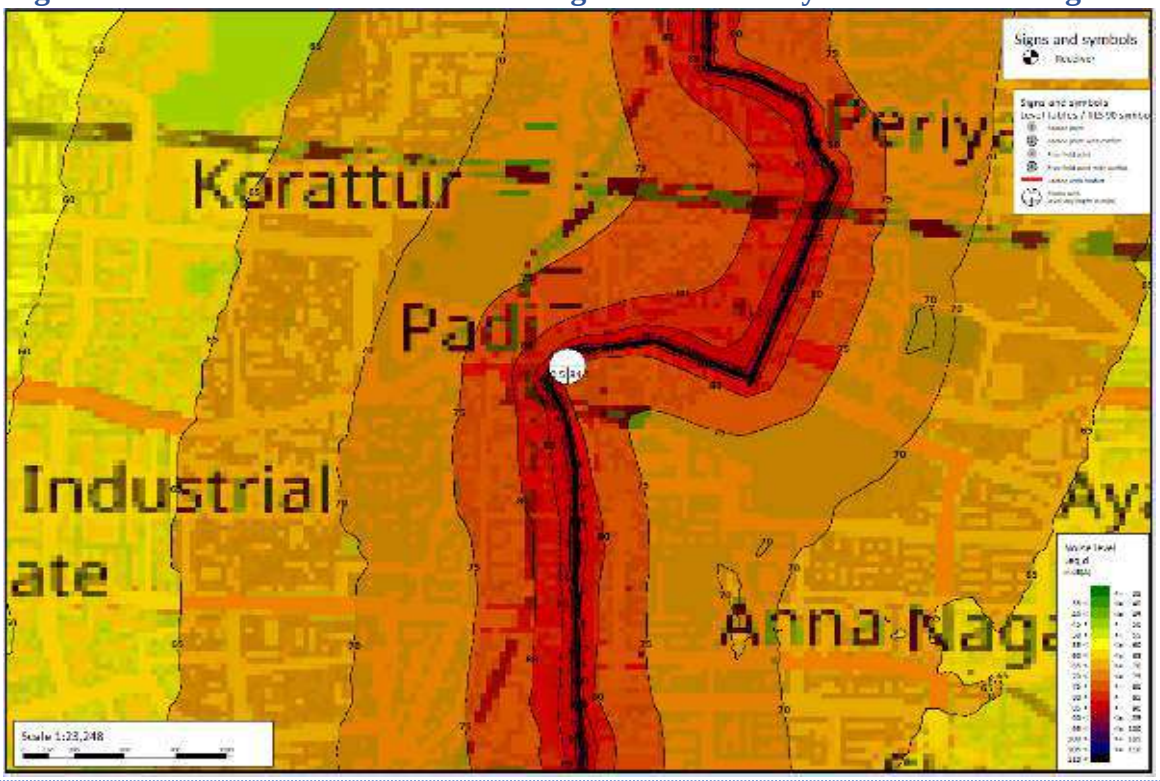


Figure 6-49: Construction Phase-Piling at HR-11– Day Time- No Mitigation

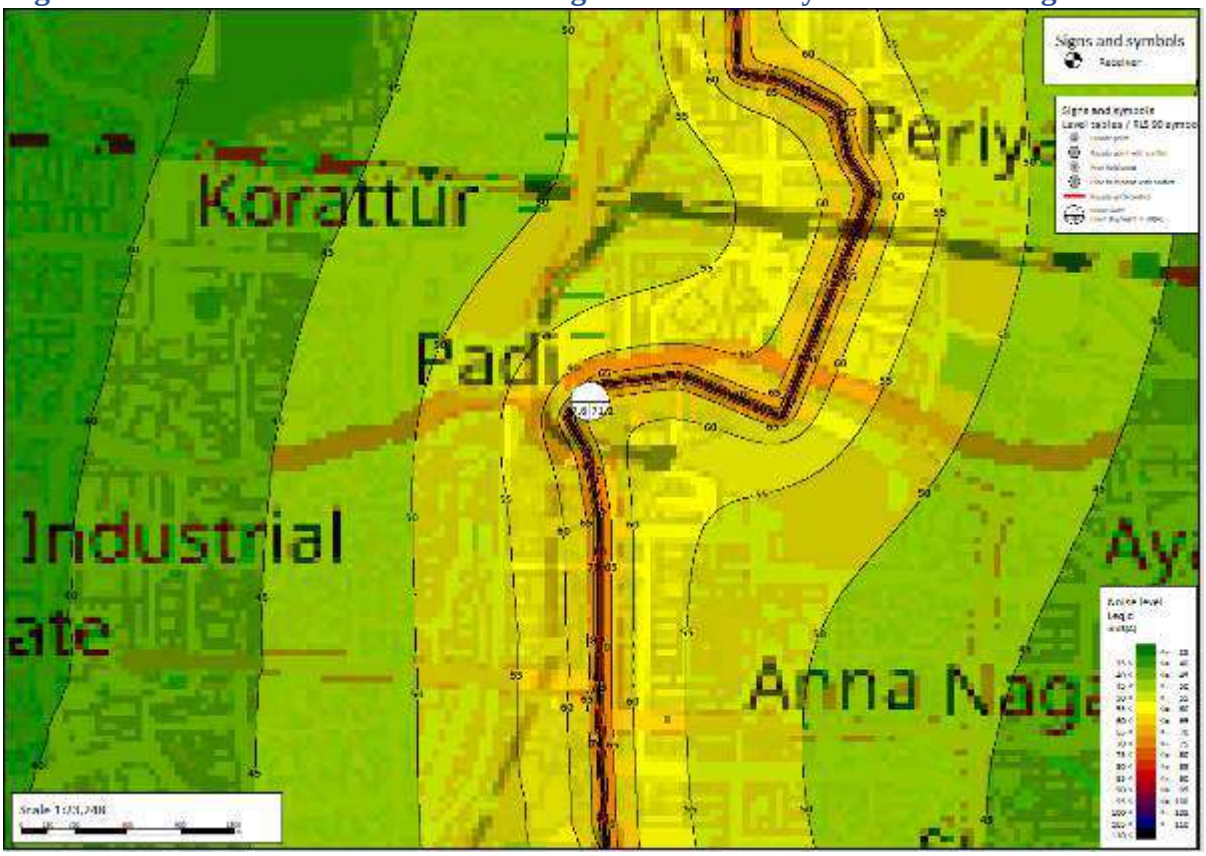
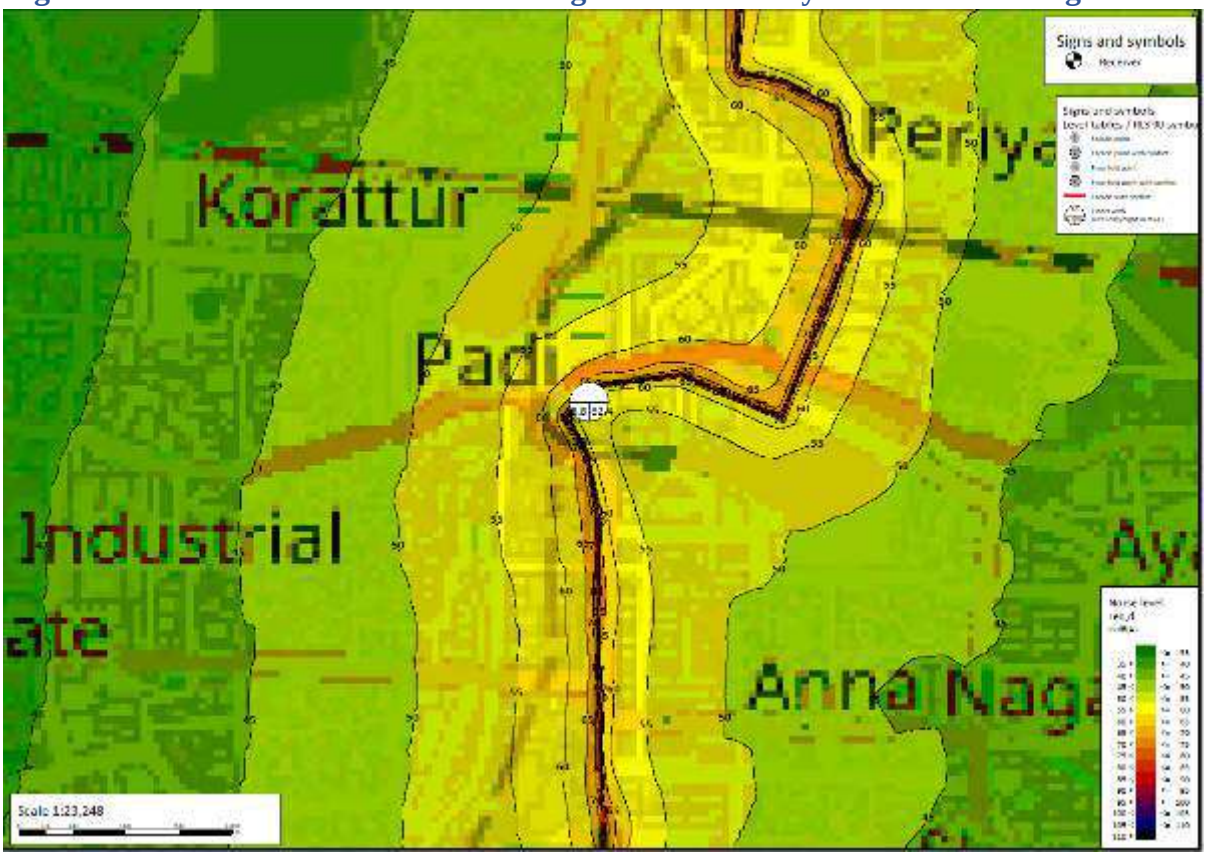


Figure 6-50: Construction Phase-Piling at HR-11– Day Time- with Mitigation Wall



6.3.7 CONSTRUCTION – PILING HR-12

It is to be noted that piling operation would not be conducted near HR-12 as the metro line near the receivers are underground therefore only TBM would be conducted. If at all any operation would be conduction would be the regular construction operation. A conservative assessment of 90 dBA and in addition an allowance of 3 dBA was added to the final noise. The 3-meter wall was able to reduce the loudness factor but due to the location of the receiver below 50 m from the noise source, there is not a significant reduction in the noise level.

Figure 6-51: Receiver Location HR-12

The succeeding Figures present the noise contour maps without and with the 3-meter noise walls during in-situ piling and footing.

Table 6-30: Construction Noise During Piling Operation- HR 12

ID	HR12							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
	Leq d	Leq N	Leq d	Leq d	Leq N	Leq d	Leq d	Leq N
Status				Impact	Impact		Impact	Impact
Noise Level	66.5	60.8	87.2	87	87	87	87	87
Floor								
1st	64.1	56.7	87.2	87	87	87	87	87
2nd	63.5	55.8	88	88	88	88	88	88
3rd	63	55.5	88.6	89	89	89	89	89
4th	63.4	54	89.2	89	89	89	89	89
5th	64	56.8	89.9	90	90	90	90	90
6th	63.9	54.2	90.4	90	90	90.4	90	90
7th	65.5	59.7	90.6	91	91	90.6	91	91
8th	65.6	56.5	90.7	91	91	90.7	91	91
9th	64.5	59	90.7	91	91	90.7	91	91

Table 6-31: Construction Noise During footing Operation- HR 12

ID	HR12							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
Status				No-Impact	Impact		No-Impact	Impact
Noise Level	67	61	66	69	67	66	69	67
Floor								
1st	64	57	66	68	66	66	68	66
2nd	64	56	66	68	67	66	68	67
3rd	63	56	67	68	67	67	68	68

ID	HR12							
	Ambient Noise		Construction - No Mitigation			Construction - With Wall		
			Predicted	Final Noise		Predicted	Final Noise	
4th	63	54	68	69	68	68	69	68
5th	64	57	68	70	69	68	70	69
6th	64	54	69	70	69	69	70	69
7th	66	60	69	71	69	69	71	69
8th	66	57	69	71	69	69	71	70
9th	65	59	69	70	69	69	70	70

Figure 6-52: Construction Phase-Piling at HR-12– Day Time- No Mitigation

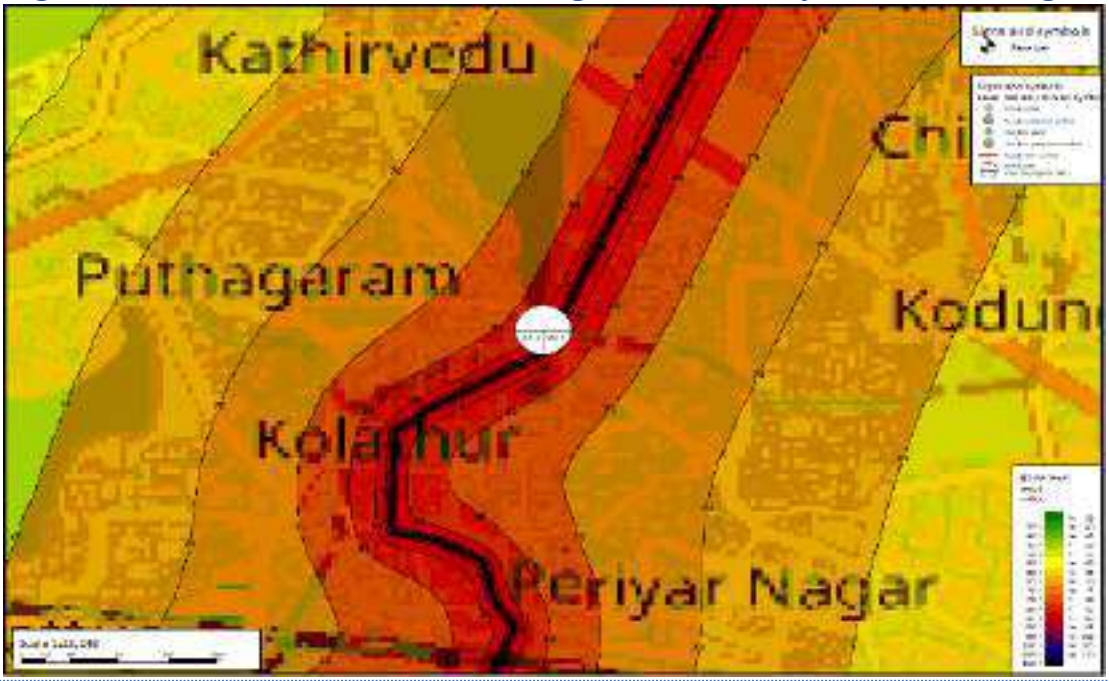


Figure 6-53: Construction Phase-Piling at HR-12– Day Time- with Mitigation

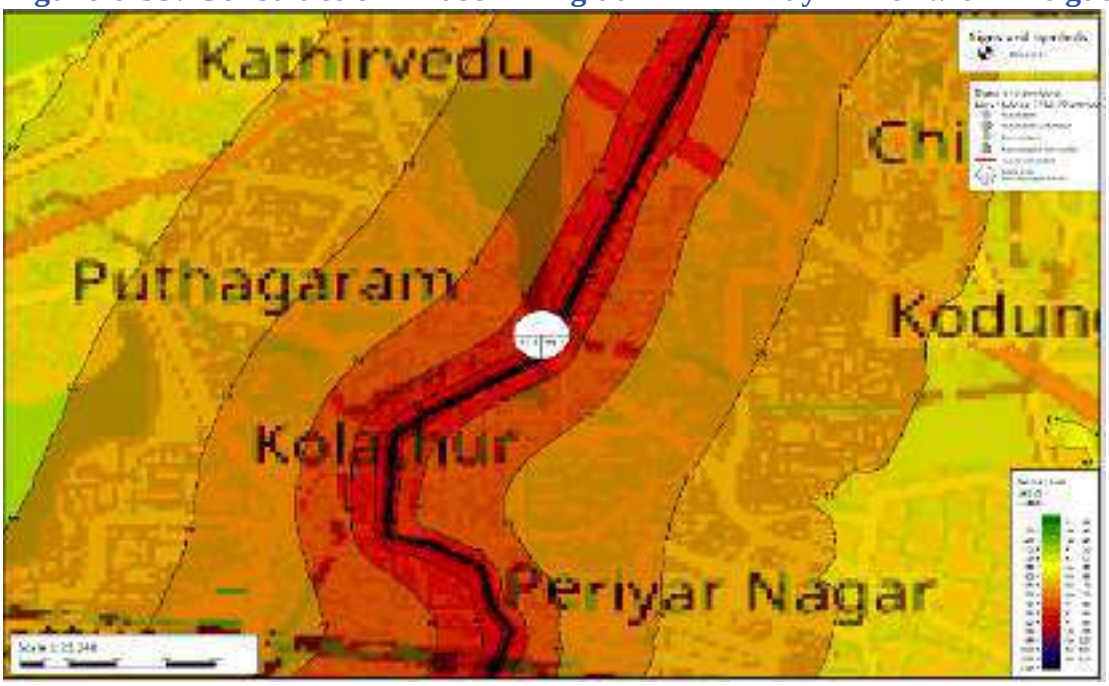


Figure 6-54: Construction Phase-Piling at HR-12– Day Time- No Mitigation

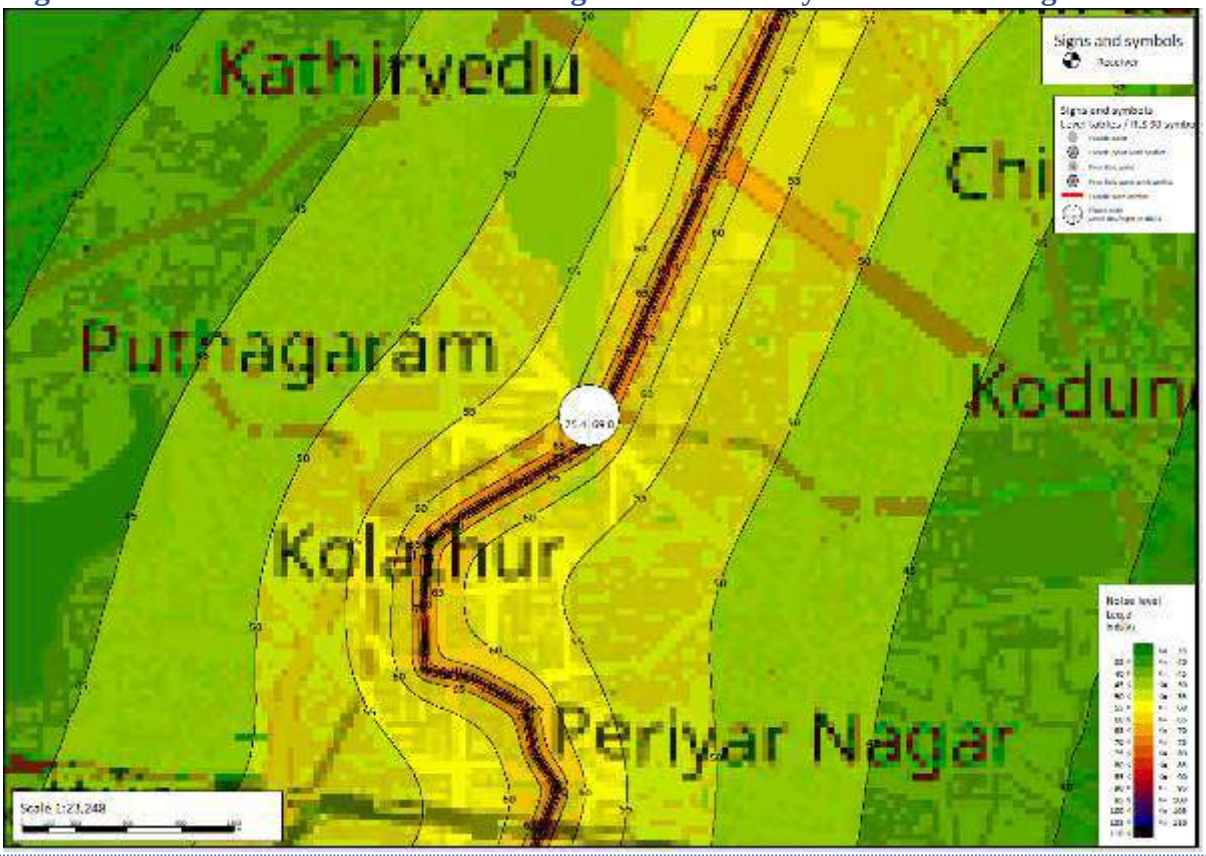


Figure 6-55: Construction Phase-Piling at HR-12– Day Time- with Mitigation Wall

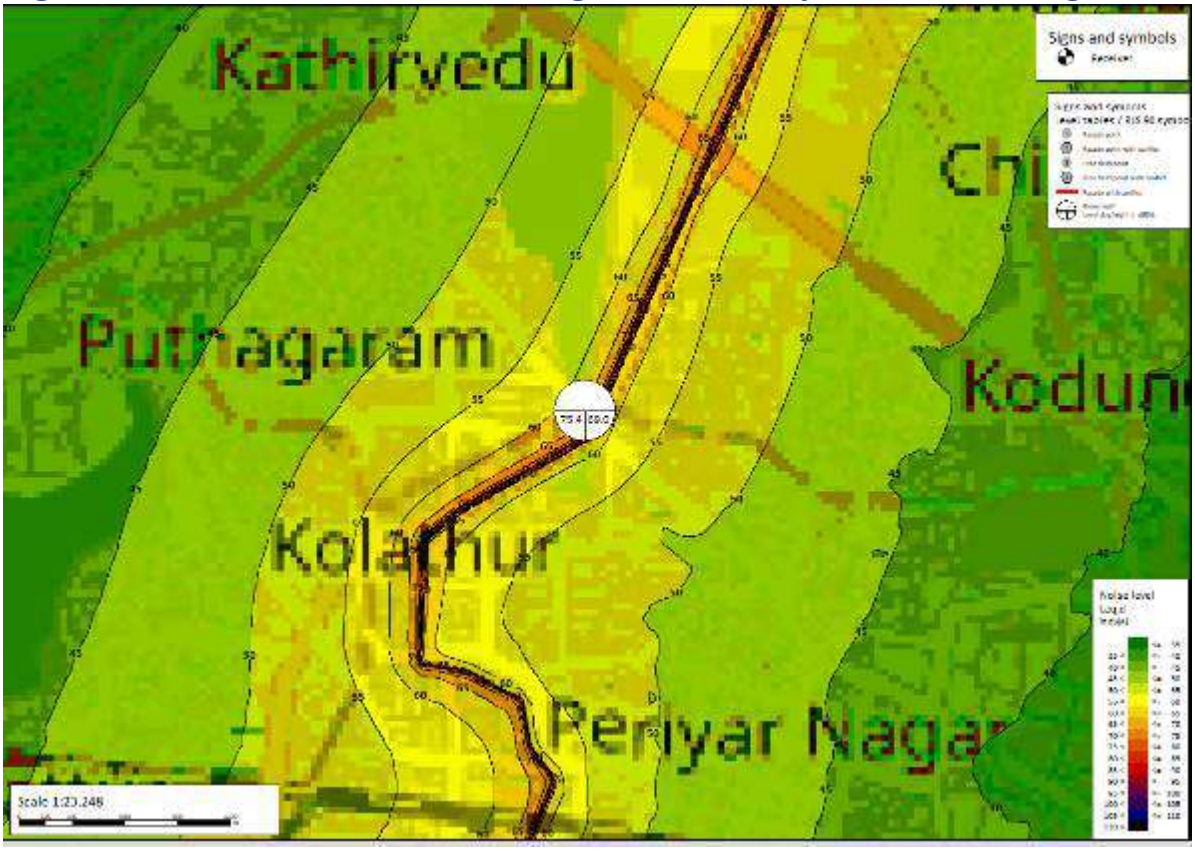


Table 6-32: Summary of Noise level db(A) during Construction phase.

No	Name of the Sensitive Receptors	Distance (m)	Construction										
			Baseline		Without Barrier					With Barrier			
			Noise levels db(A)		Predicted Noise levels db(A)	Final Noise		Status - No Barrier		Mitigation - Model	Final Mitigated Noise		Status	
			L_{eq},d	L_{eq},n	L_{eq},d	L_{eq},d	L_{eq},n	L_{eq},d	L_{eq},n	L_{eq},d & Leq,n	L_{eq},d	L_{eq},n	L_{eq},d	L_{eq},n
1	MM hospital	10	75	66	65	76	76	No-Impact	Impact	60	75	67	No-Impact	No-Impact
2	Government boys high school, porur	78	76	62	74	78	78	No-Impact	Impact	63	76	65	No-Impact	Impact
3	St. joseph hospital	48	66	63	60	67	68	No-Impact	Impact	58	67	64	No-Impact	No-Impact
4	Kalpana hospital	30	61	51	72	72	72	Impact	Impact	65	66	65	Impact	Impact
5	Cantonment board high school	100	66	61	63	68	69	No-Impact	Impact	55	66	62	No-Impact	No-Impact
6	Anjakha hospital	30	66	62	72	73	73	Impact	Impact	64	68	66	No-Impact	Impact
7	St. joseph school	70	76	66	66	77	77	No-Impact	Impact	65	77	68	No-Impact	No-Impact
8	Ravindra bharathi global school	42	69	63	68	71	72	No-Impact	Impact	63	70	66	No-Impact	Impact
9	National school	160	74	67	57	74	75	No-Impact	Impact	50	74	67	No-Impact	No-Impact
10	Sri varasidhi vinayagar temple	45	60	55	60	63	64	No-Impact	Impact	59	63	61	No-Impact	Impact

Note:

- there will no construction activity conducted during night time.
- The places are highly impacted are receptors which are closer to the rail line

6.4 IMPACTS AND RECOMMENDATIONS DURING CONSTRUCTION PHASE

6.4.1 IMPACTS

During the construction phase, the following activities among many are considered to be important towards creating environmental impacts:

- Site preparation (fencing, boundary & clearing of site).
- Excavation, backfilling and leveling.
- Hauling and dumping of earth materials & construction spoils.
- Foundation works (Pile driving).
- Fabrication erection of Steel structures.
- Construction of internal roads, drains & water supply.
- Demolition of structures to be removed.
- Pile driving for viaduct piers and buildings
- Tunneling.

6.4.2 MITIGATION MEASURES

- Adherence to site rules and restrictions, including making due allowance with detailed programme of works to be carried out at site.
- Employment of best working practices and methods, including consideration of alternative methods, materials and products which minimise the requirements to make noise.
- Continually investigate and employ plant and methods which minimise noise impact and general nuisance.
- The type of plant/machinery being used is appropriate and it had been constructed to meet the requirements. Research the level of noise generated by plant and equipment before it arrives on site.
- Ensure that all fixed items of construction plant are electrical powered rather than diesel or petrol driven if possible. Where this is not practicable, suitable attenuation measures should be provided if necessary.
- When breaking concrete do not employ percussion type plant when practicable.
- Where practicable, rotary drills and bursters actuated by hydraulic or electrical power should be used for excavating hard materials.
- All equipment used is maintained in good mechanical order and fitted with the appropriate shields, silencers, mufflers or acoustic covers/enclosures.
- Fixed noise sources are sited as far as possible from the noise sensitive areas, and where necessary acoustic barriers and screens should be used to shield them.
- Briefing of management and operatives to ensure all restrictions are clearly noted with method statements. State the types of plant being used including manufacture literature to advise of the sound power level of the plant, and the proposed noise control methods.
- Movement of vehicles and plant to and from the site is controlled and within the permitted hours unless otherwise agreed.

- Liaise with contract administrator and relevant parties in advance of problems, out of hours working or where deviations are required.
- Compliance with human exposure regulations associated with vibration in construction.
- Activities are carried out in such a way that vibrations arising will not cause damage to adjacent structures, residents and passers-by.
- Consider and employ noise and vibration monitoring and measurements if appropriate.

7 OPERATION PHASE NOISE IMPACT ASSESSMENT

7.1 EVALUATION OF THE IMPACT: NOISE SCREENING PROCEDURES

The noise screening procedure is intended to be conservative to broadly capture the potential for impact with minimal effort. To make the procedure conservative, the project system must be assumed to be operating under relatively high-capacity conditions, which would produce more noise than normal operating conditions.

Table 7-1: Reference Sound Exposure Level from Tract (one vehicle) (Ref: 1)

Source	Type	Reference Conditions	Reference SEL (SELref), dBA
Rail Transit and Streetcars at 80 kph		At-grade, ballast, welded rail	82
Rail Transit and Streetcars at 40 kph		At-grade, ballast, welded rail	76
Transit whistles / warning devices		Within 1/8 mile of grade crossing	93

7.1.1 SOUND PRESSURE LEVEL EVALUATION AND MODELLING ASSUMPTIONS

To evaluate the project SPLs a grid 10 x 10 meters has been used.

- This calculation grid provided with little clearances (1 m) between calculation points has been chosen to obtain a more detailed noise map.
- The calculation has been carried out at 1.5 meters (average height of human ear) above ground level and to determine the height of taller buildings appropriate height of the floors were used,.
- The calculation is based on the international ISO 9613 standard *"Attenuation of sound during propagation outdoors"*
- The calculation has been carried out considering a wind condition favourable to the propagation of acoustic sound wave (in case any wind statistics data are defined, ISO 9613 conservatively considers a downwind situation for every direction).
- For the numerical simulation, a normal/steady operation of the sources has been assumed.

In detail, the calculations consider:

- SPL of equipment at 1 m distance or otherwise specified
- Geometrical lay-out of the viaduct with the rail
- Geometrical characteristics of the sources
- Atmospheric absorption, reflection, and diffraction.

The modelled noise sources are listed in tables referenced under different scenario studies together with expected Power Level and spectrum if available.

All values are expressed in dB(A) scale. Equipment dimensional characteristics and relevant heights above ground are also reported.

Small sources, e.g. pumps and motors, have been considered as point, linear or area sources, depending on their geometrical characteristics. In a different way, large units have been simulated as radiating buildings.

Table 7-2: Model settings

S.No	Model settings	Parameter setting/standard
1	Calculation Standard	ISO 9613 'Acoustics – Attenuation of Sound during Propagation Outdoors – Part 2: General Calculation Method' (ISO, 1996) [6]
2	Ground Absorption Coefficient	1: Paved Area
3	Maximum Order of Reflection	3
4	Reflection Loss by Obstacles and Barriers	Default: 1 dB
5	Meteorological Data	Humidity: 70% Air Pressure: 1033 mbar Monthly Mean Temperature: 30ºC
6	Calculation Grid Size	Site-wide calculations: 1 m resolution

7.1.2 NOISE EMISSION SOURCES

Noise radiated from train operations and track structures generally constitute the major noise sources. Airborne noise is radiated from at-grade and elevated structures, while ground-borne noise and vibration are of primary concern in underground operations. Basic sources of wayside airborne noise are:

- Wheel / Rail Noise: Due to wheel /rail roughness
- Propulsion Equipment: Traction motors, cooling fans for TM, reduction gears etc.
- Auxiliary Equipment: Compressors, motor generators, brakes, ventilation systems, other car mounted equipment

Predicted noise levels for the project area were modelled in accordance with the Federal Transit Administration (FTA) guidelines. Predicted future noise levels in the project area were based on existing measured sound levels and future daily transit operations.

Figure 7-1: Major transit rail noise sources

7.1.3 TRAIN NOISE

The reference noise level of the proposed trains were taken from the bidding documents for the Chennai Metro Rail Project that requires suppliers of the rolling stock should comply with the following specification for the exterior noise level for elevated and at-grade (free field):

- When measured at 7.5m from the center of the track along the train, the equivalent continuous noise level ($L_{pAeq20sec}$) measured over an observation period of 5 sec I free field conditions as specified in ISO 3095 while a train is stationary all auxiliary equipment operating simultaneously at maximum capacity will not exceed 67 dBA at 1.2 meters above the rail

- When measured at 7.5m from the center of the track, the equivalent continuous noise level (LpAeq20sec) measured while a train running in the free field conditions, specifies in the ISO3095, is passing will not exceed 82 dB(A), at a stabilized speed of 75 kmph

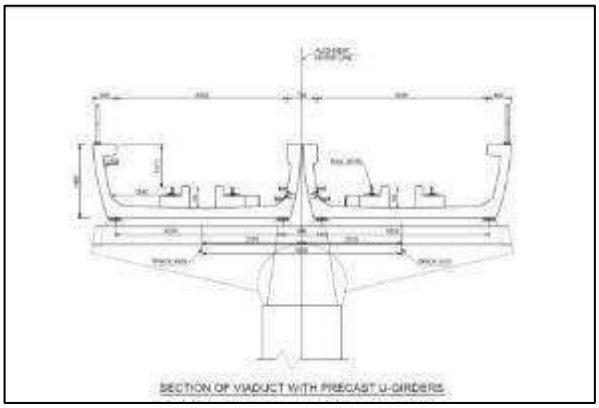
Table 7-3: FTA/Federal Railroad Administration Input Values for Noise Model

Detail	Train
Reference SEL at 15m	
Propulsion, dB(A)	86
Wheel Rail, dB(A)	95
Aerodynamic dB(A) 2/	0
Speed Coefficient, K forPower Units	0
Speed Coefficient, K forRail Cars	20
Reference heightsPropulsion Wheel-Rail (m)	0.61 0.30
Train Speed (km/h)	34-60
Number of Propulsion	2
Number of Cars per train	6
Total Length (m)	126.3 (6 x 21.05)

7.1.4 U-GIRDER DETAILS

The Figure below provides the typical cross-section of the precast U-girder designed for the project. The height of the parapet walls above the railhead is considered in this study that defines the initial noise wall design scenario and taken at 1.072m.

Figure 7-2: Details of the Pre-Cast U-Girders Highlighting the Height of the Parapet Wallabove the Railhead



7.1.4.1 GROUND ELEVATION AND DIGITAL GROUND MODEL

The study team was not able to secure more detailed ground elevation data within the 2500 meter screening distance and defaulted to use the Open Street Map elevation data and building input. The use of the OSM elevation data is a sufficient characterization of the general flat terrain of Chennai, however, it does not capture the elevated roads that runs along the proposed metro.

7.1.4.2 RAIL ELEVATION

The rail elevations from the engineering vertical profiles were used to establish the absolute and relative height of the railway every 20 meters.

7.1.4.3 BUILDING LOCATION AND HEIGHTS

Building locations were taken from Open Street Map and Google Maps while the building heights were extrapolated from the number of floors as observed from field survey.

7.1.4.4 NOISE MODEL

Using SoundPlan 8.2, the calculation options that were selected for this project provided a balance between accuracy of noise assessment and time to complete the computation. As mentioned earlier, in addition to the FTA/FRA-HSGT (2005) standards that were applied, the following options were adopted:

- Assessment: Day, Night, Ldn
- Emission time slices: 7-22, 22-7
- Reflection order: 3
- Maximum Search Radius: 1,500 km
- Maximum reflection distance: 200m
- Grid noise map spacing: 10 m

7.1.5 INPUTS FOR MODELING

The required inputs for modeling of Noise and vibration were collected from CMRL. Two types of train were proposed by CMRL which are to be operated in the proposed corridor and they are,

- 3 Car (DMC+TC+DMC).
- 6 Car (DMC+TC+MC+MC+TC+DMC).

The length of each coach is 22.6 m. The following data were taken from CMRL Detailed Project report,

Number of trains/hr,

- MMC to Sholinganallur – 10 trains/hr – a maximum of 220 trains during day and 90 trains during night.

The track properties are summarized **Error! Reference source not found.**. The rolling stock p roperties are summarized **Error! Reference source not found.**. The soil properties are given in **Error! Reference source not found.**3.

Table 7-4 Track properties.

S.No.	Track Properties	Remarks
1	Track type:	Slab track in tunnel & Plinth track on viaducts
2	Width of track or Ground interaction area(m)	Track slab 2.2 m(Underground) Track plinth 830 mm(elevated)
3	Rail type:	UIC 60 IRS-T-12-2009 60E1 PROFILE
4	Rail mass per unit length (Kg/m)	60.21 kg/m
5	Rail moment of inertia (cm^4)	I_{XX} = 3038.3 cm^4, I_{YY} = 512.3 cm^4
6	Rail Young's Modulus (GPa)	200 Gpa
7	Rail fastener spacing (m)	Standard spans 0.650 m (max);
8	Rail fastener stiffness (KN/mm)	As per Annexure C2 of Procedure for Safety Certification and Technical Clearance of Metro Systems; Vertical static stiffness shall be 35kN/mm(max)
Note: The above properties were provided by CMRL.		

Table 7-5 Rolling stock properties

S.No.	Rolling Stock Properties	Remarks
1	Vehicle type:	Metro or Sub-urban on resilient wheels
2	Car body mass (Kg)	Max. 64000 kg
3	Wheel radius (m)	New 860mm Fully worn 780mm
4	Axle laod (KN)	16000 kg
5	Wheel centre spacing (m)	Max 1.36 m
6	Bogie centre spacing (m)	14.85±0.25 m
7	overall vehicle length (m)	Max 21.84 m
8	Total number of vehicles	6 car
9	Vehicle axle load (KN)	16000 kg
Note: The above properties were provided by CMRL.		

Table 7-6 Soil properties

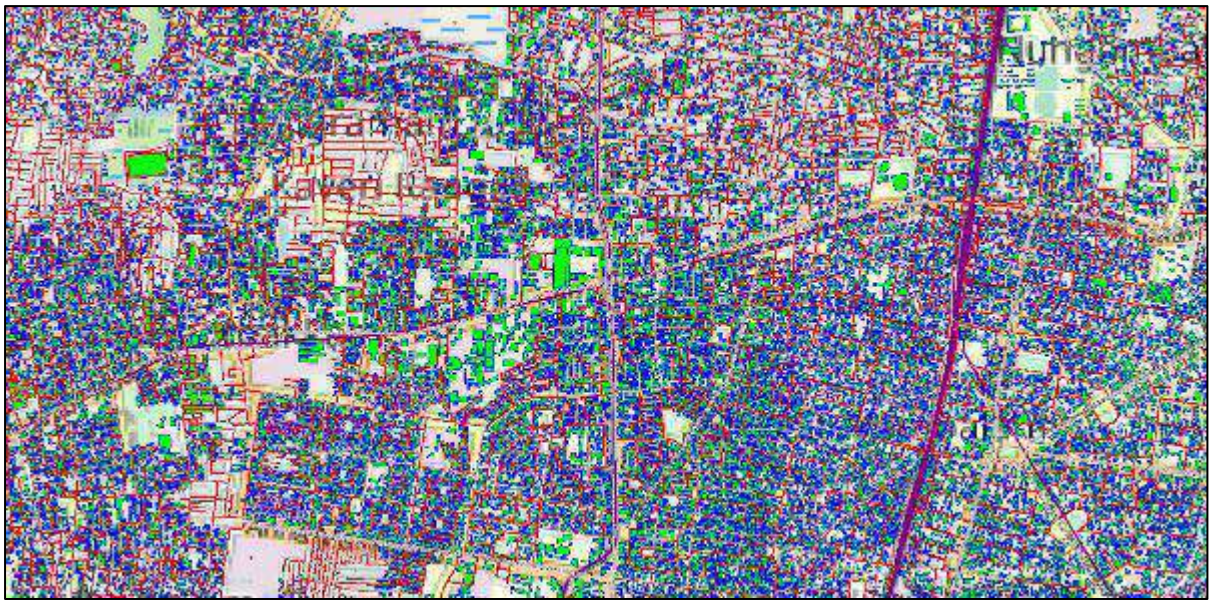
	Soil type
Corridor 5	
CMBT to Alapakkam	Clay soil
Alapakkam to porur to DLF	Sandy soil
DLF to Sholinganallur	Hard rock
Note: The above properties were provided by CMRL.	

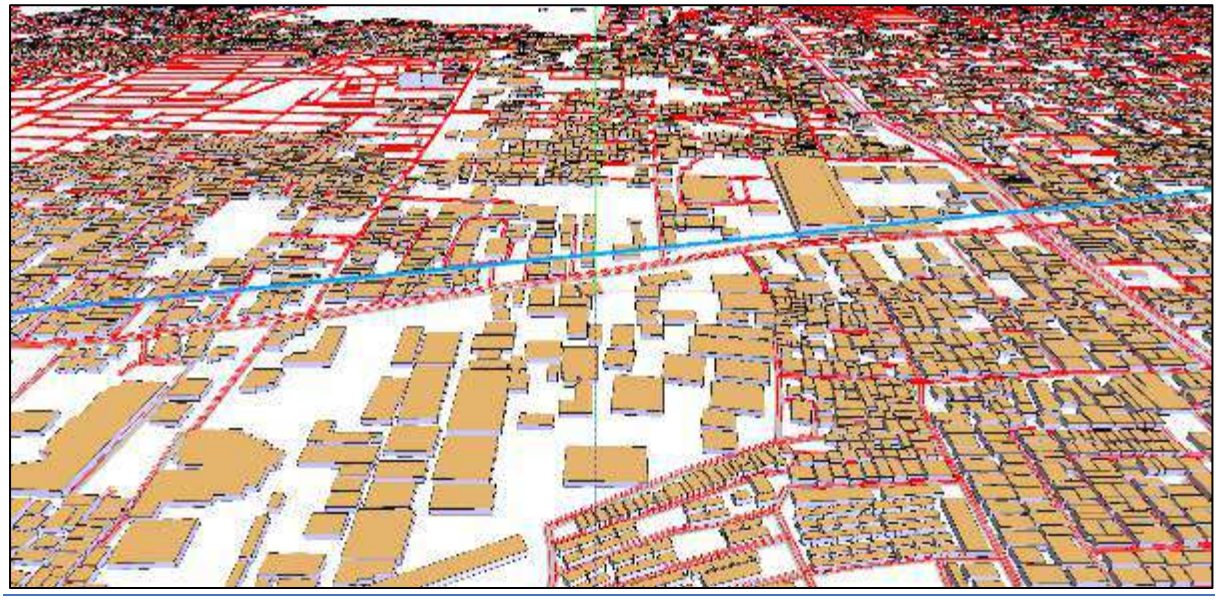
7.2 ASSUMPTIONS

The following assumptions have been made for the modelling assessment:

- Equipment elevations have been based on the viaduct Layout Plot Plans and site elevation sections provided
- The noise contour plots have been calculated at height of 1.5 m.
- Ground absorption has been modelled as concrete surfaces for via duct and road surface for the ground level surface
- Calculations are as per a steady-state operation with continuous duty cycles;
- The noise prediction calculations are as per meteorological modelling Category D (neutral) classification. Class Modelling with ISO 9613 Part 2 does not consider metrological conditions such as wind and temperature inversion, however temperature and relative humidity are incorporated into the calculations.
- The environmental conditions applied in the noise model: Humidity 70%, Air Pressure 1033 mbar and Temperature 30°C which is represents the annual average climatic conditions for the Chennai area.

Figure 7-3: Sound Plan with input of buildings and Roads





7.2.1 SUMMARY OF RESIDENTIAL RECEPTORS ASSESSMENT FINDINGS

The summary of the single point noise calculations for Phase 2 for operating years 2045 and design conditions. The key findings and recommendations are as follow:

- For the CR-4, the project rail noise was predominantly less than the GOI noise Standards and was identified to be less than the ambient noise. The designed noise mitigation wall height is adequate to ensure noise level increase is kept within the 3 dB(A). No residual noise impacts are anticipated, and no further mitigation is required.
- The noise assessment was carried out with the following Particulars

Corridor 5 Gauge(Nominal):	**1435 MM**
Route Length:	26.8km • 10.3 km Underground – HR 7 & 8 • 16.5 km Elevated – HR 1, 2, 3, 4, 5 & 6
Speed:	
Design Speed	80 kmph
Train Operation Plan:	
Particulars	2055 (Max)

Trains/hour (3 Car, 6 Car)	15
Head Way (Second)	240

Figure 7-4: Operation Noise at overall - Day Time and Night-time – No Mitigation

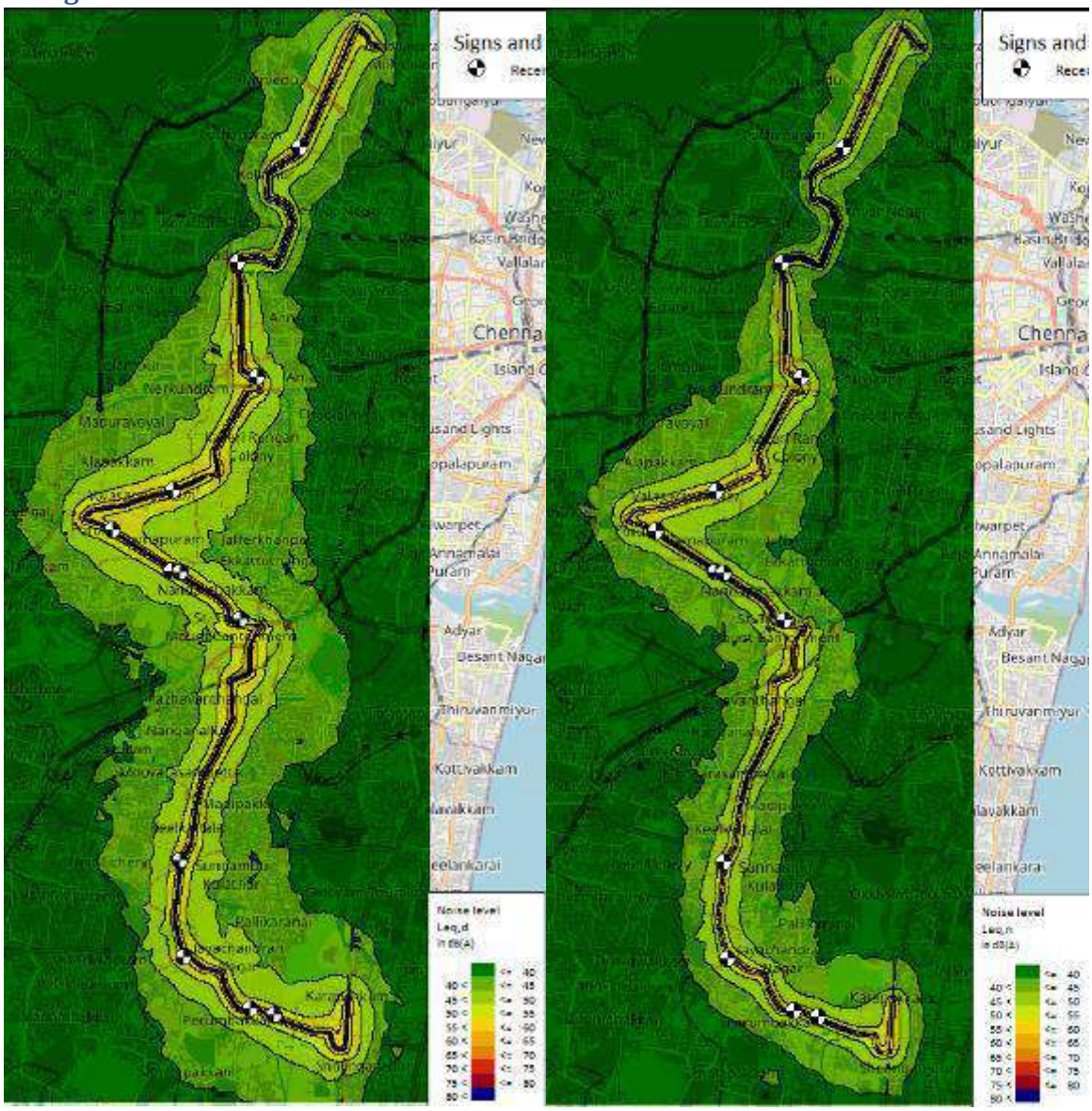
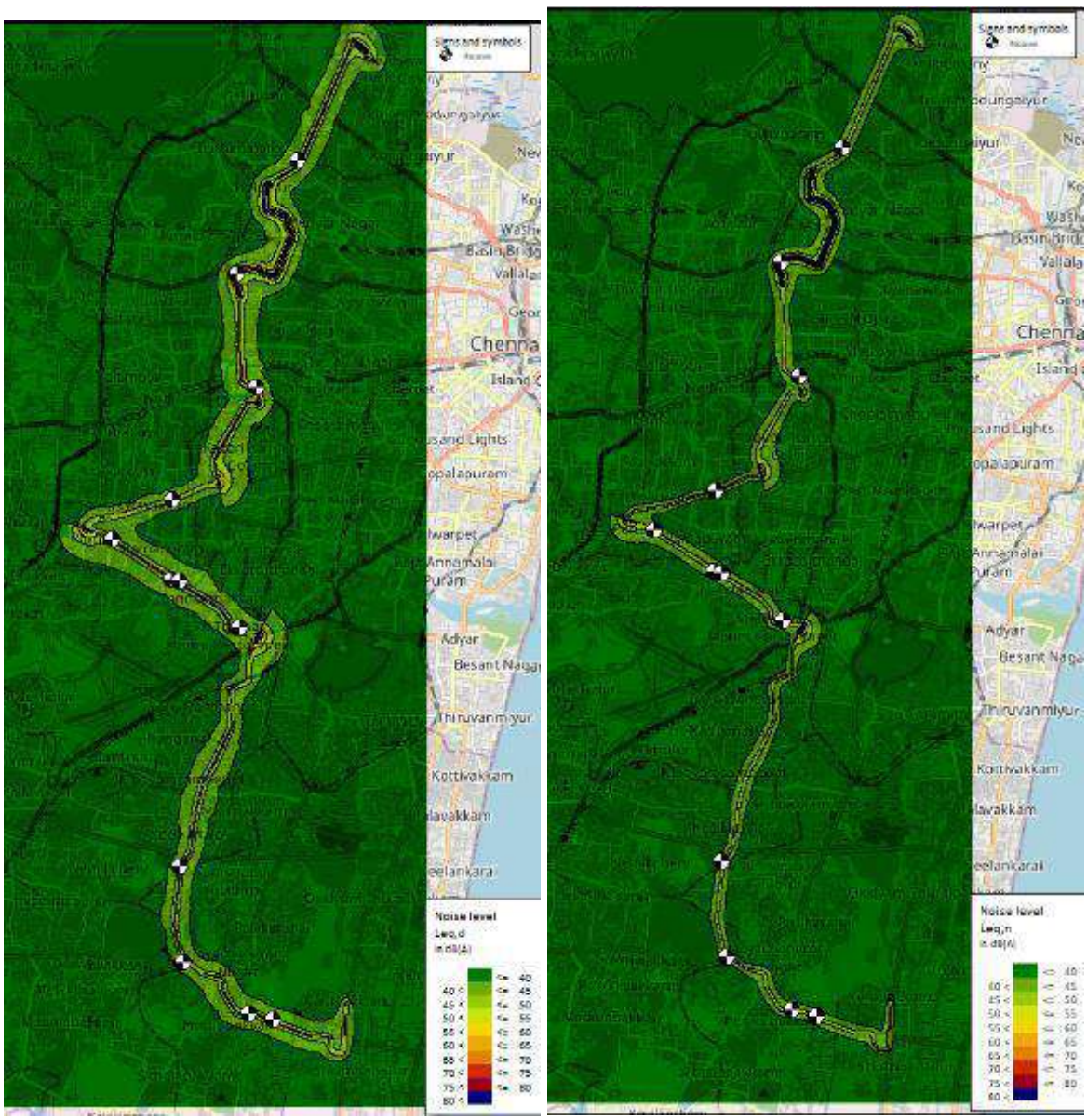


Figure 7-5: Operation Noise at overall - Day Time and Night – With Mitigation Wall



7.3 OPERATION NOISE ASSESSMENT AT SENSITIVE RECEPTORS

7.3.1 ANJAKHA HOSPITAL

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (Medavakkam Koot Road Bus Stop to Venkateswara Nagar) is shown in **Figure 7-6** and **Figure 7-7** respectively.

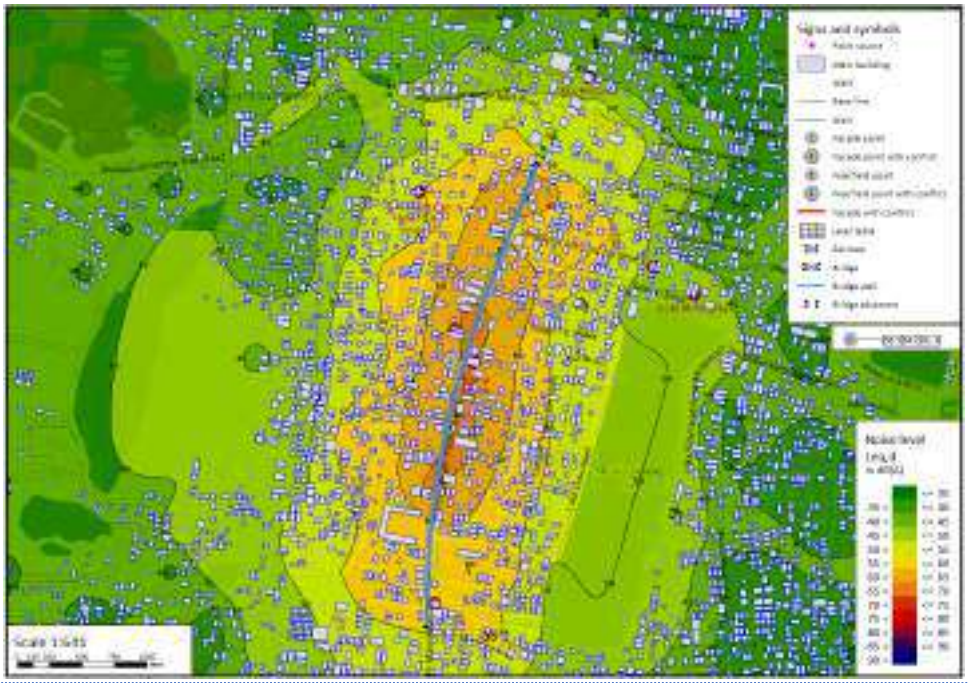


Figure 7-6 Day time Noise contour map for Operation phase (Medavakkam Koot road Bus Stop to Venkateswara nagar).

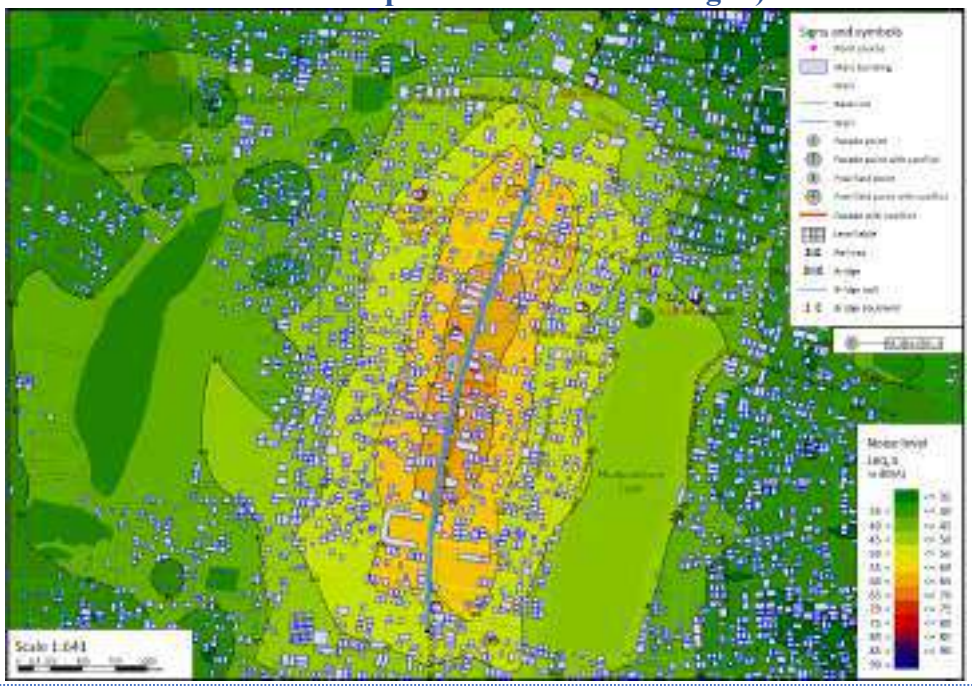


Figure 7-7: Night time Noise contour map for Operation phase (Medavakkam Koot road Bus Stop to Venkateswara nagar).

Figure 7-8: Anjakha Hospital Day time - Noise contour map for Operation phase after Mitigation

Figure 7-9: Anjakha Hospital Night time - Noise contour map for Operation phase after Mitigation

7.3.2 CONTONEMENT BOARD HIGH SCHOOL

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (CTC to St. Wesley Church) is shown in ***Figure 7-10*** and **Figure 7-11** respectively.

Figure 7-10: Day time Noise contour map for Operation phase (CTC to St. Wesley Church).

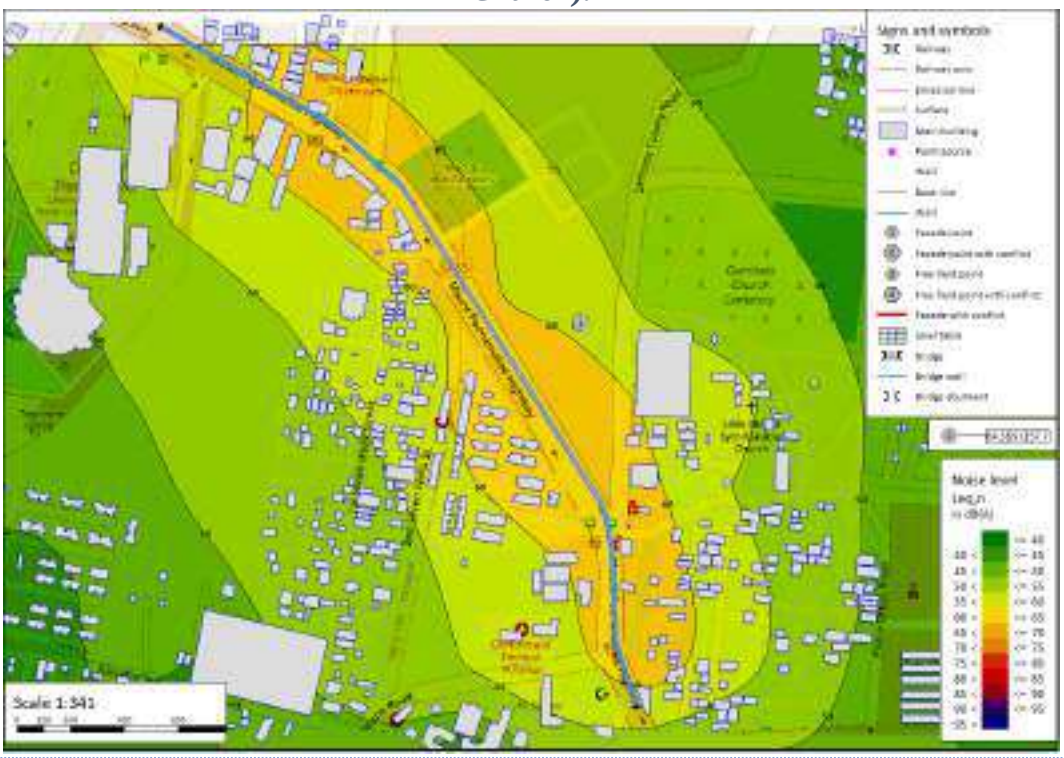


Figure 7-11: Night time Noise contour map for Operation phase (CTC to St. Wesley Church).

Figure *7-12*: Contonement Board High School - Day time - Noise contour map for Operation phase after Mitigation

Figure 7-13: Contonement Board High School - Night time- Noise contour map for Operation phase after Mitigation

7.3.3 ST.JOSEPH HOSPITAL

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (Porur to Mugalivakkam) is shown in **Figure 7-14** and **Figure 7-15** respectively.

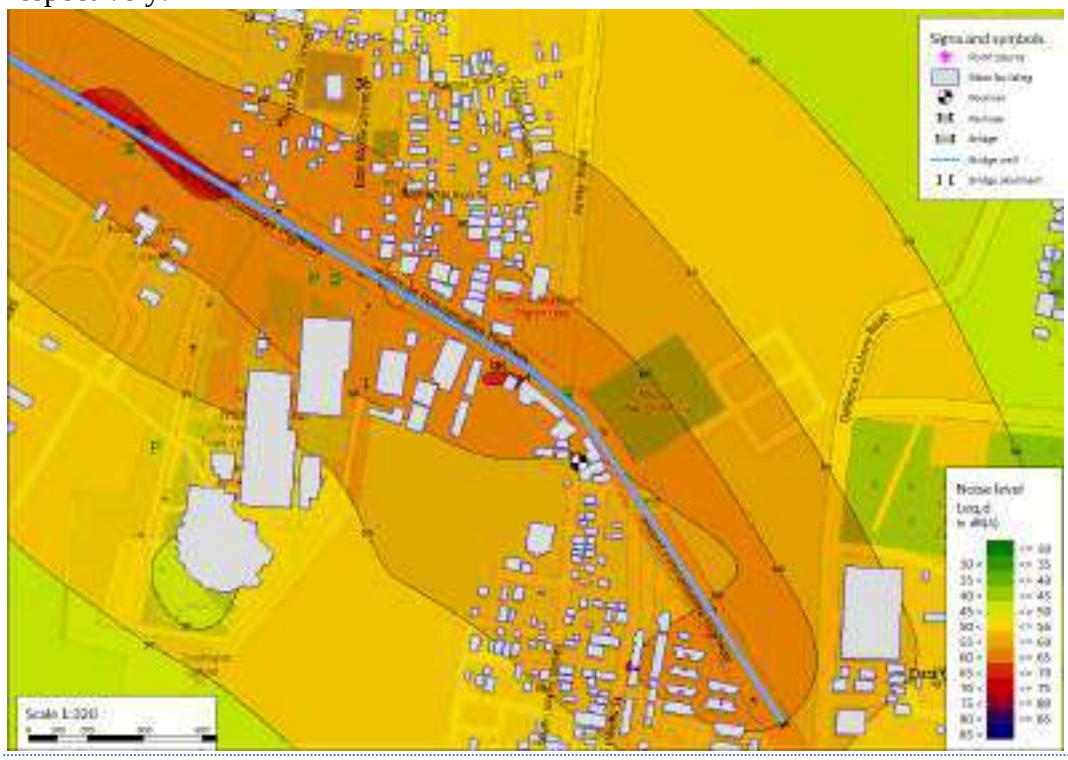


Figure 7-14: Day time Noise contour map for Operation phase (Porur to Mugalivakkam).

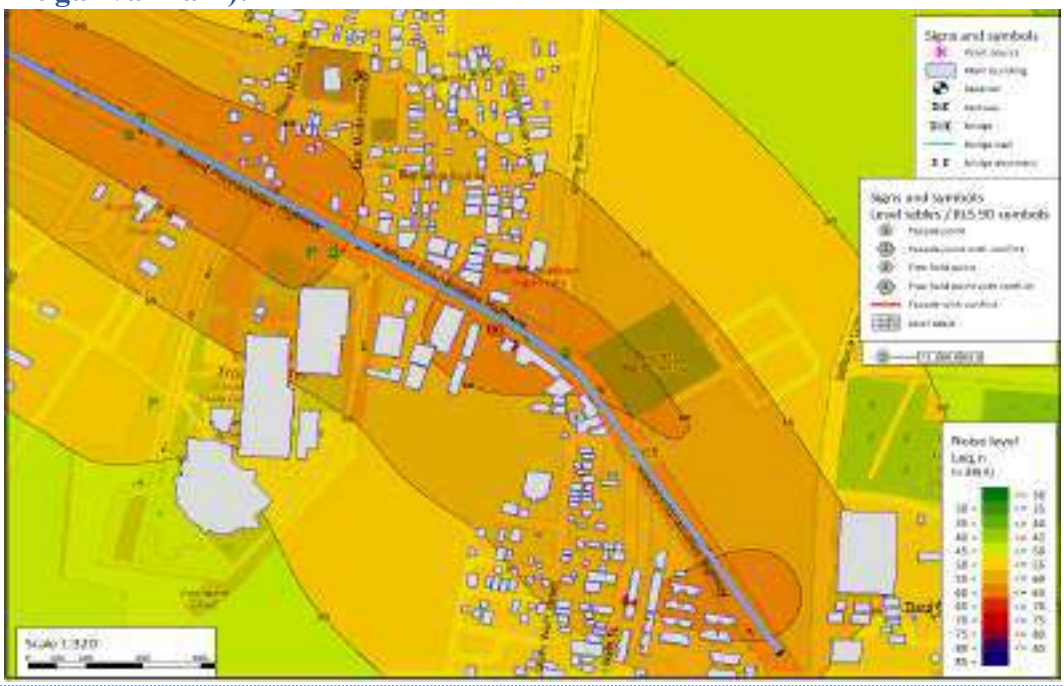


Figure 7-15: Night time Noise contour map for Operation phase (Porur to Mugalivakkam).

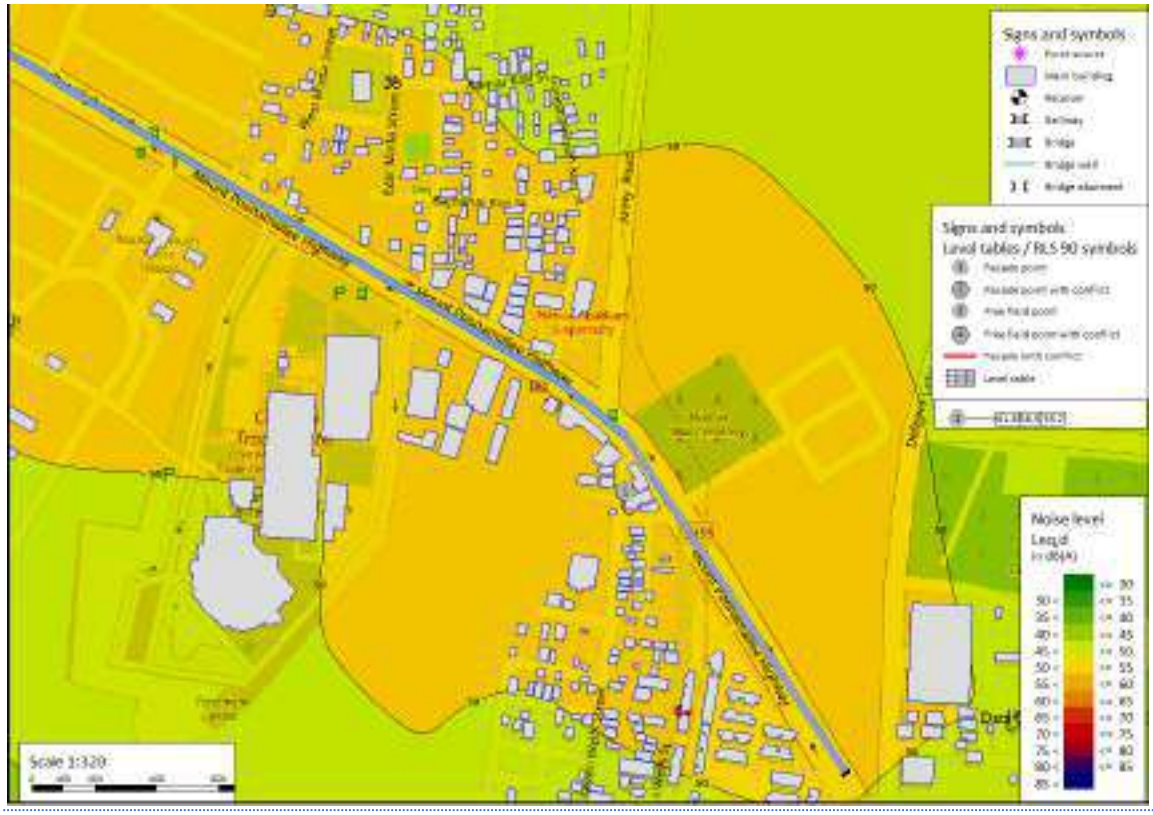


Figure 7-16: St. Joseph Hospital- Day time - Noise contour map for Operation phase after Mitigation

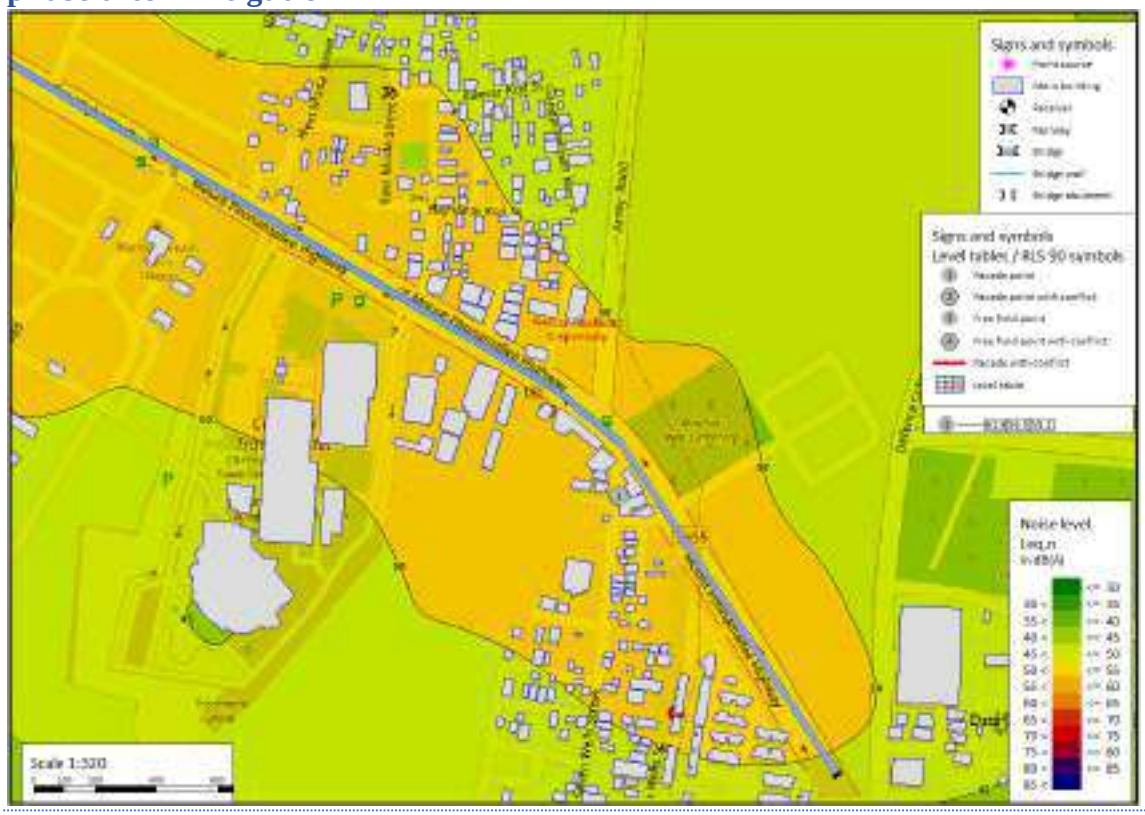


Figure 7-17: St. Joseph Hospital - Night time- Noise contour map for Operation phase after Mitigation

7.3.4 GOVERNMENT BOYS SCHOOL PORUR

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (Porur to Mugalivakkam) is shown in **Figure 7-18** and **Figure 7-19** respectively.

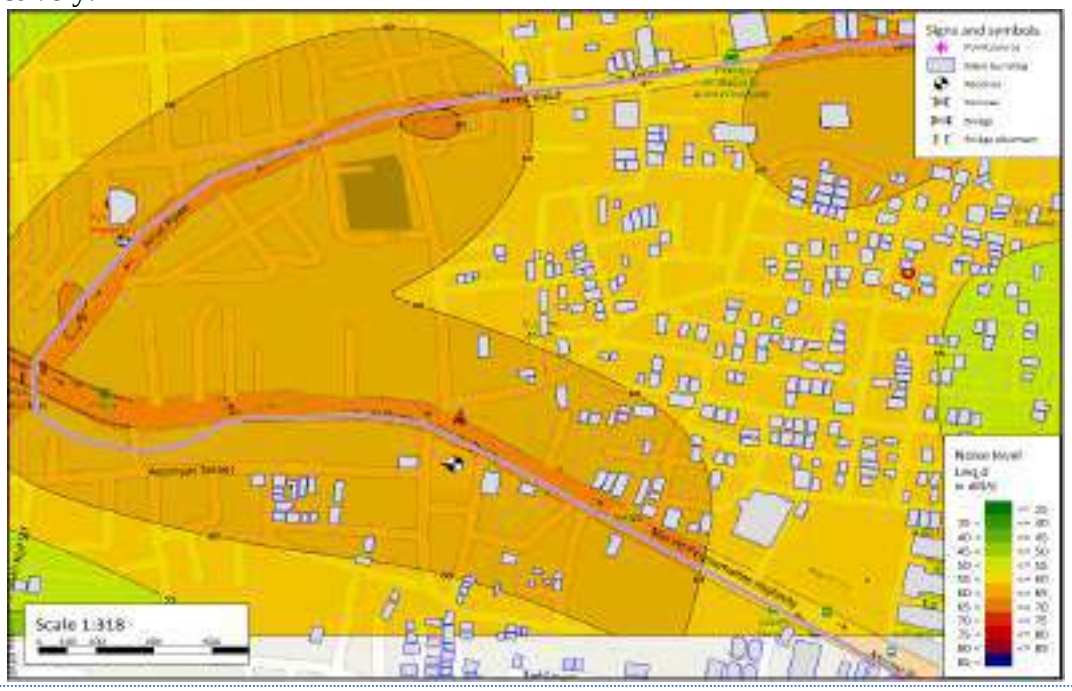


Figure 7-18: Day time Noise contour map for Operation phase (Porur to Mugalivakkam).

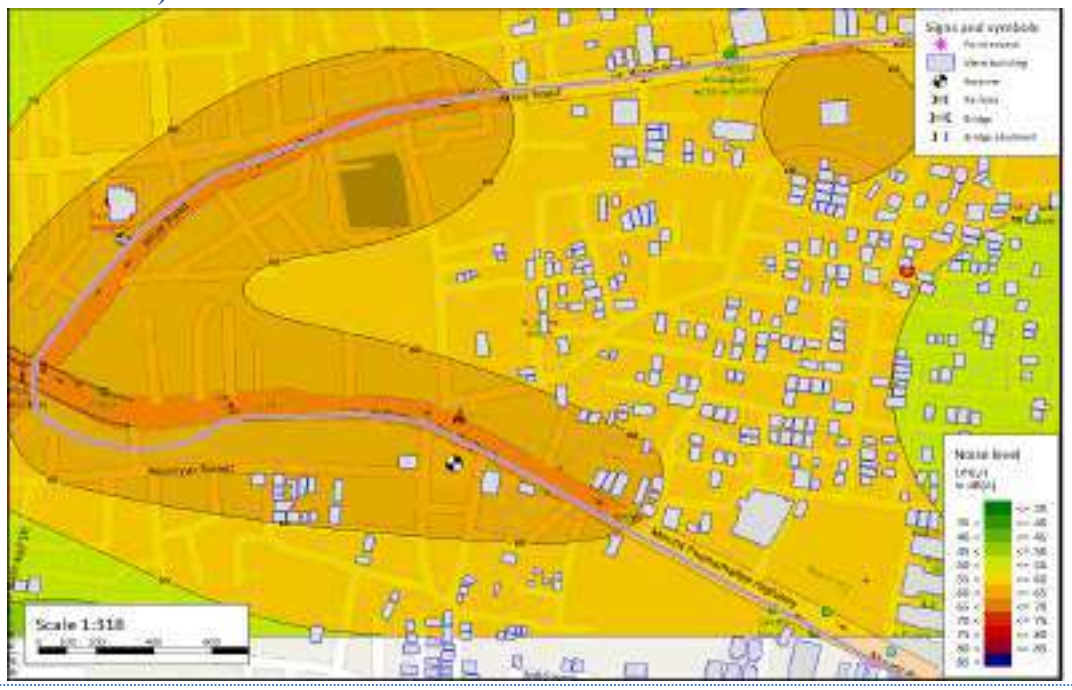


Figure 7-19: Night time Noise contour map for Operation phase (Porur to Mugalivakkam).

Figure 7-20: Government Boys School Porur - Day time - Noise contour map for Operation phase after Mitigation

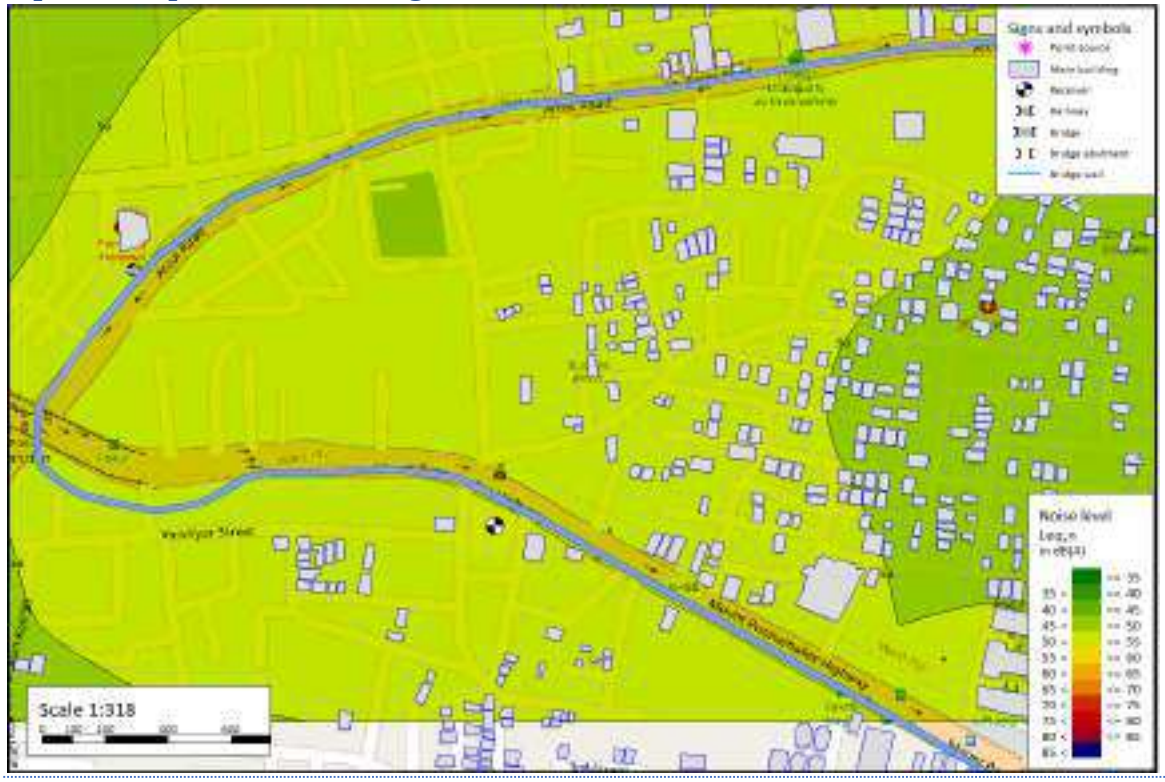


Figure 7-21: Government Boys School Porur - Night time- Noise contour map for Operation phase after Mitigation

7.3.5 KALPANA HOSPITAL

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (Adambakkam MRTS to Medavakkam Main road) is shown in **Figure 7-22** and **Figure 7-23** respectively.

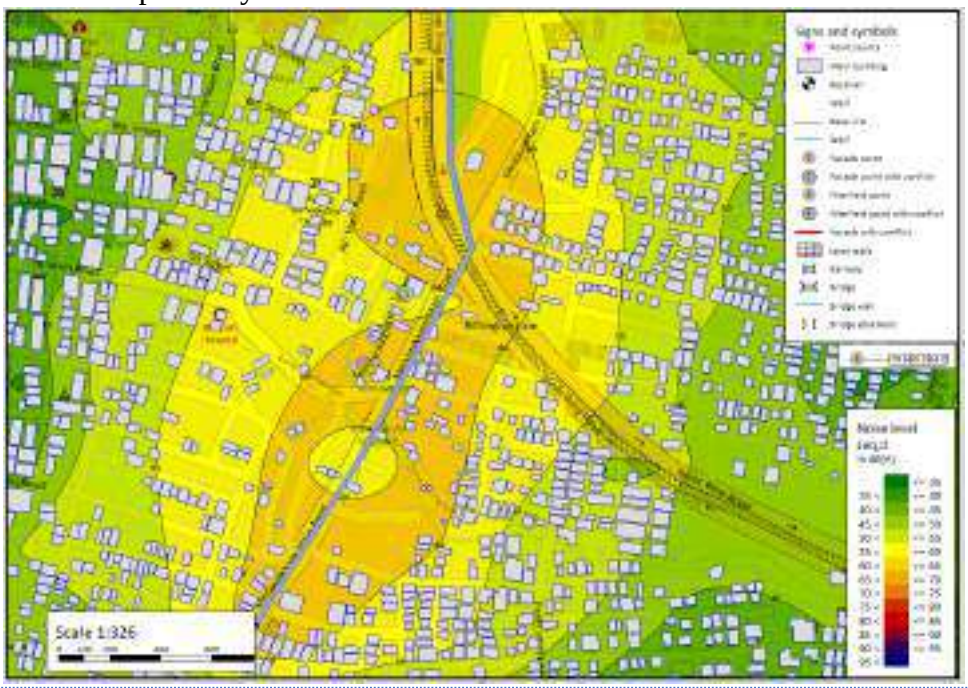


Figure 7-22: Day time Noise contour map for Operation phase (Adambakkam MRTS to Medavakkam Main road).

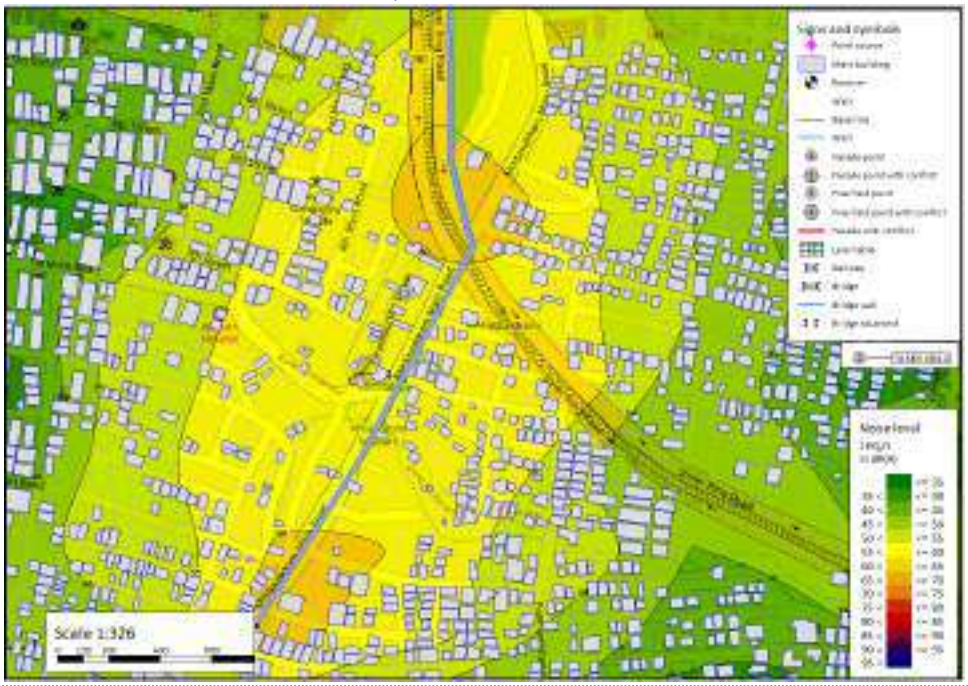


Figure 7-23: Night time Noise contour map for Operation phase (Adambakkam MRTS to Medavakkam Main road).

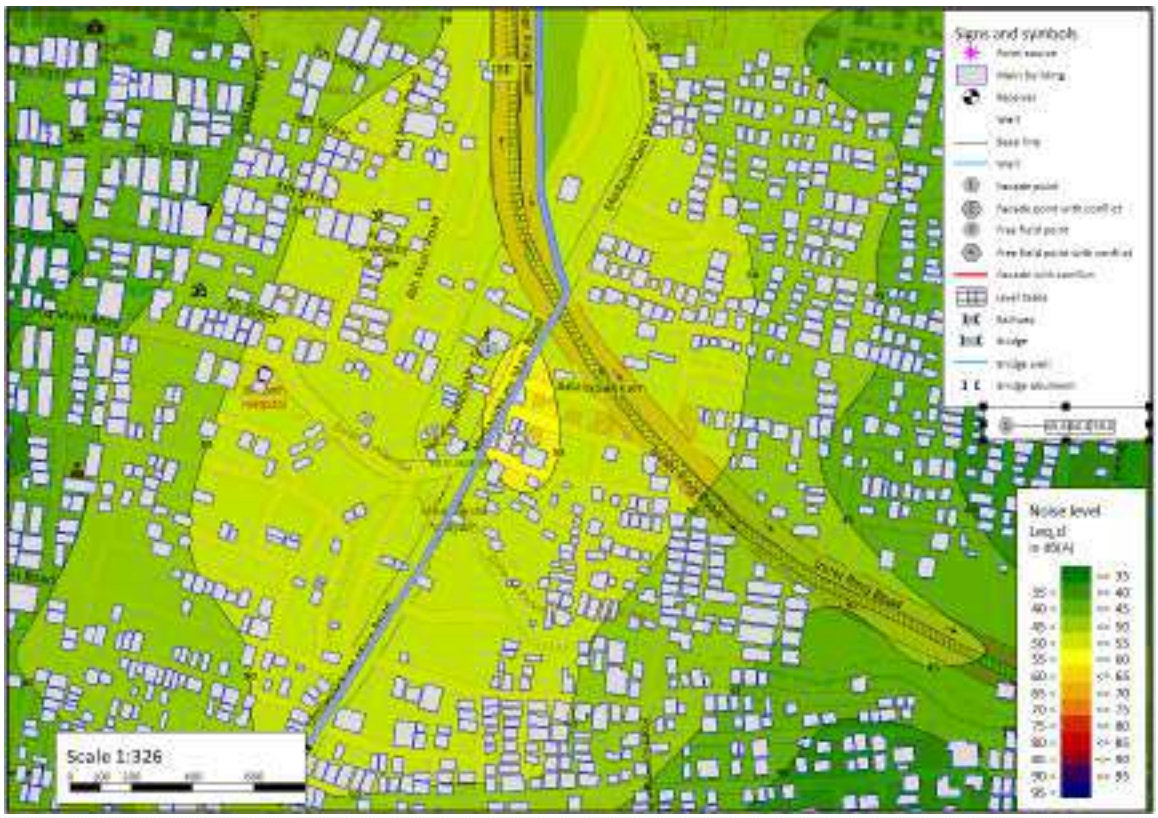


Figure 7-24: Kalpana Hospital- Day time - Noise contour map for Operation phase after Mitigation

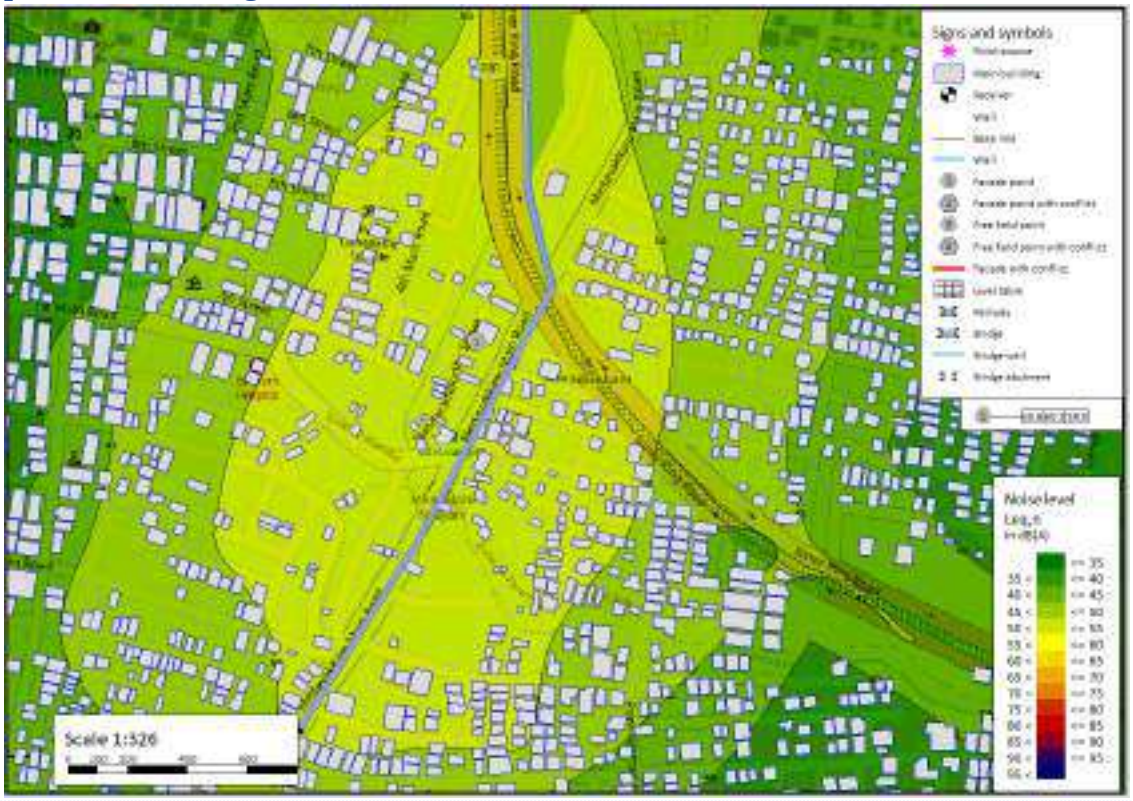


Figure 7-25: Kalpana Hospital - Night time- Noise contour map for Operation phase after Mitigation

7.3.6 MM HOSPITAL

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (Sai nagar Bus stop to Elango nagar Bus Stop) is shown in.

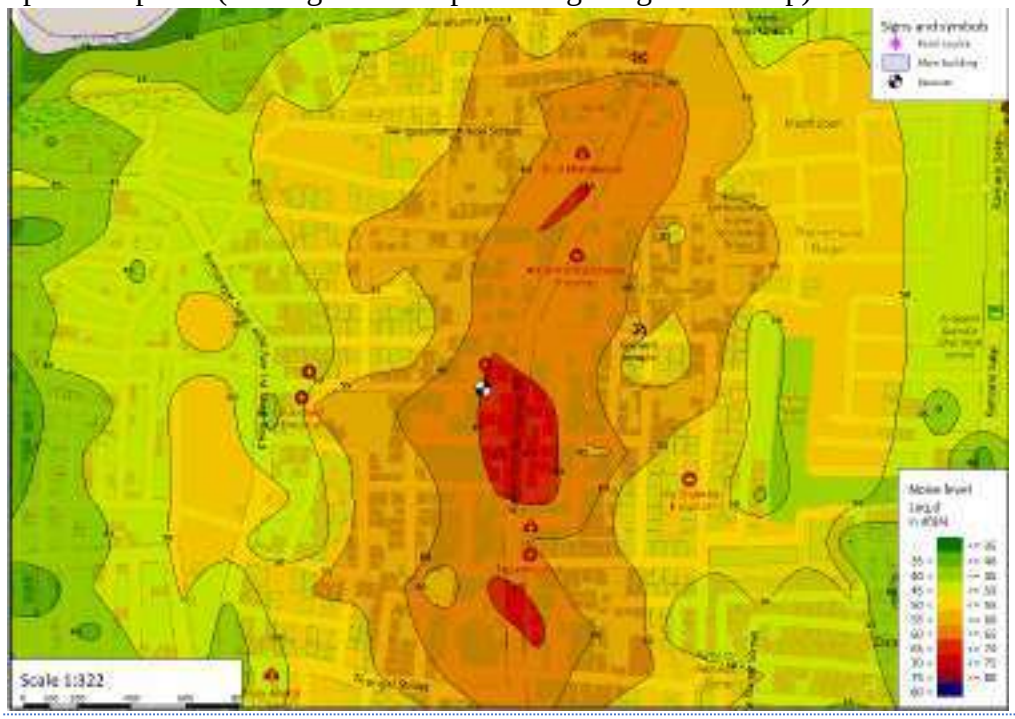


Figure 7-26: Day time Noise contour map for Operation phase (Sai nagar Bus stop to Elango nagar Bus Stop).

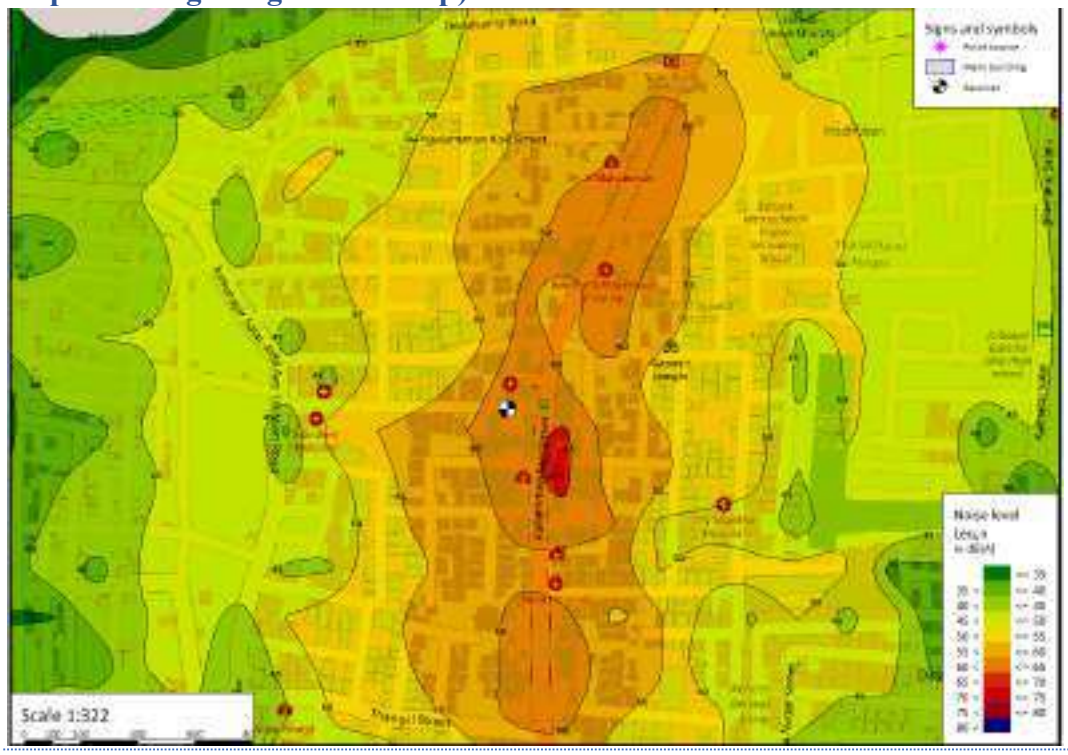


Figure 7-27: Night time Noise contour map for Operation phase (Sai nagar Bus stop to Elango nagar Bus Stop).

Figure 7-28: MM Hospital - Day time - Noise contour map for Operation phase after Mitigation

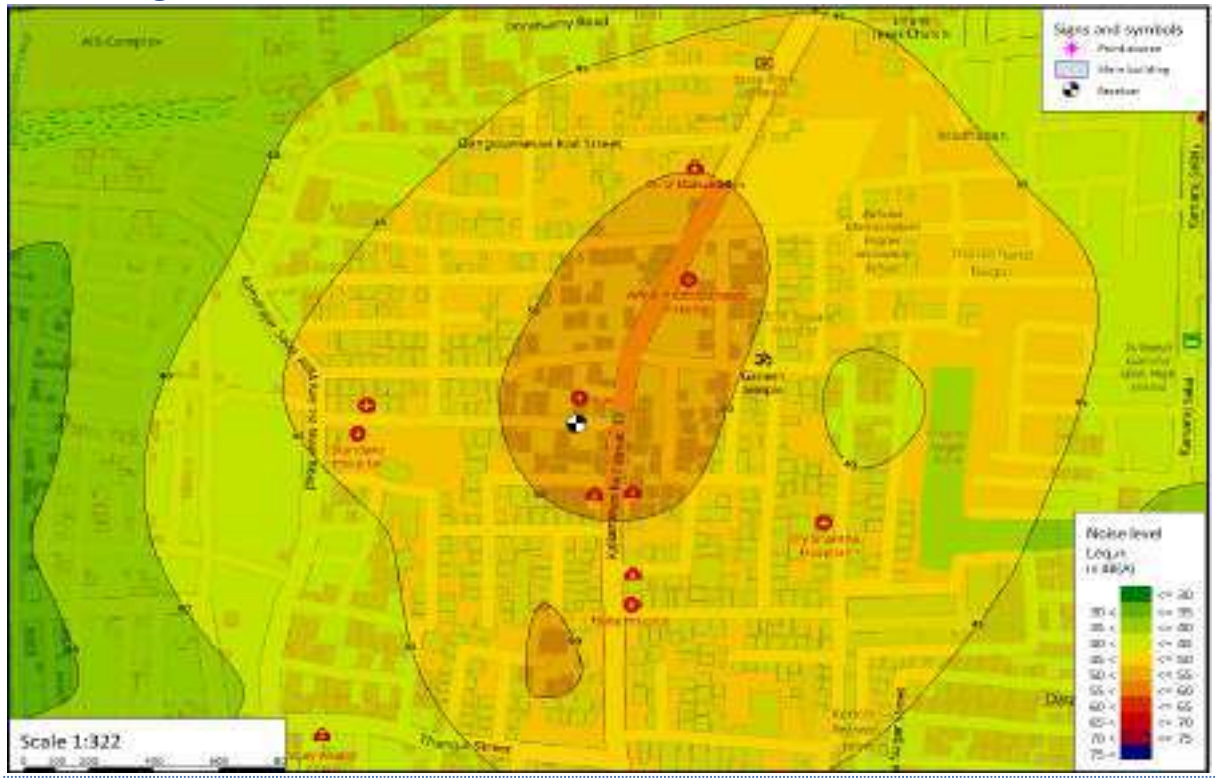


Figure 7-29: MM Hospital - Night time - Noise contour map for Operation phase after Mitigation

7.3.7 NATIONAL SCHOOL

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (St. Wesley church to Alandur) is shown in **Figure 7-30** and **Figure 7-31** respectively**.**

Figure 7-30: Day time Noise contour map for Operation phase (St. Wesley church to Alandur).

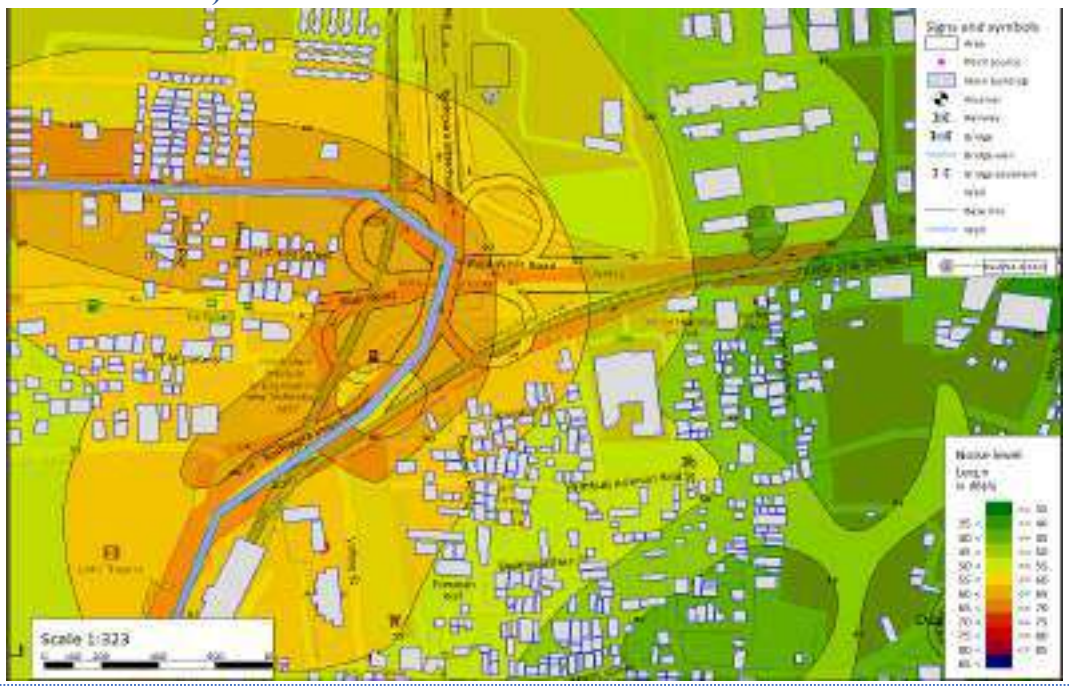


Figure 7-31: Night time Noise contour map for Operation phase (St. Wesley church to Alandur).

Figure 7-32: National School - Day time - Noise contour map for Operation phase after Mitigation

Figure 7-33: National School - Night time- Noise contour map for Operation phase after Mitigation

7.3.8 RAVINDRA BHARATHI GLOBAL SCHOOL

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (Venkateswara Nagar to Echankadu Bus Stop) is shown in **Figure 7-34** and **Figure 7-35** respectively.

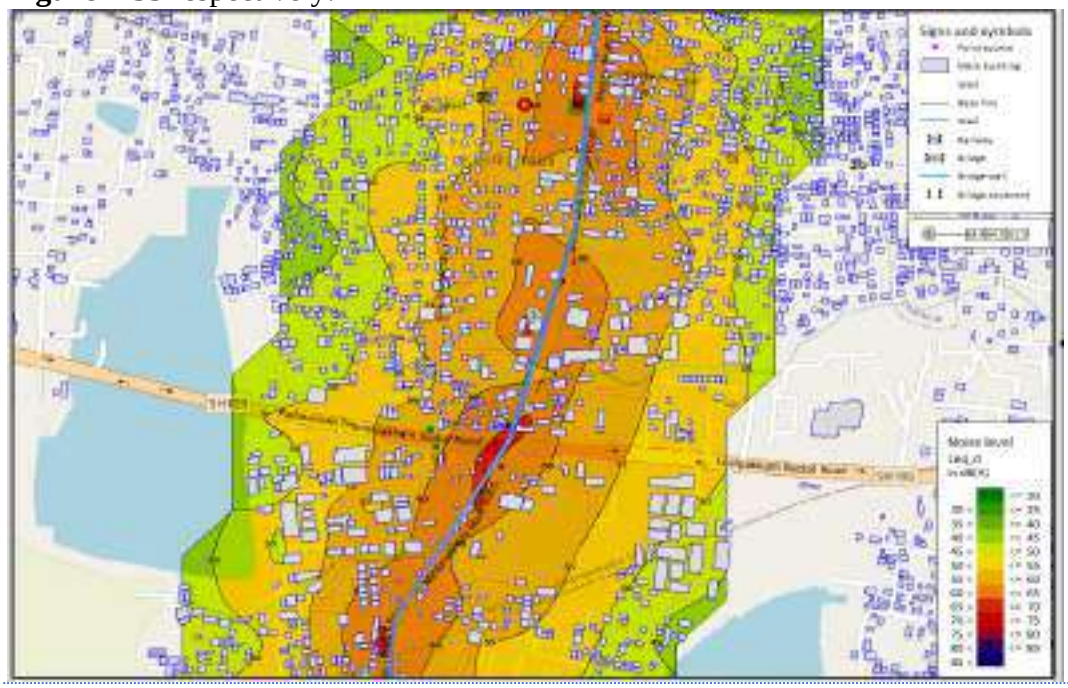


Figure 7-34: Day time Noise contour map for Operation phase (Venkateswara Nagar to Echankadu Bus Stop).

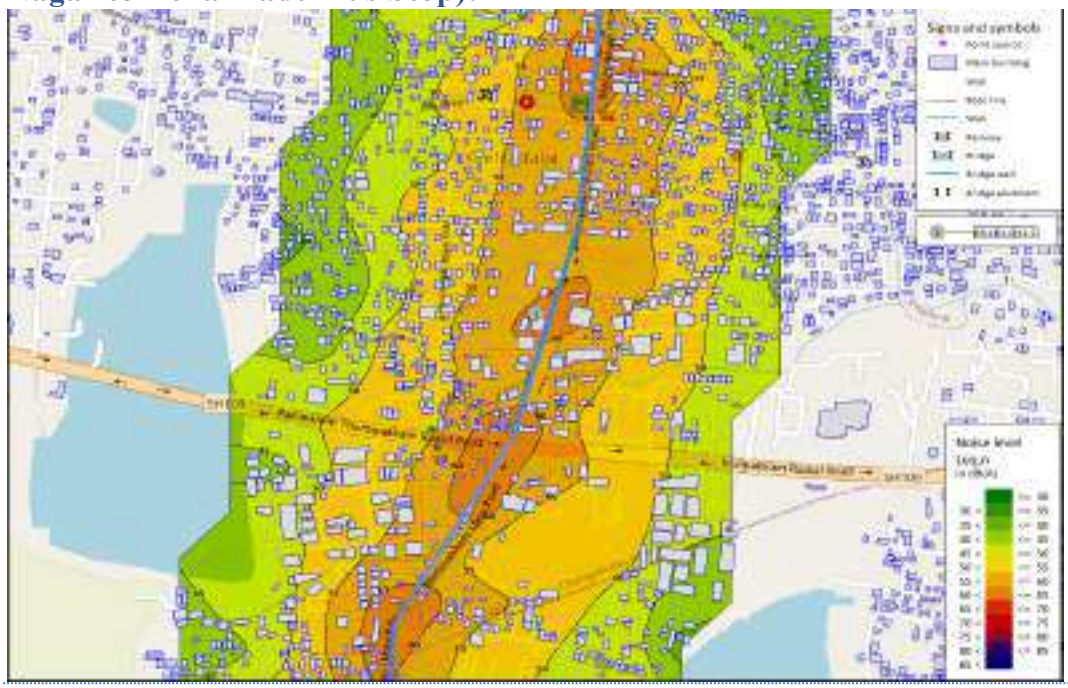


Figure 7-35: Night time Noise contour map for Operation phase (Venkateswara Nagar to Echankadu Bus Stop).

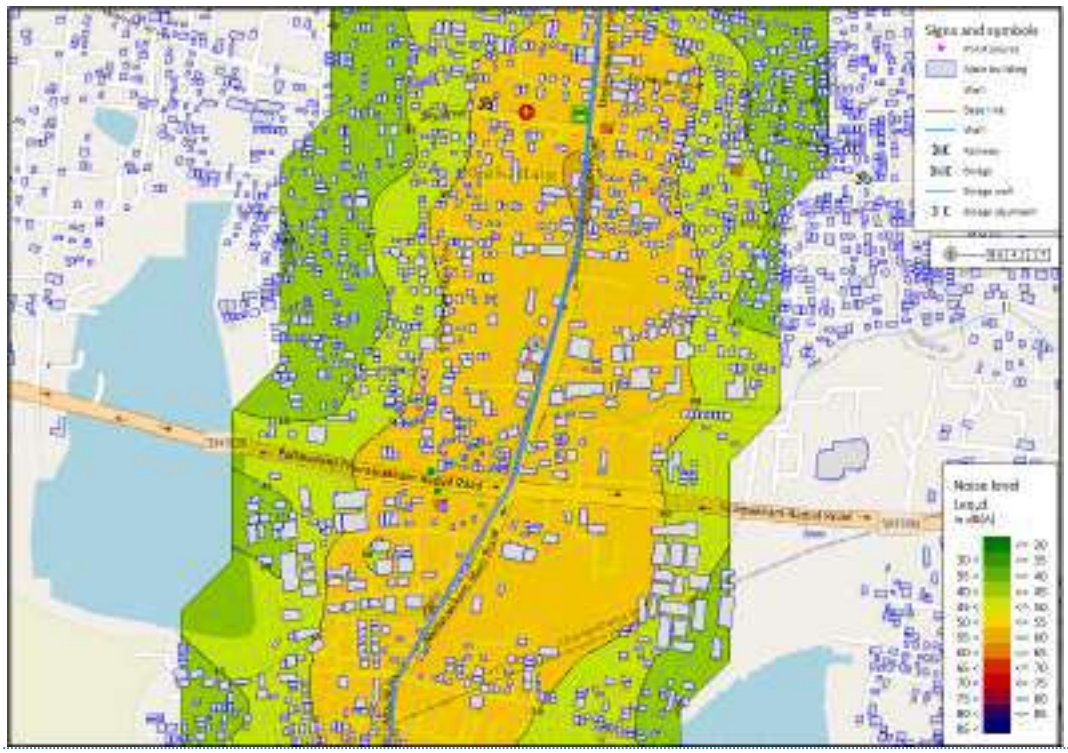


Figure 7-36: Ravindra Bharathi Global School - Day time - Noise contour map for Operation phase after Mitigation

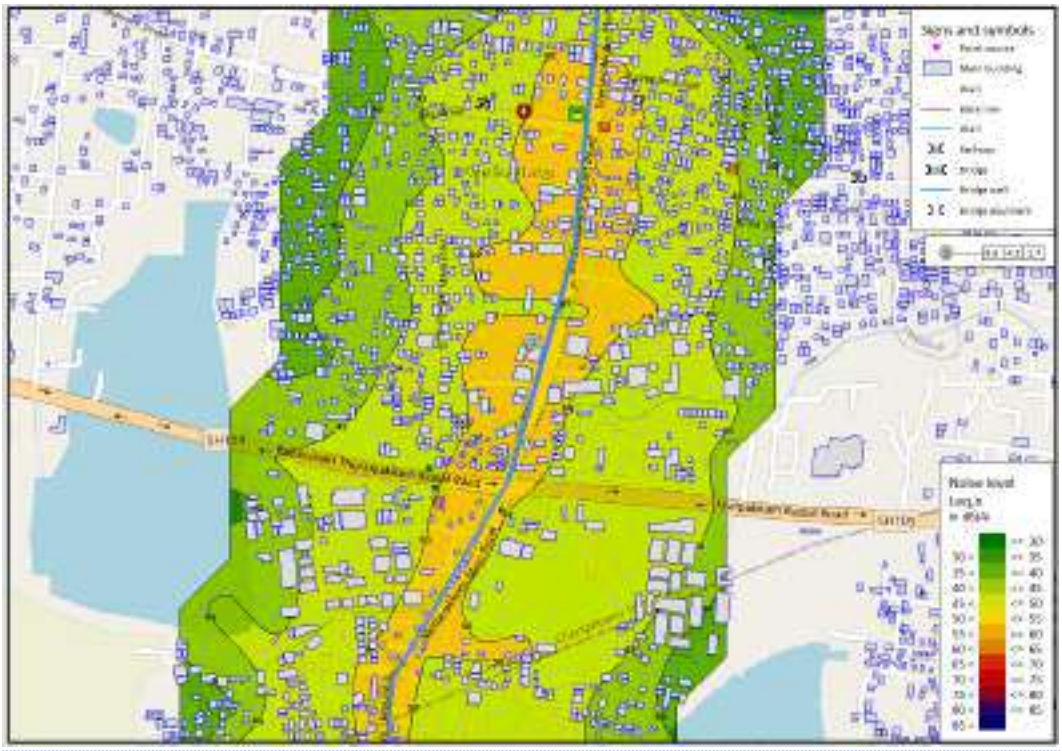


Figure 7-37: Ravindra Bharathi Global School - Night time- Noise contour map for Operation phase after Mitigation

7.3.9 SRI VARASIDHI VINAYAGAR TEMPLE

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (Vellakallu Bus Stop to Medavakkam Koot Road Bus Stop) is shown in **Figure 7-38** and **Figure 7-39** respectively.

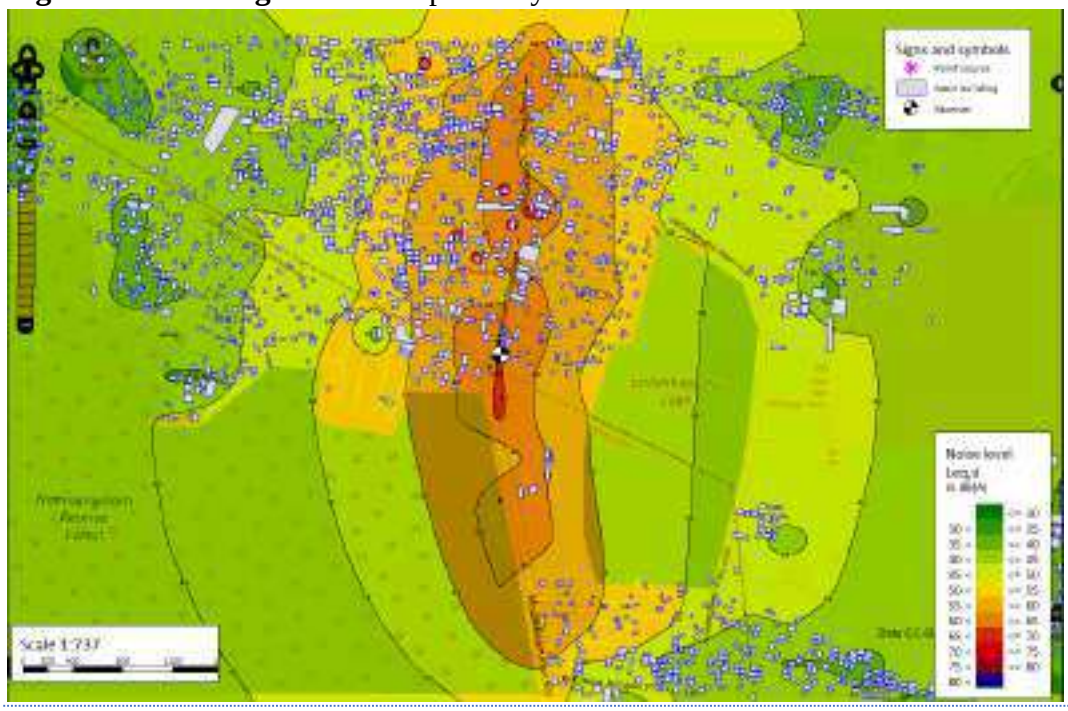


Figure 7-38: Day time Noise contour map for Operation phase (Vellakallu Bus Stop to Medavakkam Koot Road Bus Stop).

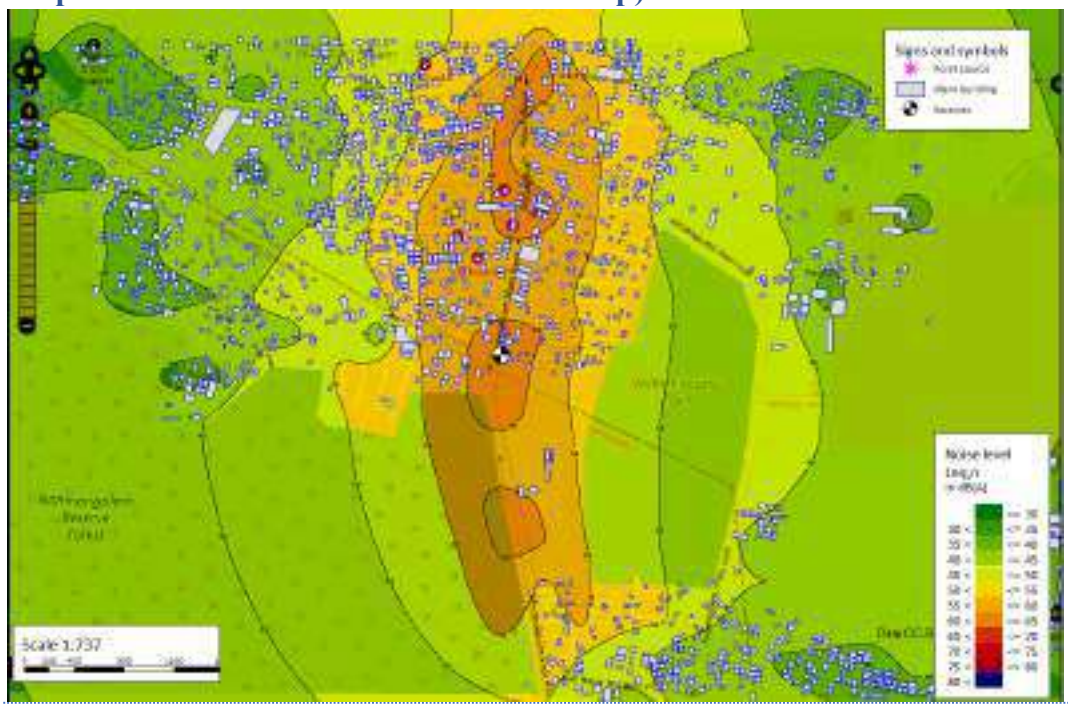


Figure 7-39: Night time Noise contour map for Operation phase (Vellakallu Bus Stop to Medavakkam Koot Road Bus Stop).

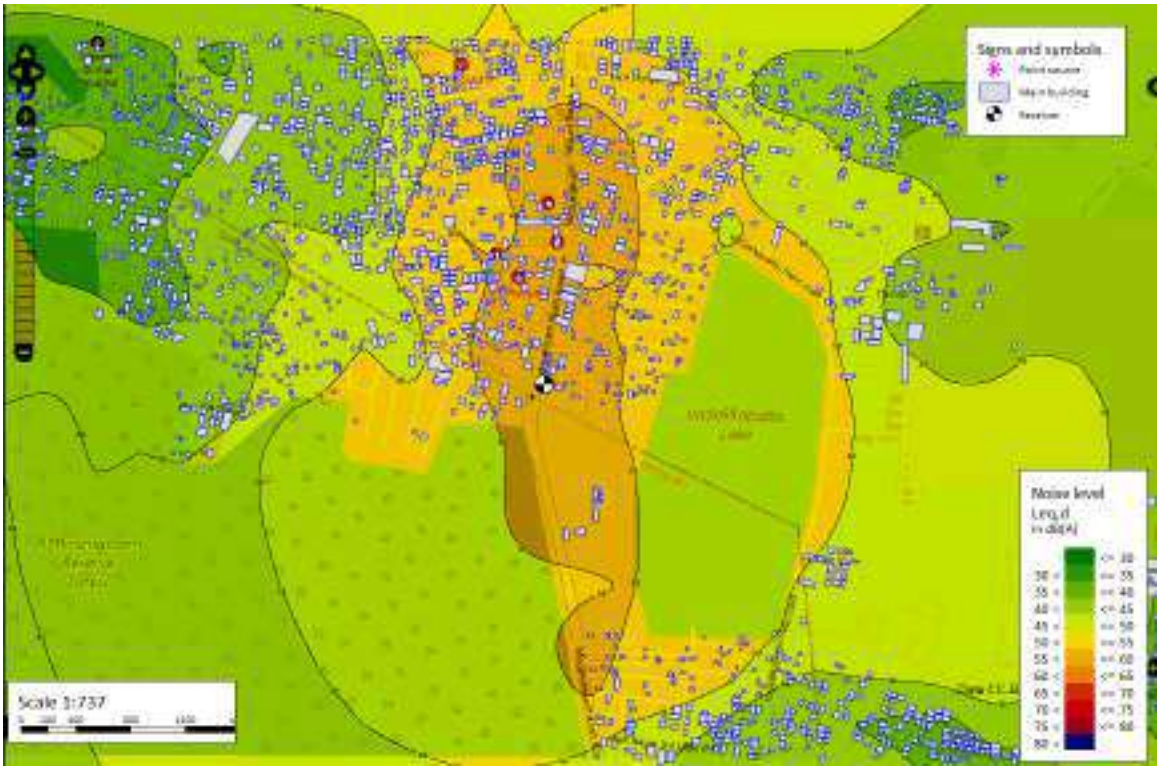


Figure *7-40*: Sri Varasidhi Vinayagar Temple- Day time - Noise contour map for Operation phase after Mitigation

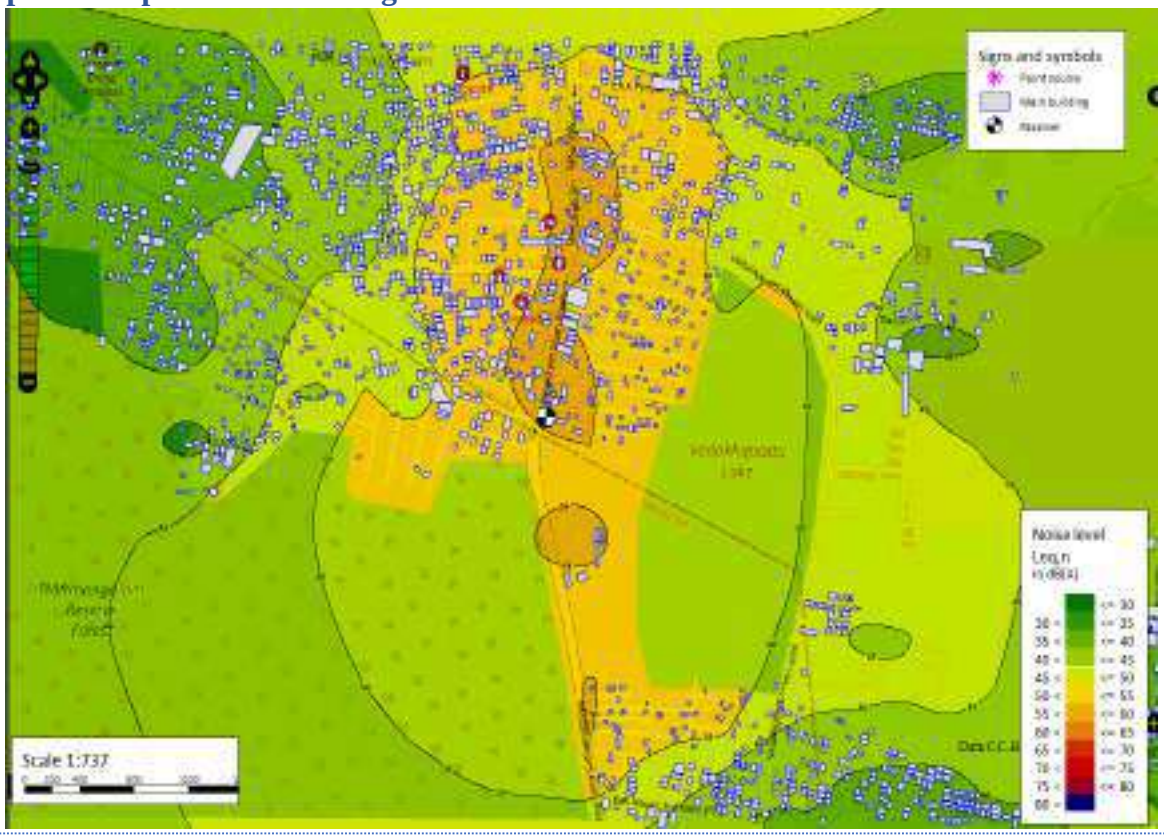


Figure 7-41: Sri Varasidhi Vinayagar Temple- Night time- Noise contour map for Operation phase after Mitigation

7.3.10 ST. JOSEPH SCHOOL

The Day (7.00 A.M – 10 P.M) and Night (10.00 P.M – 7.00 A.M) Noise contour map for the operation phase (CTC to St. Wesley Church) is shown in **Figure 7-38** and **Figure 7-39** respectively.

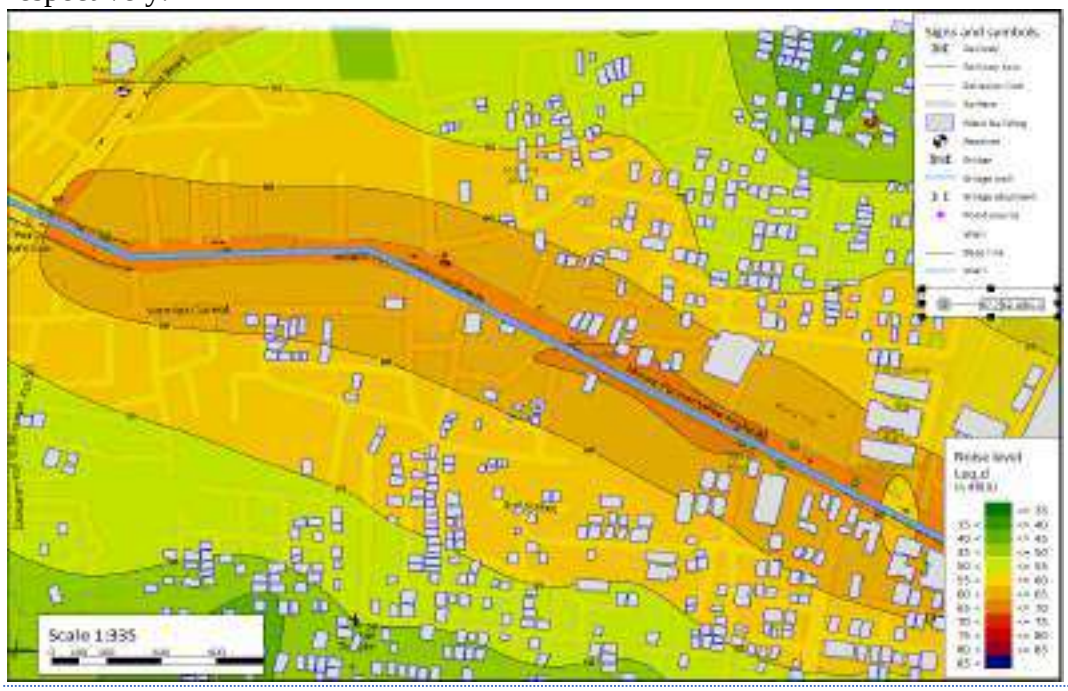


Figure 7-42: Day time Noise contour map for Operation phase (CTC to St. Wesley Church).

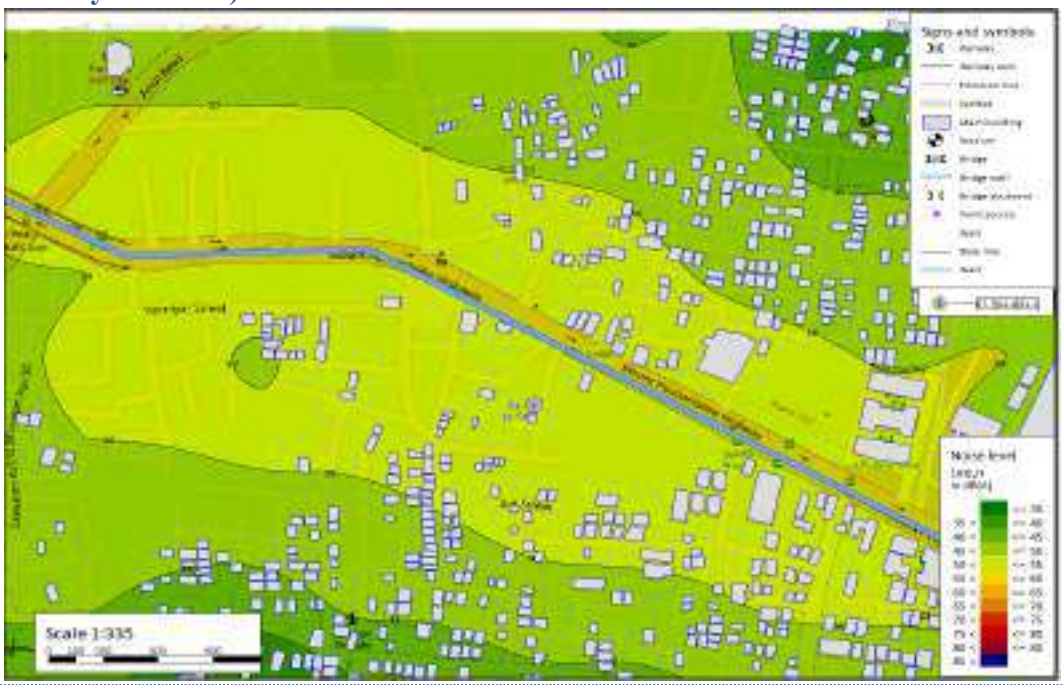


Figure 7-43: Night time Noise contour map for Operation phase (CTC to St. Wesley Church).

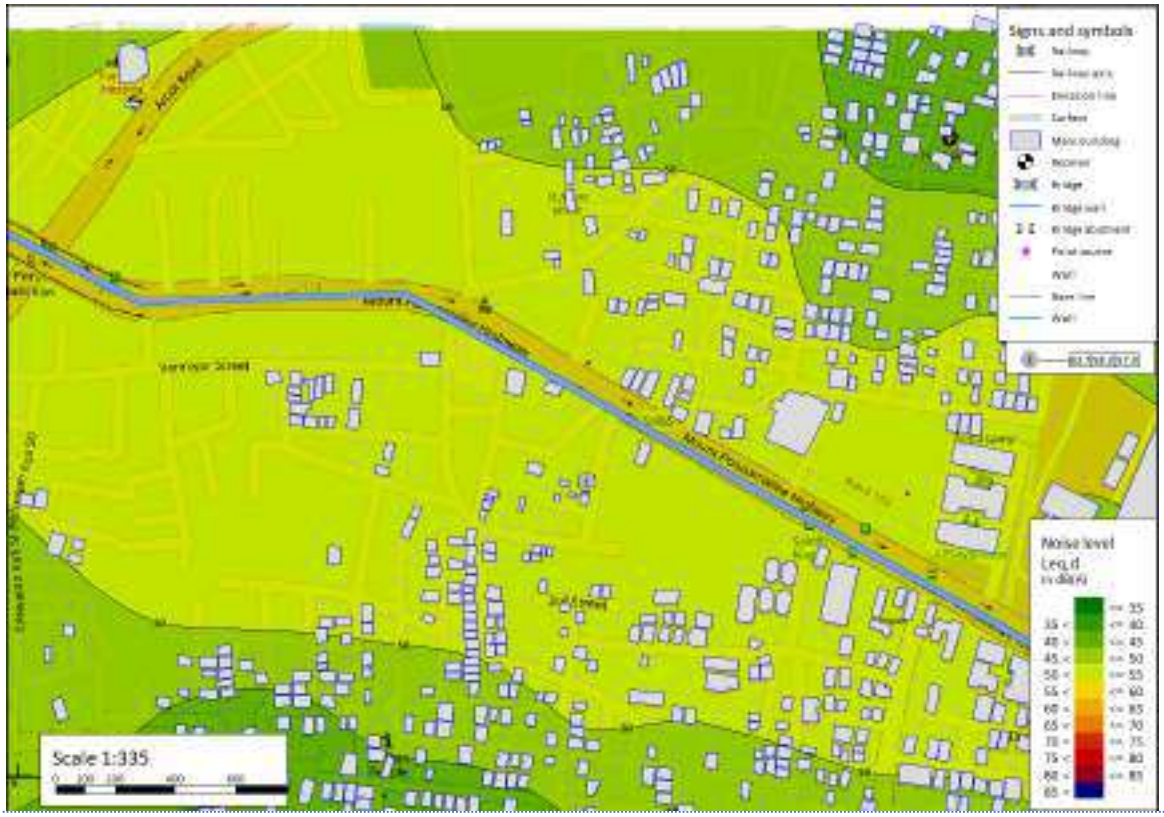


Figure 7-44: St. Joseph School - Day time - Noise contour map for Operation phase after Mitigation

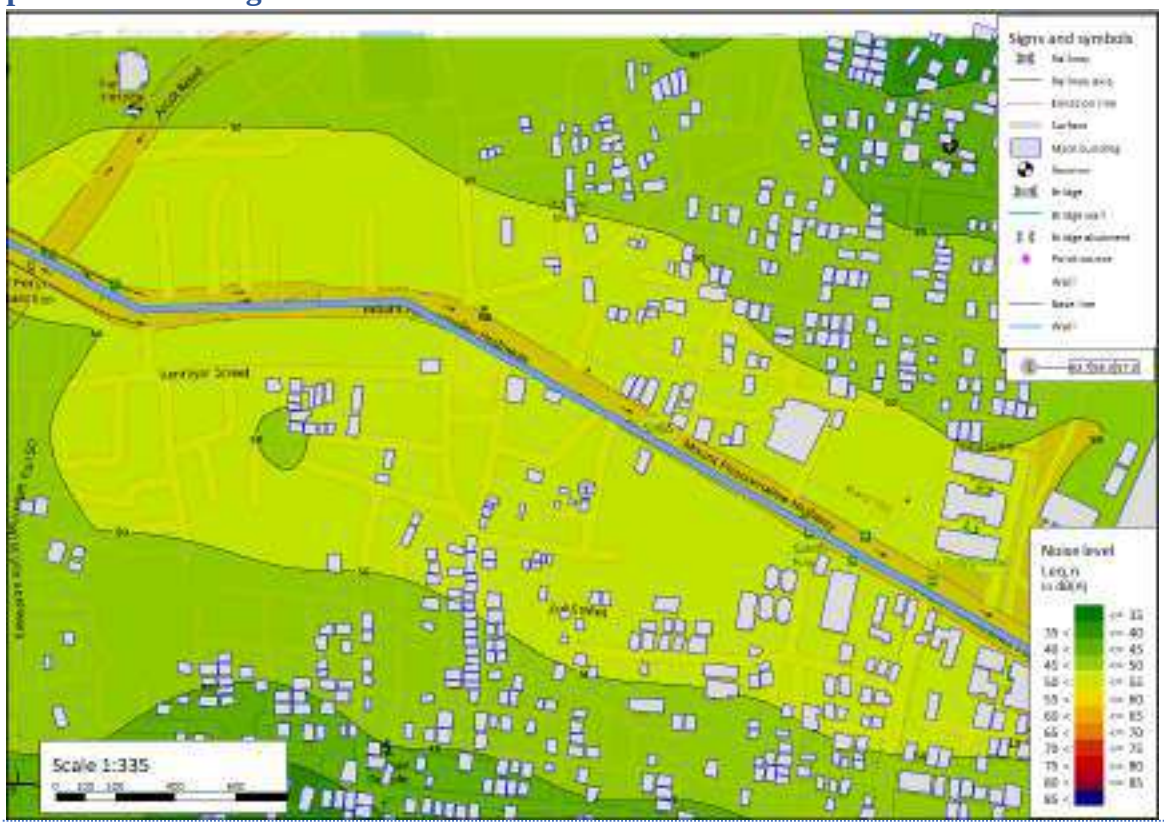


Figure 7-45: St. Joseph School - Night time- Noise contour map for Operation phase after Mitigation

7.4 OPERATION NOISE ASSESSMENT AT RESIDENTIAL RECEPTORS

7.4.1 OPERATION IMPACT ANALYSIS FOR HR-1 AND HR-2

Table 7-7: Operation Noise- HR-1– with and without mitigation

ID	HR1									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	71	65	60	58	71	66	49	46	71	65
Floor										
1st	65	57	60	58	66	62	49	46	65	57
2nd	61	57	61	58	64	62	48	45	61	57
3rd	60	53	62	59	64	62	48	45	60	53
4th	62	56	62	59	65	63	47	45	62	56
5th	64	59	62	59	66	64	47	44	64	59

HR- 1 showed no Impact as per the criteria specified in Table 5-2: Noise Levels Defining Impact for Transit Projects

Table 7-8: Operation Noise- HR-2–with and without mitigation

ID	HR2									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	69	61	62	59	69	63	50	47	69	61
Floor										
1st	64	54	62	59	66	63	50	47	64	55
2nd	66	56	63	60	67	63	49	47	66	57
3rd	62	54	63	60	66	64	49	46	62	55
4th	61	54	64	61	65	64	49	46	61	55
5th	63	57	64	61	67	65	49	46	63	58
6th	62	54	64	61	66	64	49	46	62	55
7th	63	54	64	61	67	64	49	46	64	55
8th	62	54	64	61	66	64	49	46	63	55
9th	64	54	64	61	67	64	49	46	64	55
10th	62	56	63	61	66	64	48	46	62	56
11th	64	54	63	60	67	64	48	45	64	55
12th	63	56	63	60	66	64	48	45	63	56
13th	61	55	63	60	65	63	48	45	61	56

Figure 7-46: Operation Noise at HR-1 and HR-2- Day Time – No Mitigation

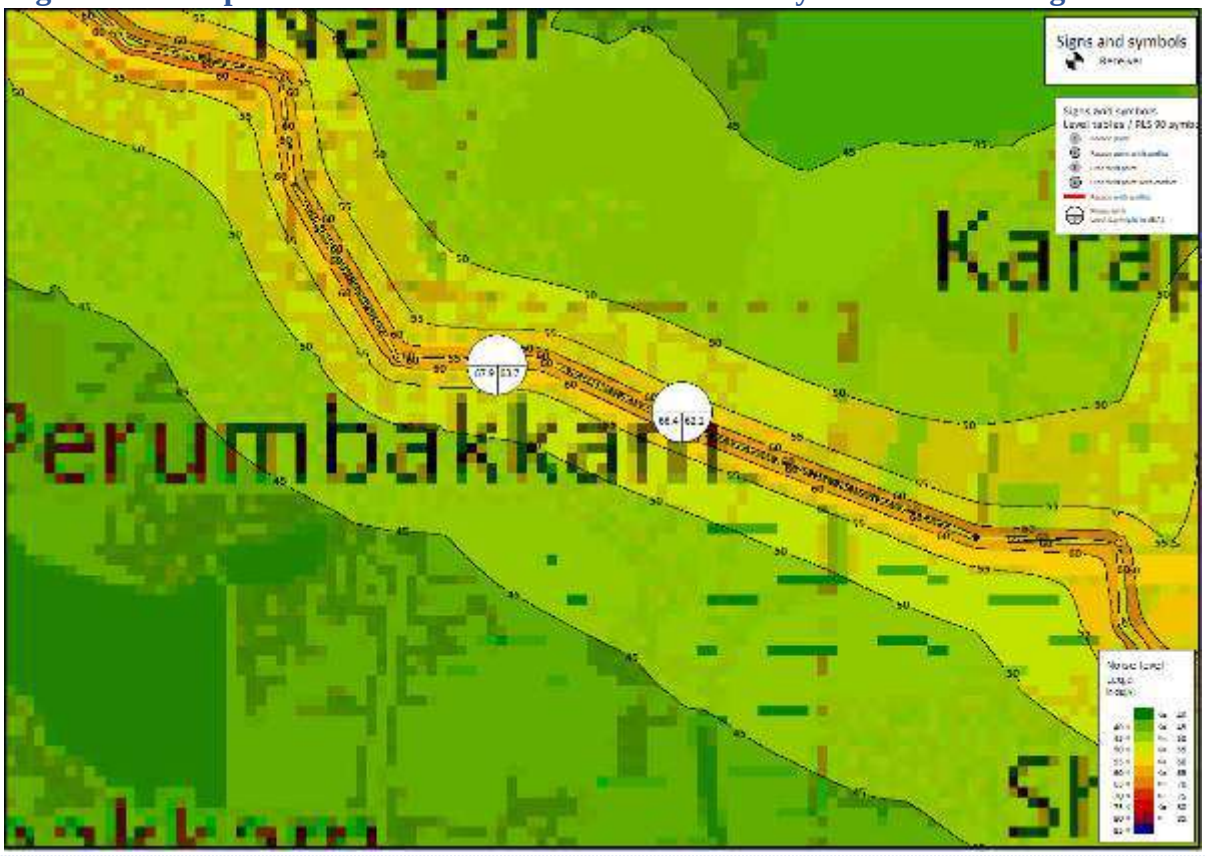


Figure 7-47: Operation Noise at HR-1 and HR-2- Night-time- No Mitigation

Figure 7-48: Operation Noise at HR-1 and HR-2- Day Time – with Mitigation

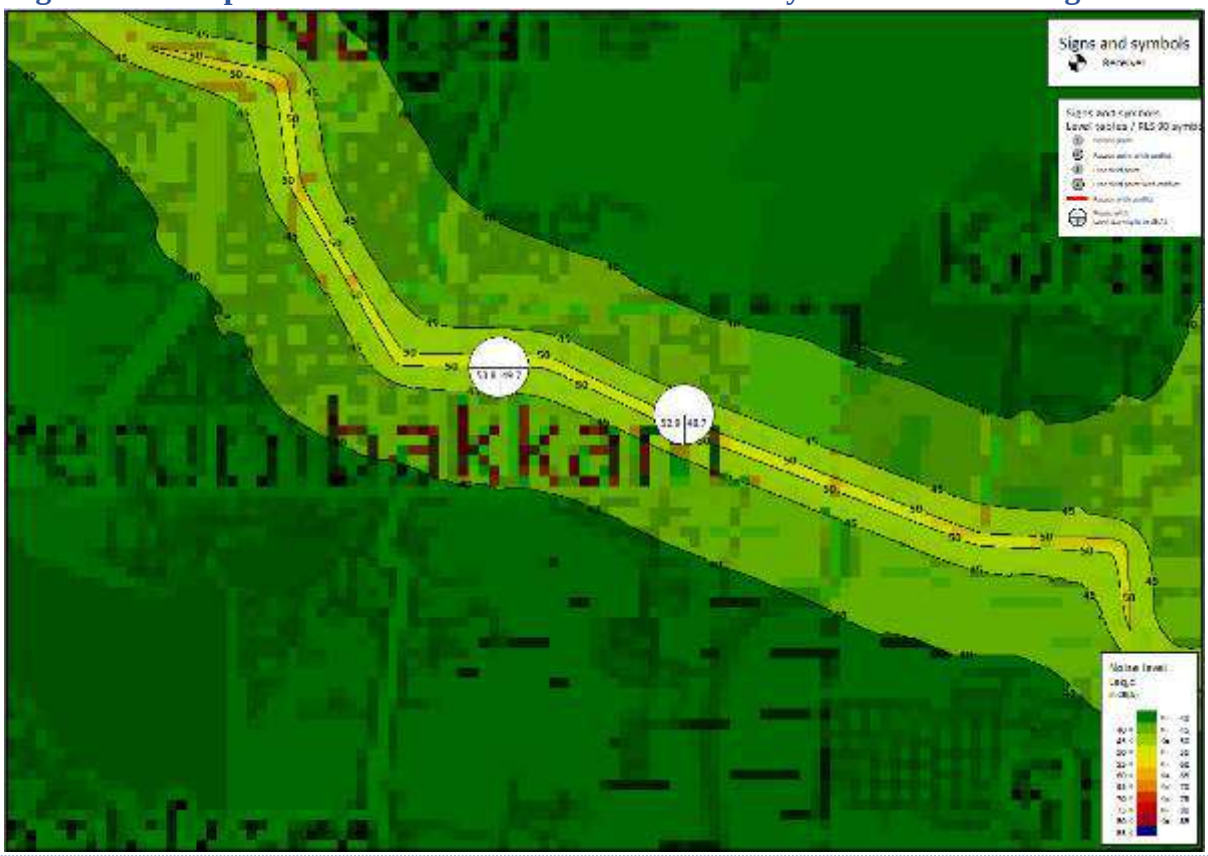


Figure 7-49: Operation Noise at HR-1 and HR-2- Night-time – with Mitigation

7.4.2 OPERATION IMPACT ANALYSIS FOR HR-3, HR-4, HR-5 AND HR-6

Table 7-9: Operation Noise- HR-3– with and without mitigation

ID	HR3									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	66	60	59	56	67	61	51	48	66	60
Floor										
1st	68	58	59	56	68	62	51	48	68	56
2nd	64	58	60	57	66	62	51	48	64	57
3rd	66	58	60	58	67	62	52	49	66	56
4th	62	56	61	58	65	62	52	50	62	56

Table 7-10: Operation Noise- HR-4– with and without mitigation

ID	HR4									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	Impact			No-Impact	No-Impact
Noise Level	63	56	60	57	65	60	47	45	63	57
Floor										
1st	60	50	60	57	63	60	47	45	60	55
2nd	62	52	61	58	64	61	47	44	62	56
3rd	63	52	61	58	65	62	46	44	63	55
4th	62	52	61	58	65	62	46	44	63	55
5th	63	53	61	59	65	62	46	44	63	57

Table 7-11: Operation Noise- HR-5– with and without mitigation

ID	HR5									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	66	61	55	53	67	61	46	43	66	61
Floor										
1st	64	57	55	53	64	59	46	43	64	55
2nd	64	58	56	53	64	60	45	42	64	56
3rd	64	58	56	53	65	60	44	41	64	54

Table 7-12: Operation Noise- HR-6– with and without mitigation

ID	HR-6									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	67	64	60	58	68	65	49	46	67	64
Floor										
1st	63	55	60	58	65	61	49	46	63	55
2nd	67	57	61	58	68	62	49	46	67	56

Figure 7-50: Operation Noise at HR-3 Day Time – No Mitigation

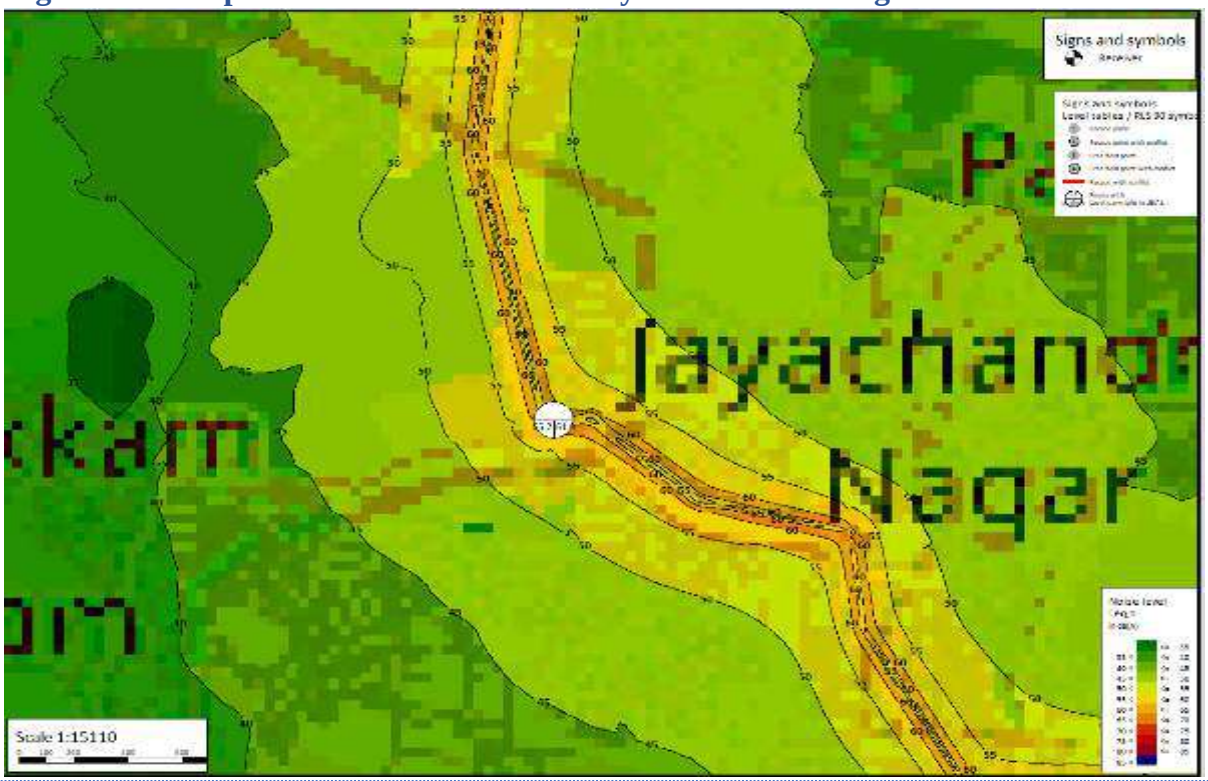


Figure 7-51: Operation Noise at HR-3 - Nighttime- No Mitigation

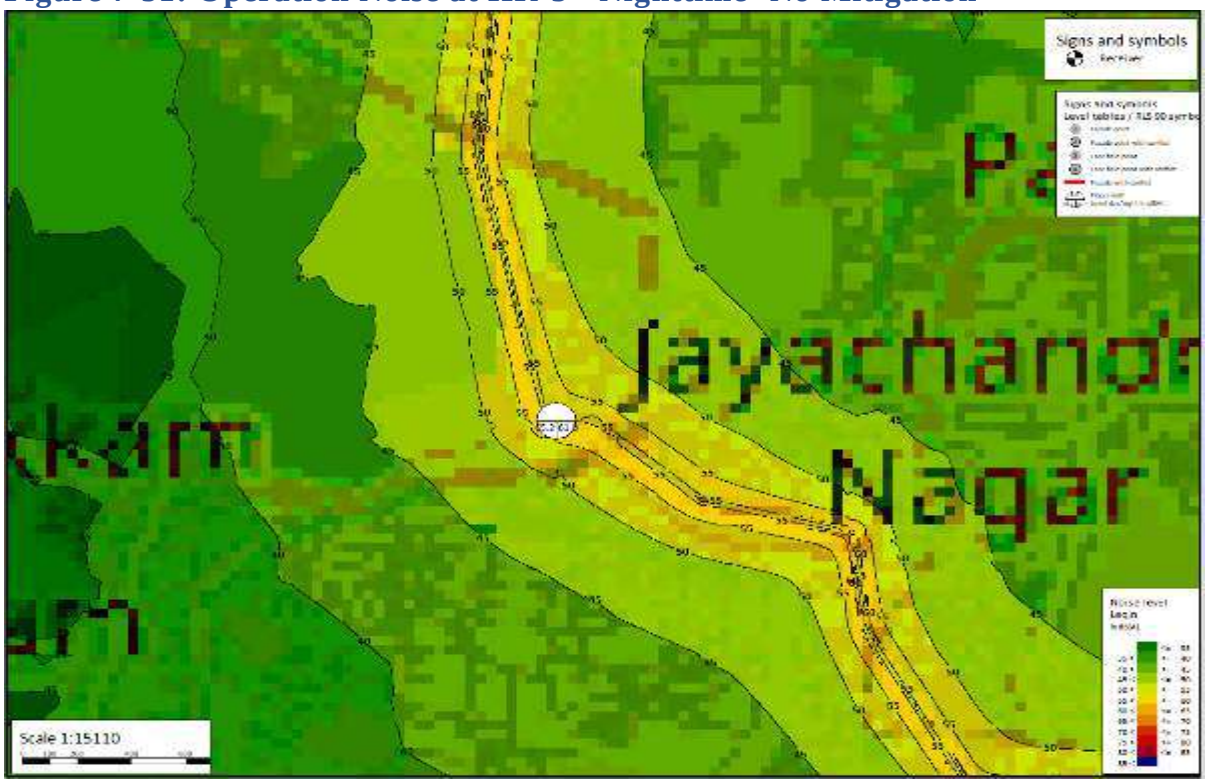


Figure 7-52: Operation Noise at HR-3 - Day Time – with Mitigation

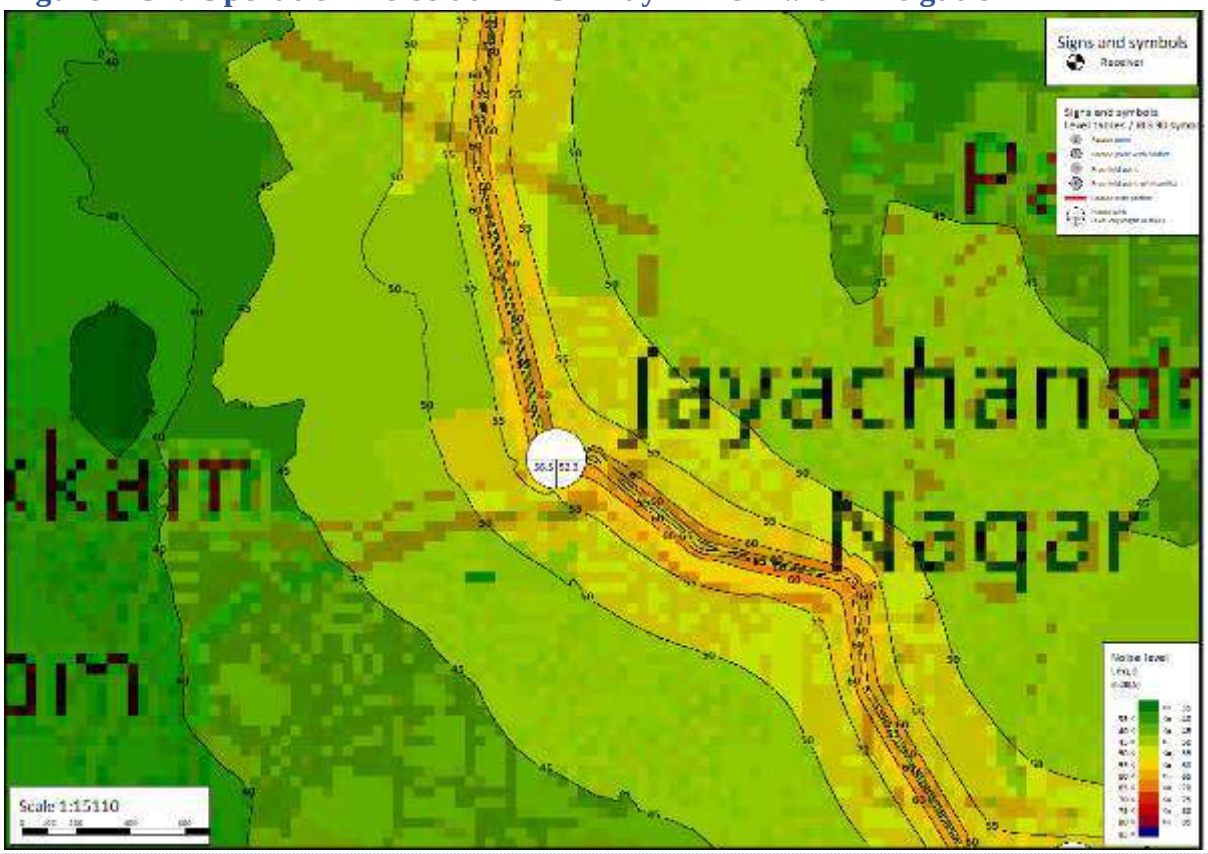


Figure 7-53: Operation Noise at HR-3- Night-time – with Mitigation

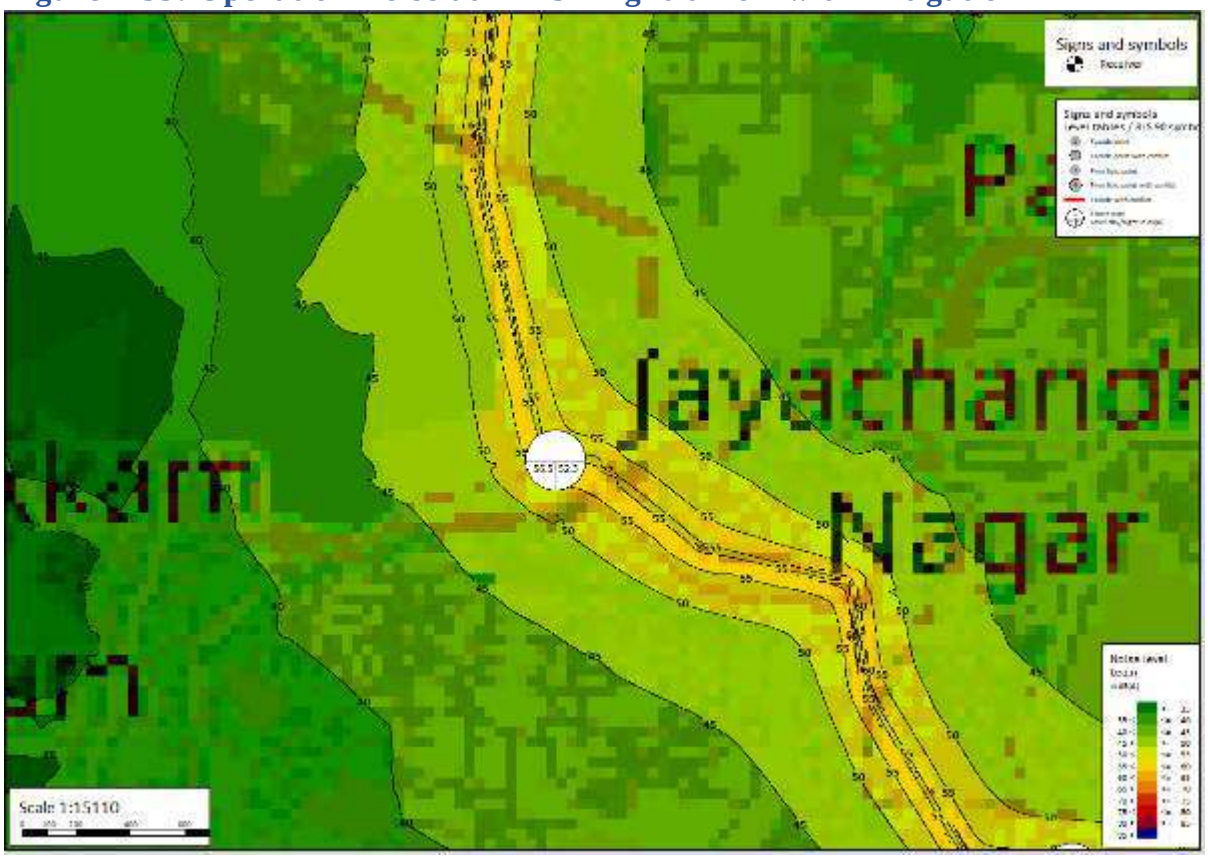


Figure 7-54: Operation Noise at HR-4 Day Time – No Mitigation

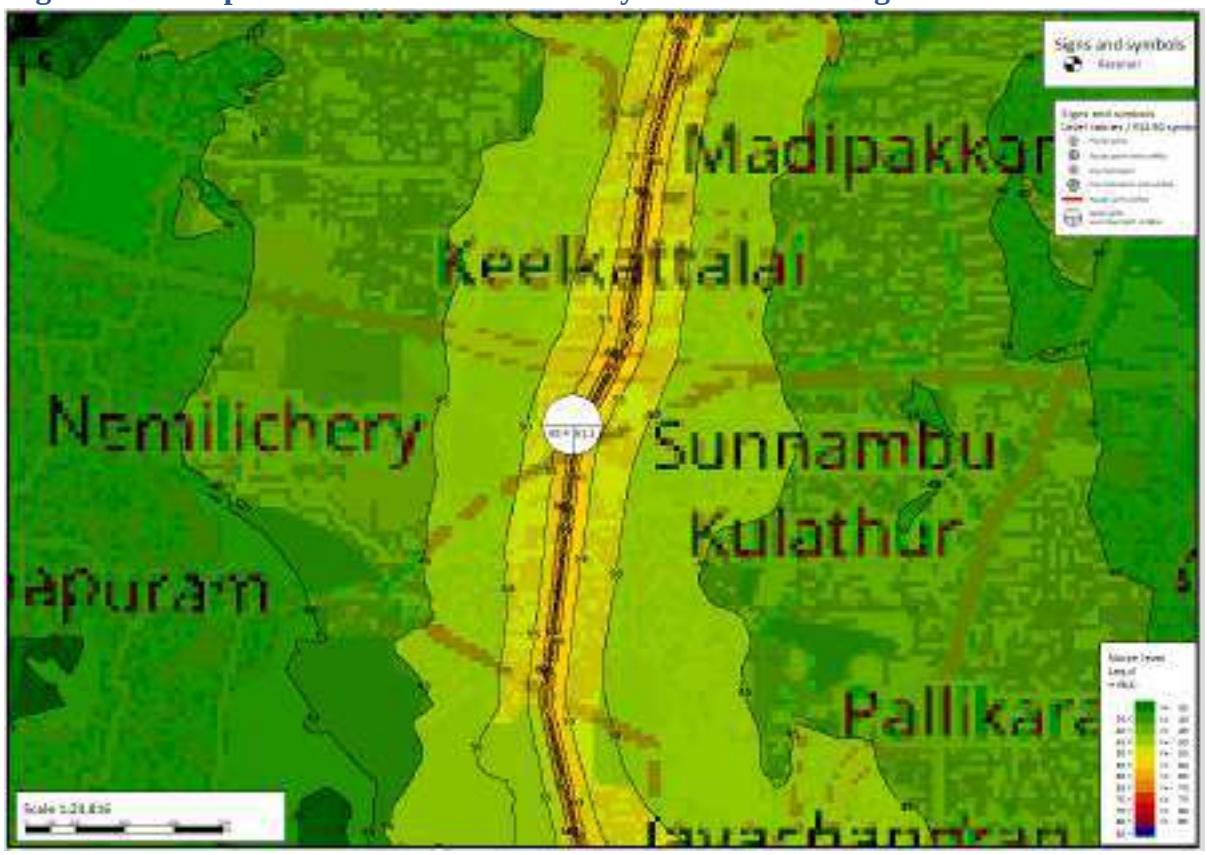


Figure 7-55: Operation Noise at HR-4- Night-time- No Mitigation

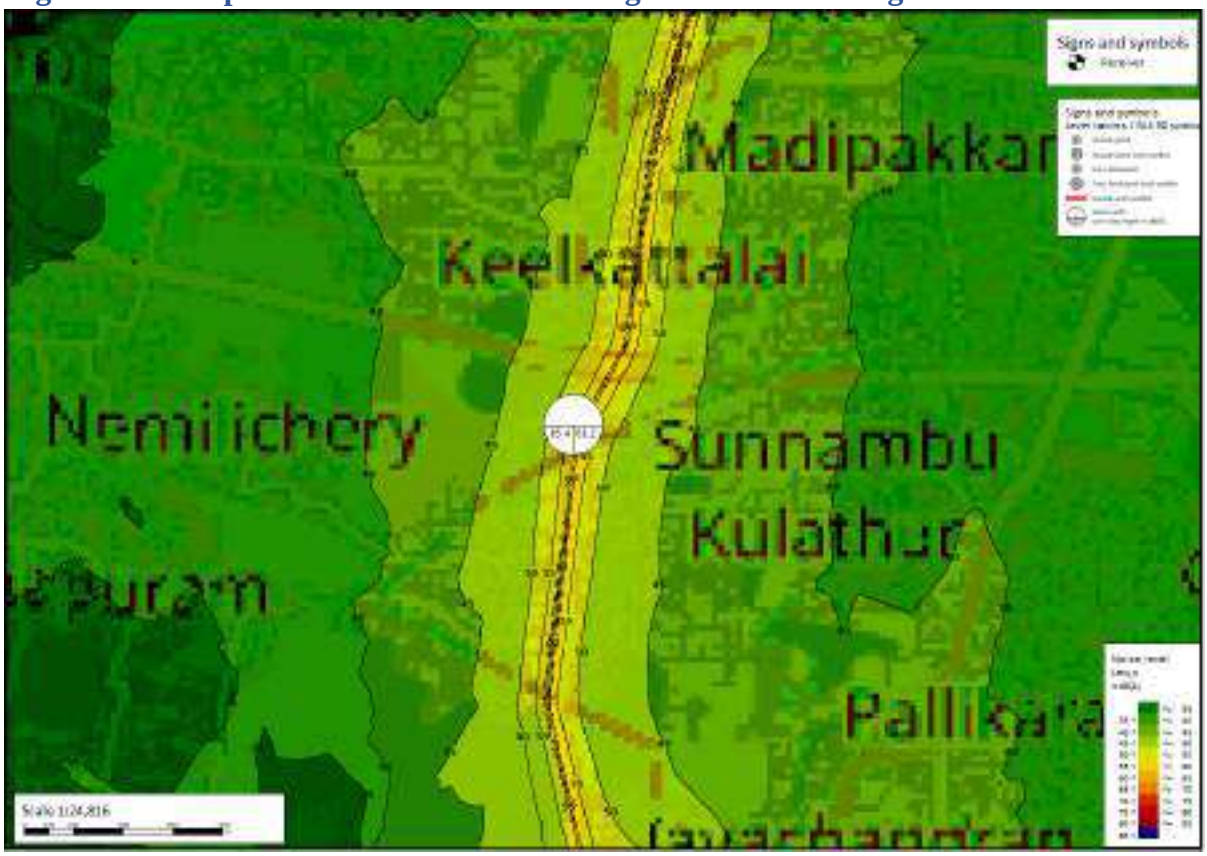


Figure 7-56: Operation Noise at HR-4- Day Time – with Mitigation

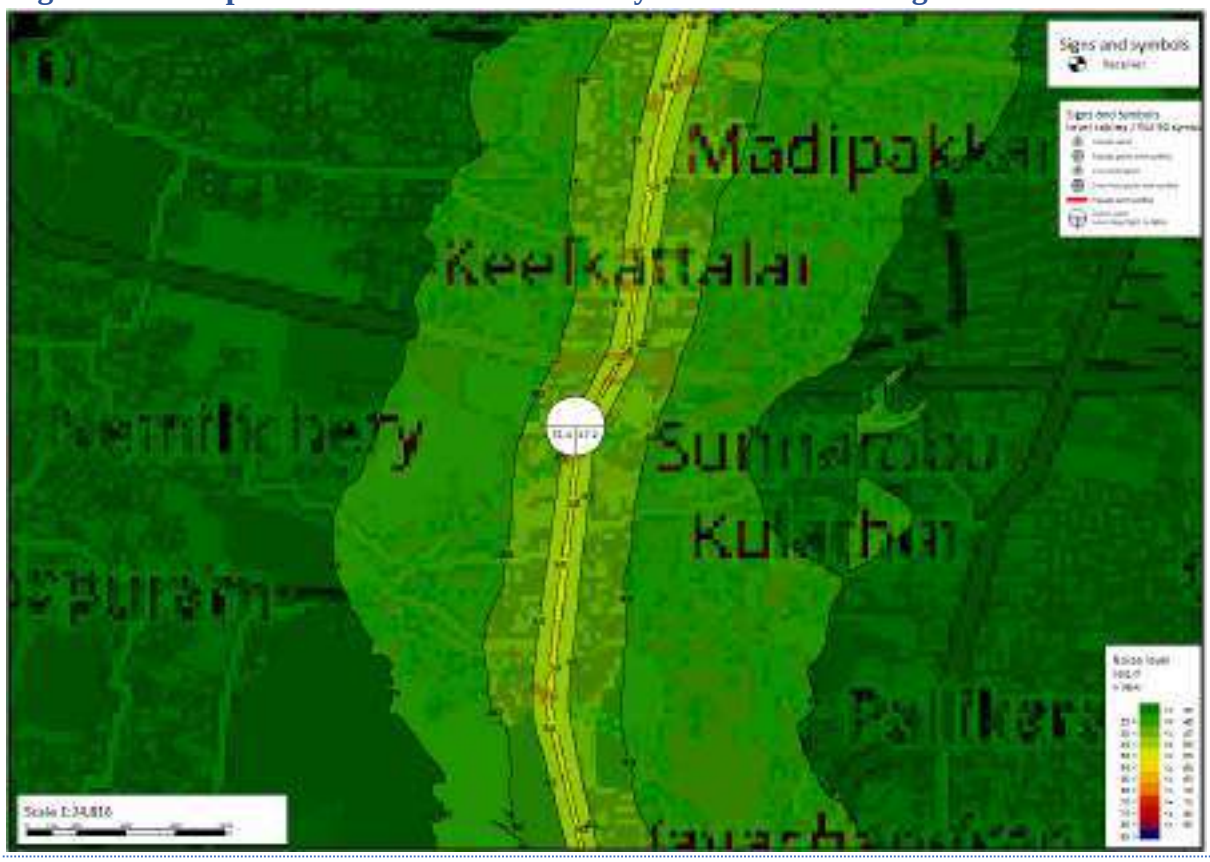
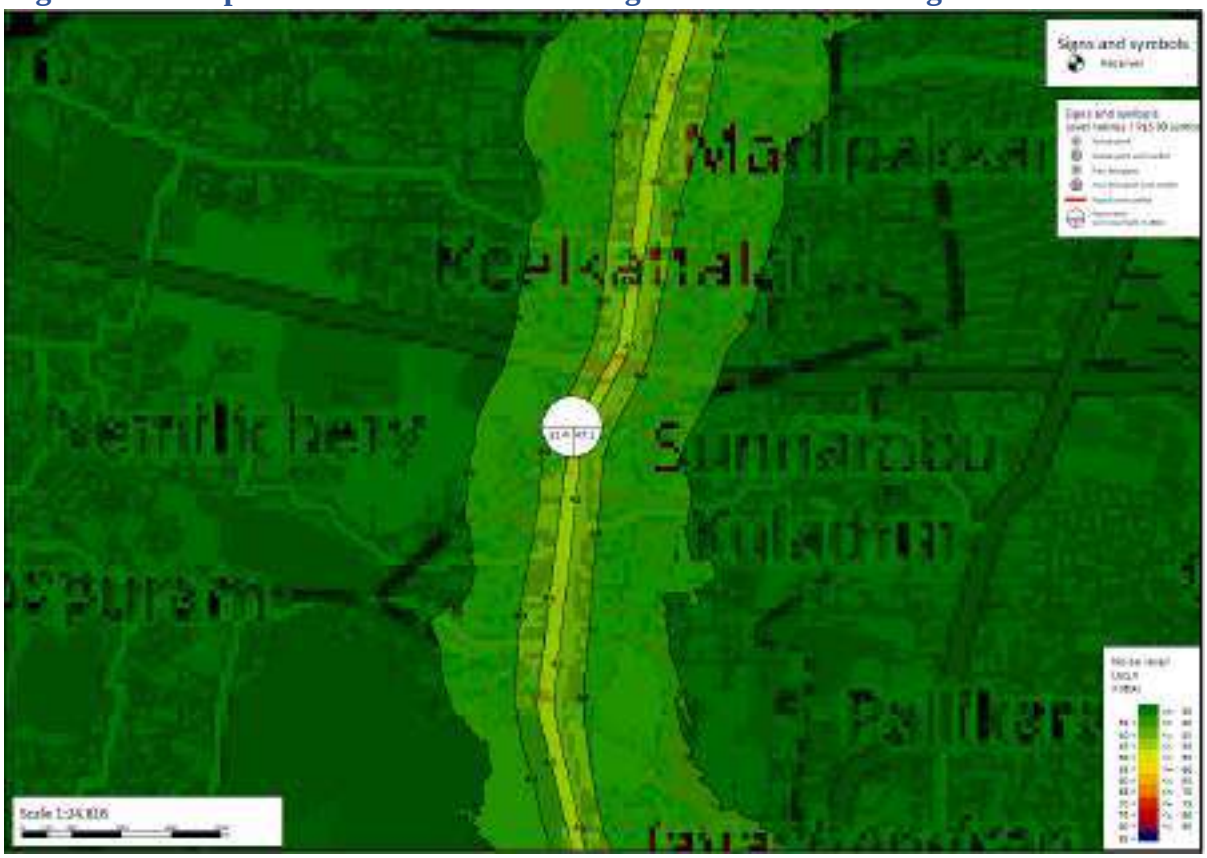


Figure 7-57: Operation Noise at HR-4- Night-time – with Mitigation



7.4.3 OPERATION IMPACT ANALYSIS FOR HR-6, HR-7, HR-8 AND HR-9

Table 7-13: Operation Noise- HR-6– with and without mitigation

ID	HR-6									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	67	64	60	58	68	65	49	46	67	64
Floor										
1st	63	55	60	58	65	61	49	46	63	55
2nd	67	57	61	58	68	62	49	46	67	56

Table 7-14: Operation Noise- HR-7– with and without mitigation

ID	HR-7									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	69.4	62.8	59	56	70	64	48	45	69	63
Floor										
1st	60.7	53.6	59.1	56.3	63	60	48	45	61	57
2nd	59.1	53.1	59.8	57	62	61	48	45	59	58
3rd	62	52.9	60.4	57.6	64	61	47	44	62	61
4th	60.8	55.5	61	58.2	64	62	46	44	61	57
5th	65.6	57.8	61.1	58.3	67	63	46	43	66	58
6th	64.8	56.9	61.1	58.3	66	62	46.2	43.4	65	58
7th	65.3	57.7	61.1	58.3	67	63	46.2	43.4	65	59
8th	65.2	57.7	61.1	58.3	67	63	46.2	43.4	65	60

Table 7-15: Operation Noise- HR-8– with and without mitigation

ID	HR8									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	65	61	61	58	66	63	49	46	65	61
Floor										
1st	61	57	61	58	64	62	49	46	61	57
2nd	62	57	62	59	65	63	49	46	62	58
3rd	61	61	62	59	65	64	48	46	61	61
4th	61	56	63	60	65	63	48	45	61	57
5th	61	58	63	60	65	64	48	45	61	58
6th	62	58	63	60	65	64	48	45	62	58
7th	63	59	63	60	66	64	48	46	64	59
8th	65	60	63	60	67	64	48	46	65	60
9th	64	61	63	60	67	65	48	46	64	61
10th	63	61	62	60	66	65	48	45	63	61

11th	62	57	62	60	65	64	48	45	62	58
12th	61	57	62	59	65	63	48	45	61	57

Table 7-16: Operation Noise- HR-9– with and without mitigation

ID	HR9									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	68	63	61	59	69	64	48	45	68	63
Floor										
1st	69	58	61	59	69	63	48	45	69	57
2nd	67	60	62	60	68	64	48	45	67	58
3rd	68	60	63	60	70	65	48	45	68	61
4th	69	60	63	61	70	65	48	46	69	57

Figure 7-58: Operation Noise at HR-5, HR-6, HR-7, HR-8 and HR-9 Day Time – No Mitigation

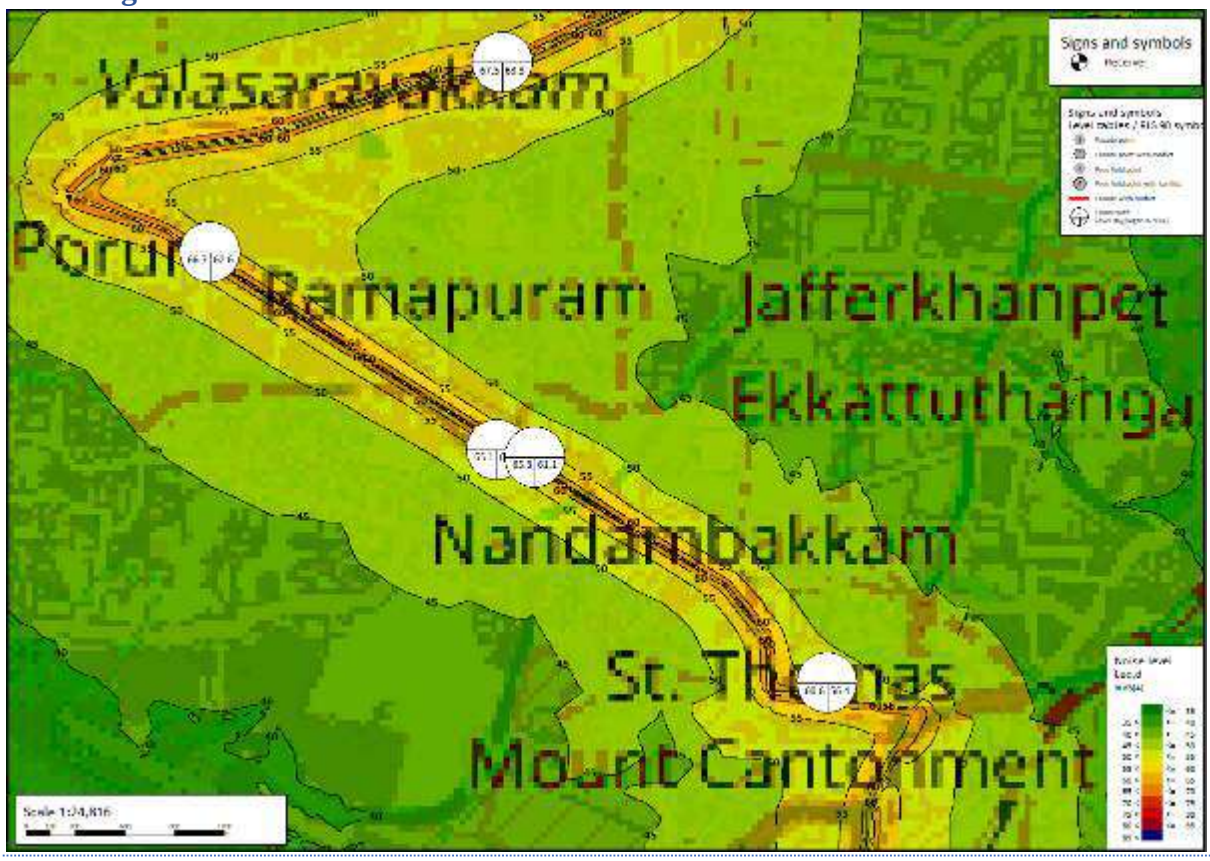


Figure 7-59: Operation Noise at HR-5, HR-6, HR-7, HR-8 and HR-9 - Night-time- No Mitigation

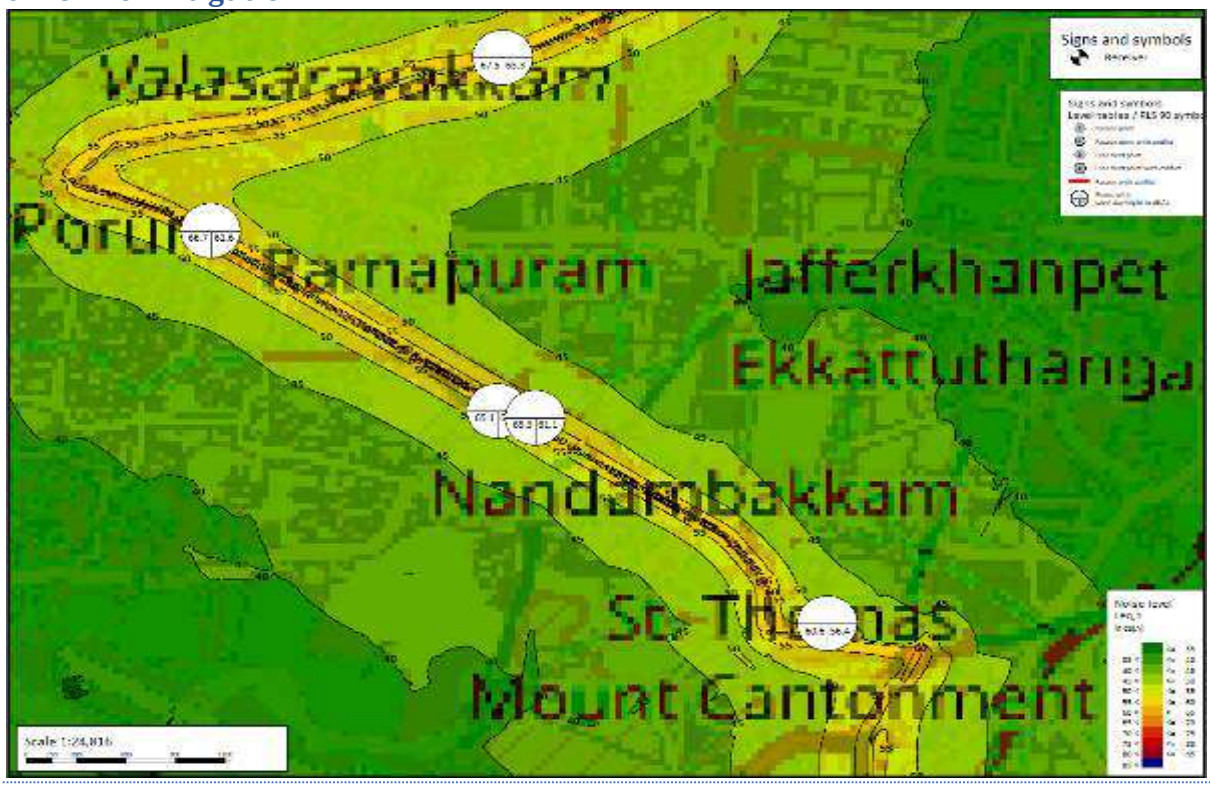


Figure 7-60: Operation Noise at HR-5, HR-6, HR-7, HR-8 and HR-9 - Day Time – with Mitigation

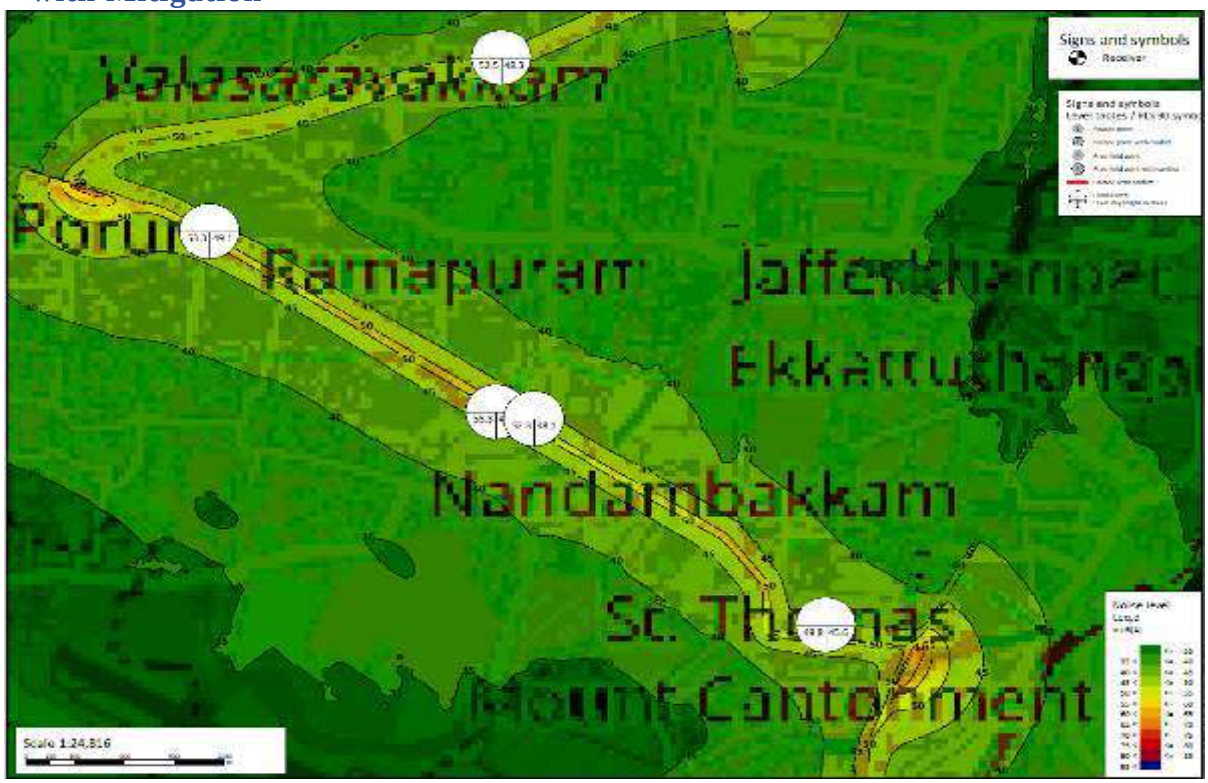
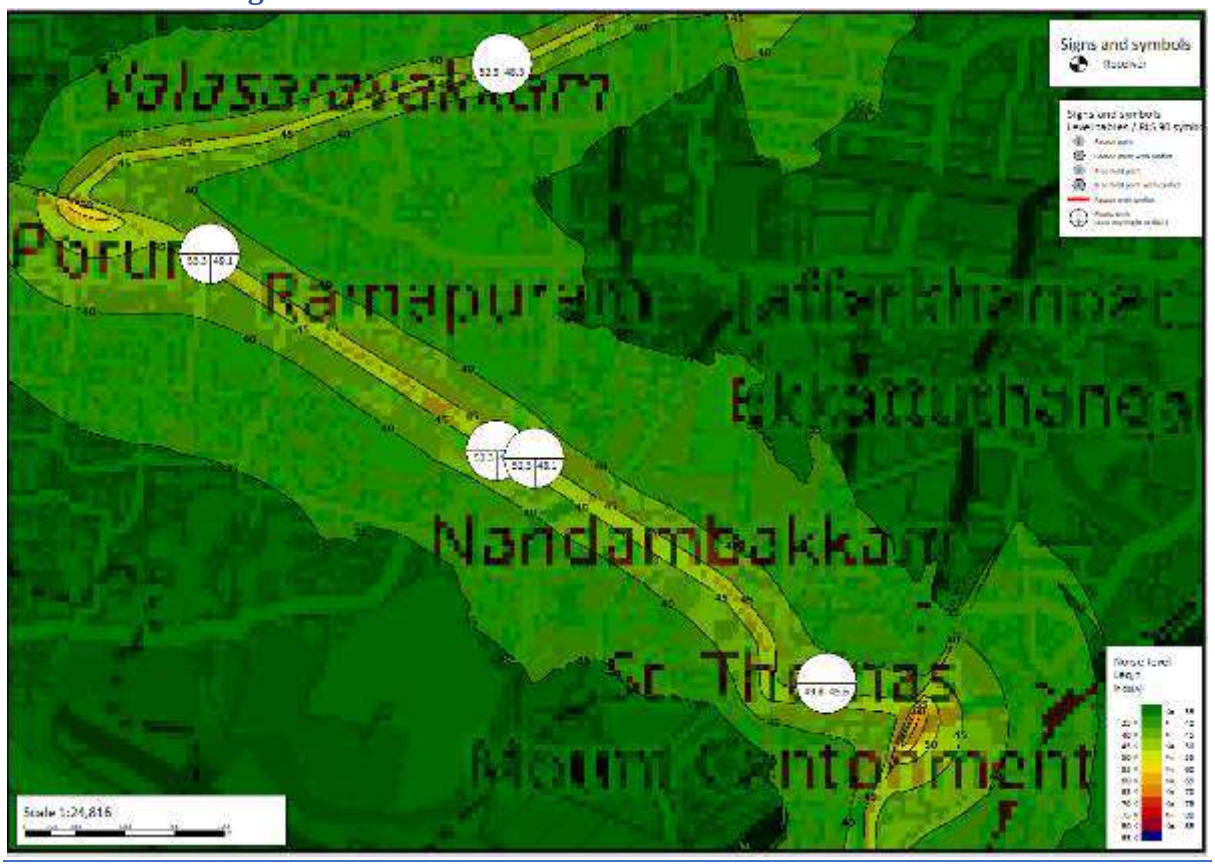


Figure 7-61: Operation Noise at HR-5, HR-6, HR-7, HR-8 and HR-9 - Night-time – with Mitigation



7.4.4 OPERATION IMPACT ANALYSIS FOR HR-10, HR-11 AND HR-12

There would be no operational impact on HR-7 and 8 as the line would be underground.

Table 7-17: Operation Noise- HR-10– with and without mitigation

ID	HR10									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	68	60	58	55	69	61	46	43	68	60
Floor										
1st	67	56	58	55	68	60	46	43	67	57
2nd	66	55	58	56	66	60	45	42	66	57
3rd	67	55	59	56	67	60	44	41	67	61
4th	68	55	59	56	69	60	44	41	68	57
5th	68	56	59	56	69	61	44	41	68	58
6th	68	56	59	56	69	61	44	41	68	58
7th	69	55	59	56	70	60	44	41	69	59
8th	69	55	59	56	69	60	44	42	69	60
9th	68	56	59	56	68	61	45	42	68	61
10th	67	55	59	56	68	60	45	42	67	61
11th	68	56	59	56	68	61	45	42	68	58
12th	67	57	59	56	68	61	45	42	67	57
13th	63	57	59	56	64	61	45	42	63	45
14th	66	56	59	56	67	61	45	42	66	45
15th	67	55	59	56	68	60	45	42	67	45

Table 7-18: Operation Noise- HR-11– with and without mitigation

ID	HR11									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	Impact			No-Impact	Impact
Noise Level	61	55	58	56	63	58	58	55	63	58
Floor										
1st	62	55	58	56	64	60	58	55	64	60
2nd	63	56	58	56	64	60	58	56	64	61
3rd	63	57	59	56	64	61	59	56	64	63

Table 7-19: Operation Noise- HR-12– with and without mitigation

ID	HR12									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	67	61	58	55	67	62	47	45	67	61
Floor										
1st	64	57	58	55	65	60	47	45	64	57
2nd	64	56	59	56	65	60	47	44	64	57
3rd	63	56	59	57	65	61	46	43	63	61
4th	63	54	60	57	65	61	45	43	63	57
5th	64	57	60	57	65	62	46	43	64	58
6th	64	54	60	57	65	61	46	43	64	58
7th	66	60	60	57	67	63	46	43	66	59
8th	66	57	60	57	67	62	46	44	66	60
9th	65	59	60	57	66	63	47	44	65	61

Figure 7-62: Operation Noise at HR-10– Day Time- No Mitigation

Figure 7-63: Operation Noise at HR-10– Night-time- No Mitigation

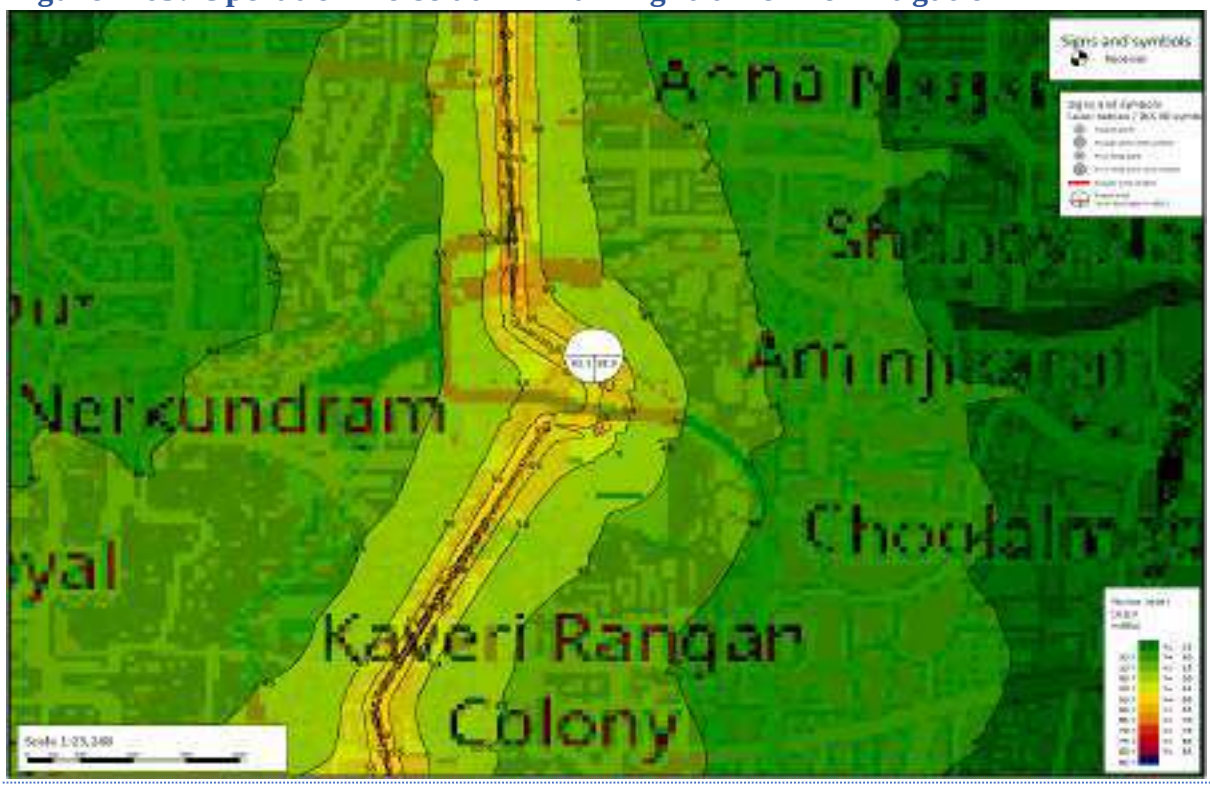


Figure 7-64: Operation Noise at HR-10– Day Time- with Mitigation

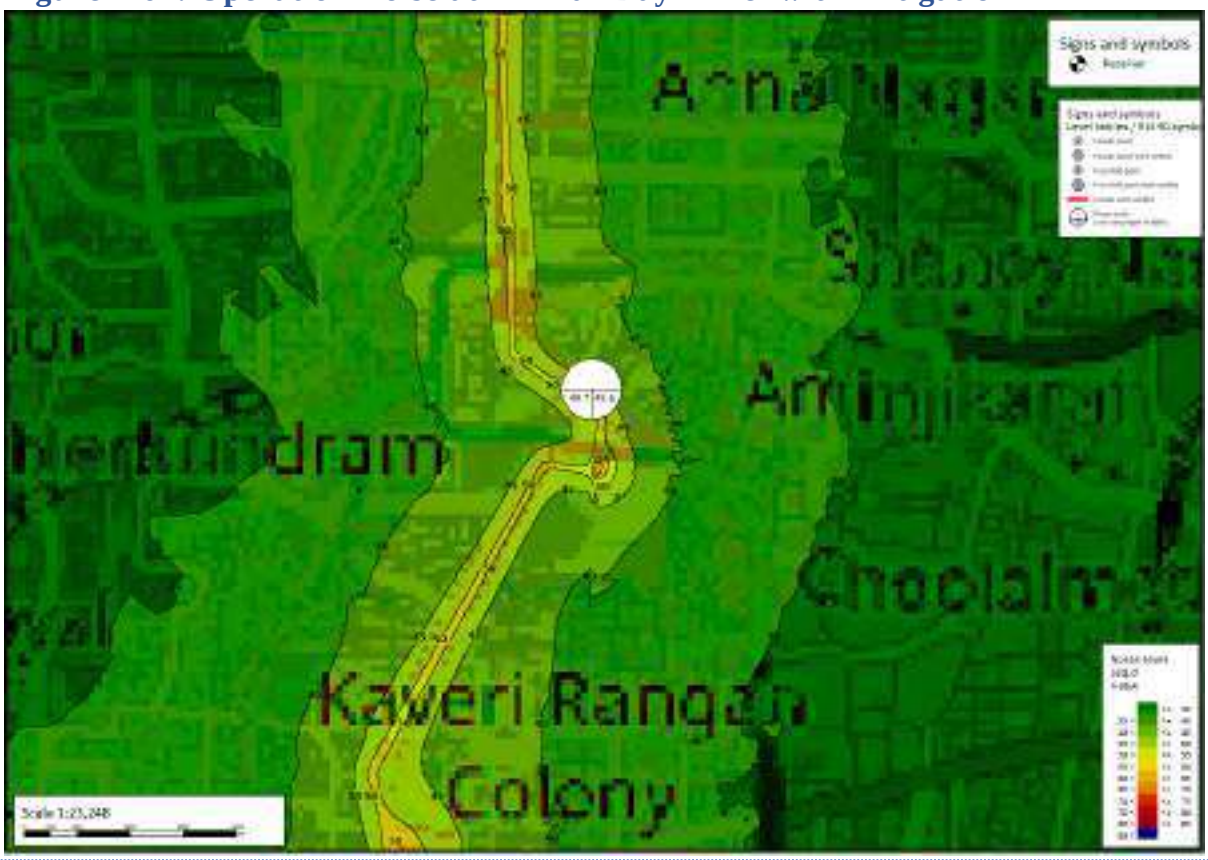


Figure 7-65: Operation Noise at HR-10– Night-time- with Mitigation

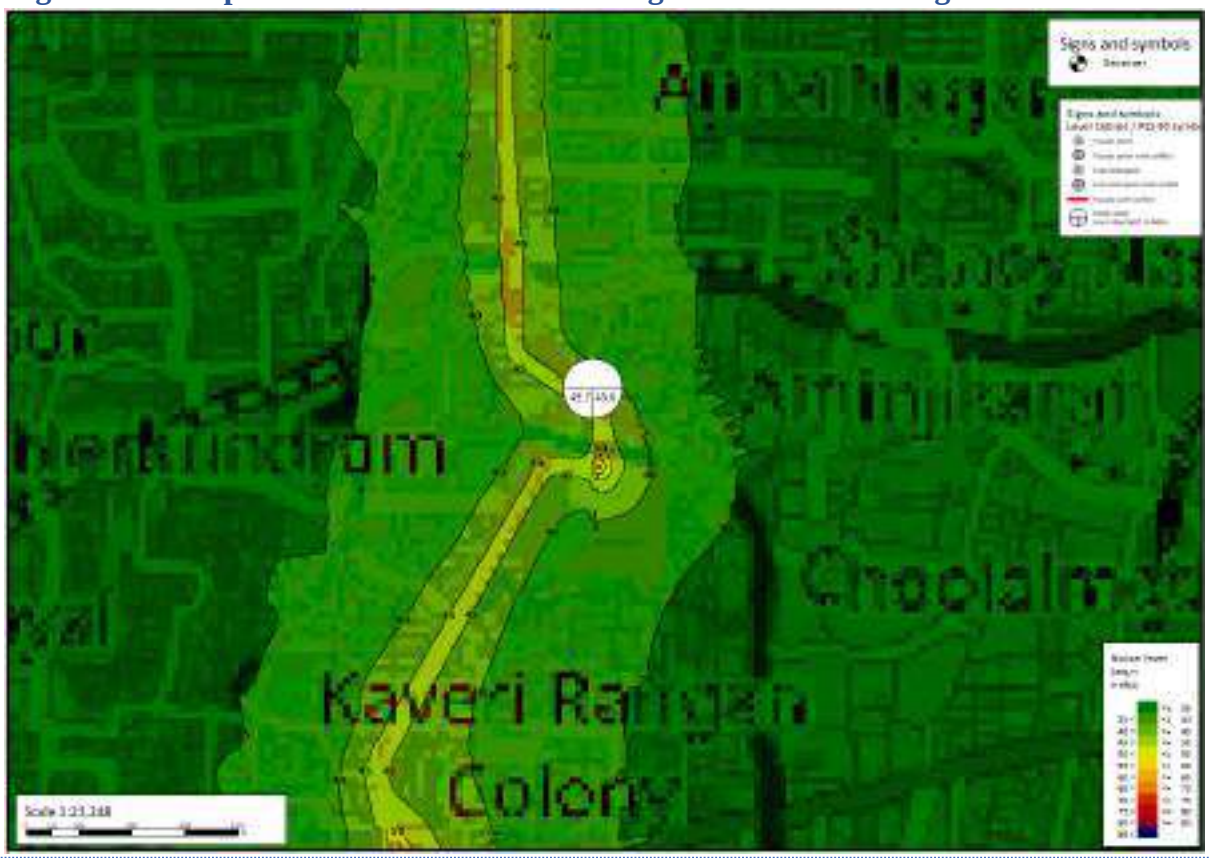


Figure 7-66: Operation Noise at HR-11– Day Time- No Mitigation

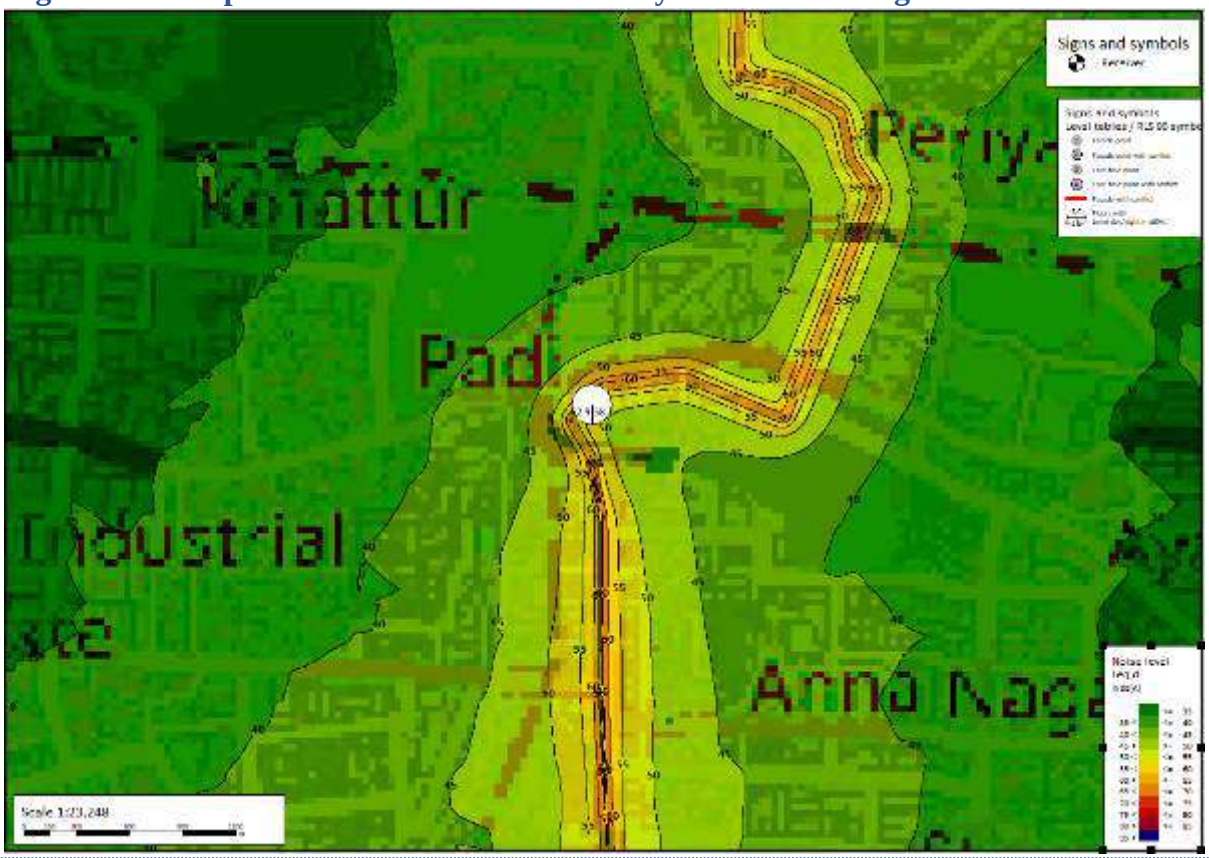


Figure 7-67: Operation Noise at HR-11– Night-time- No Mitigation

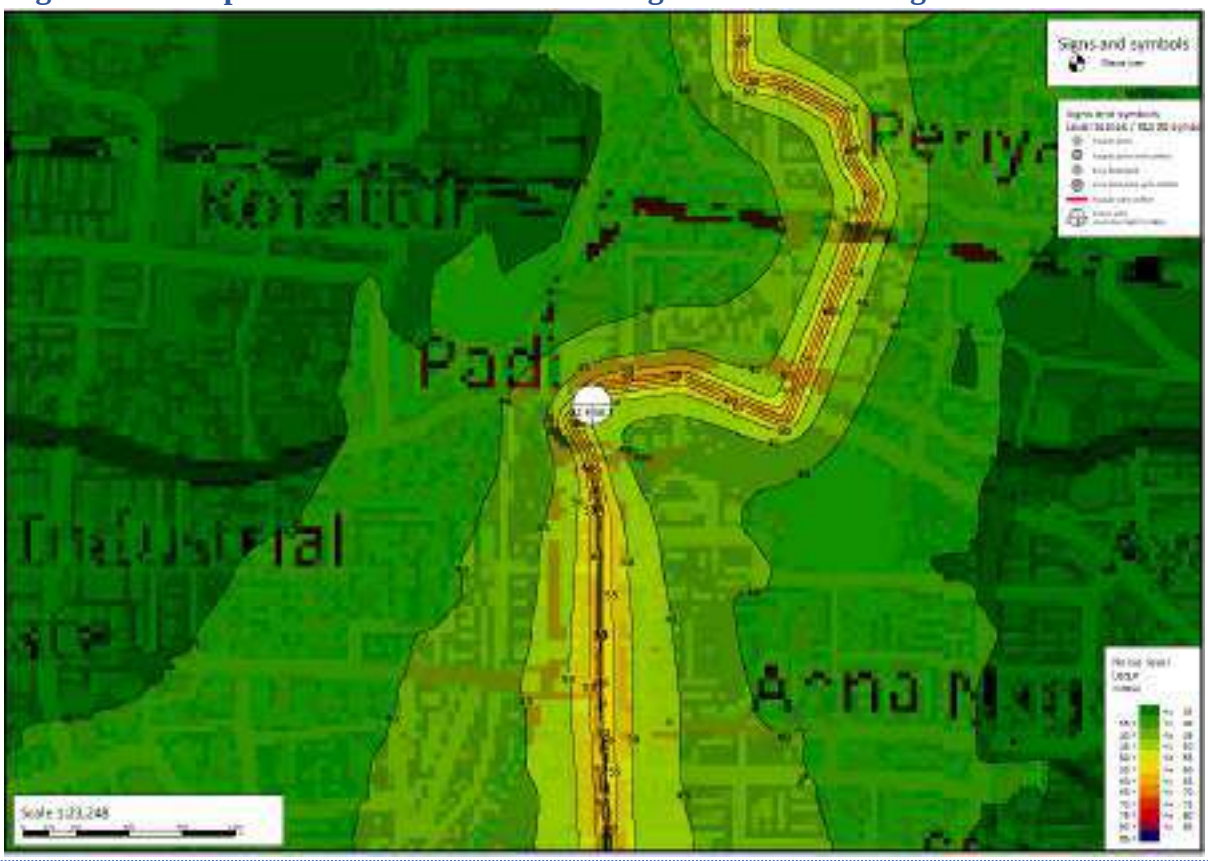


Figure 7-68: Operation Noise at HR-11– Day Time- with Mitigation

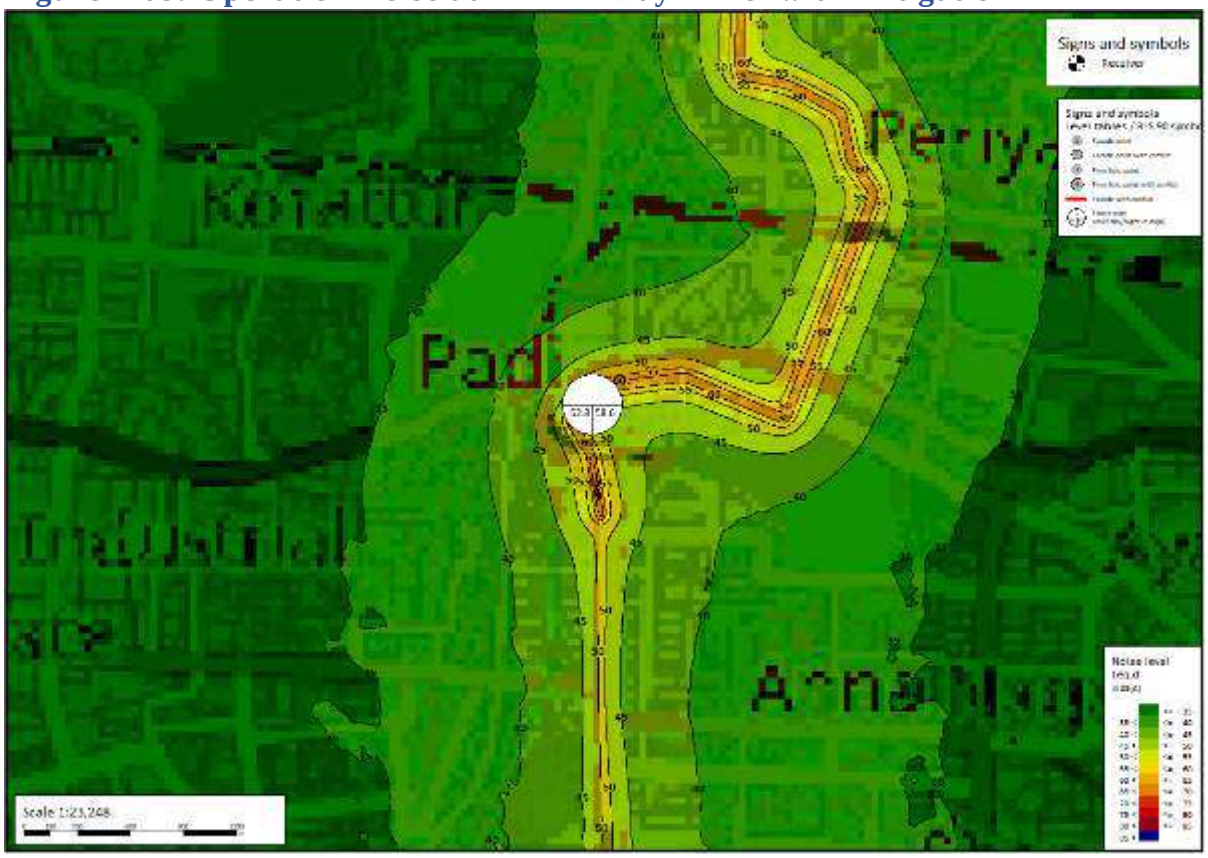


Figure 7-69: Operation Noise at HR-11– Night-time- with Mitigation

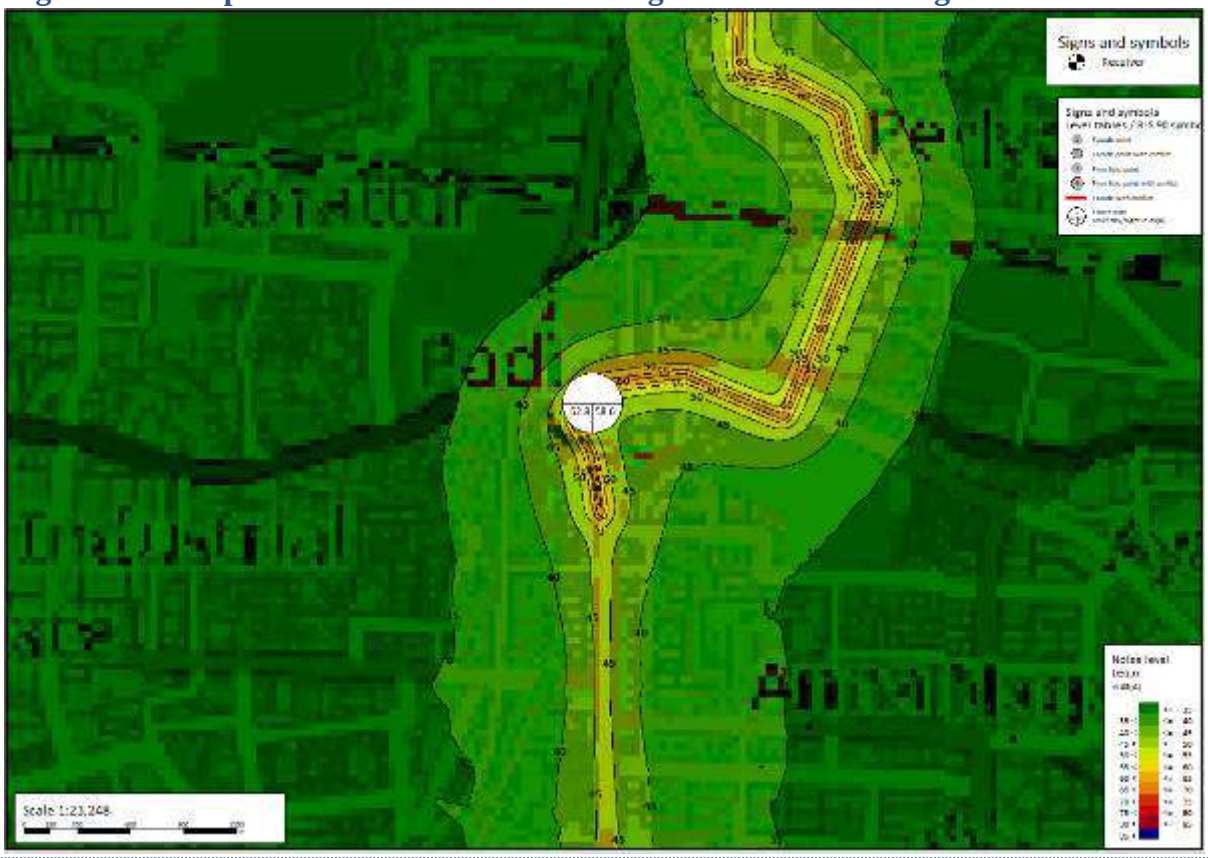


Figure 7-70: Operation Noise at HR-12– Day Time- No Mitigation

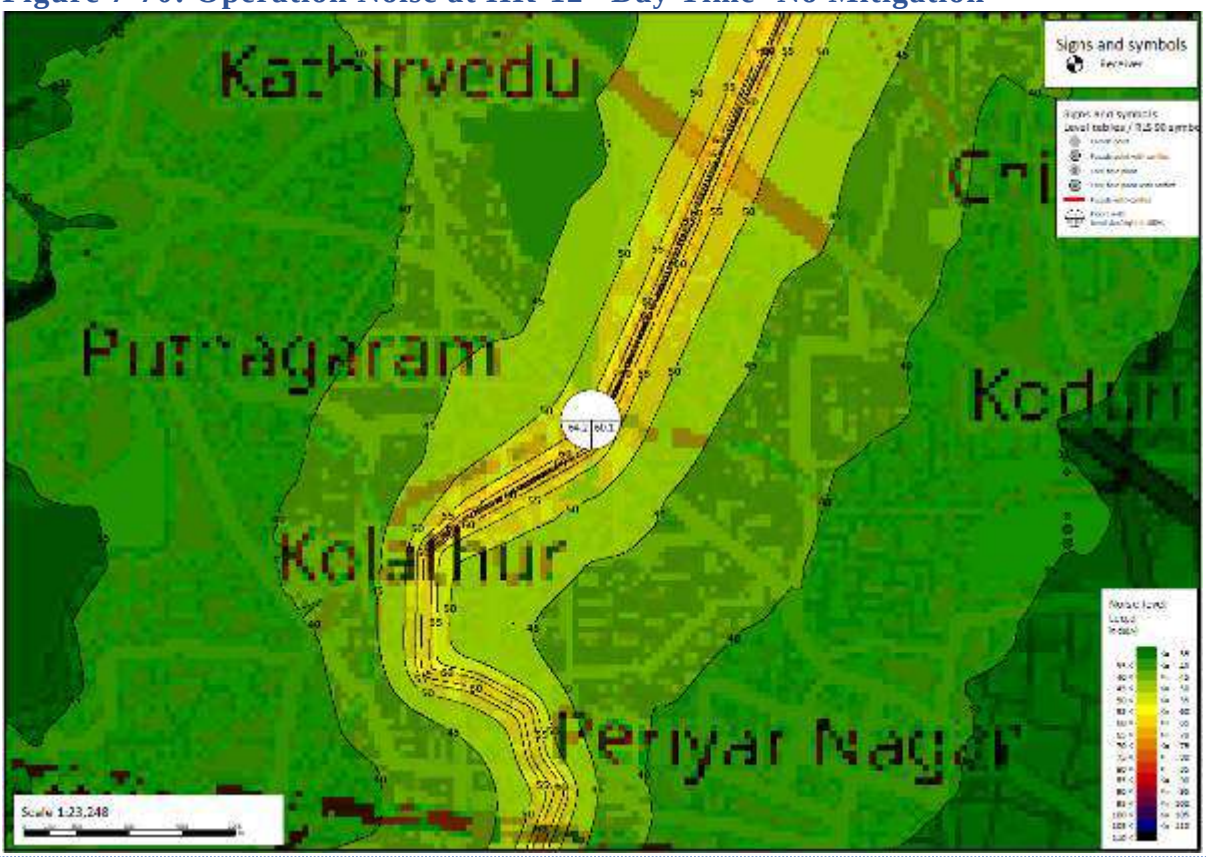


Figure 7-71: Operation Noise at HR-12– Night-time- No Mitigation

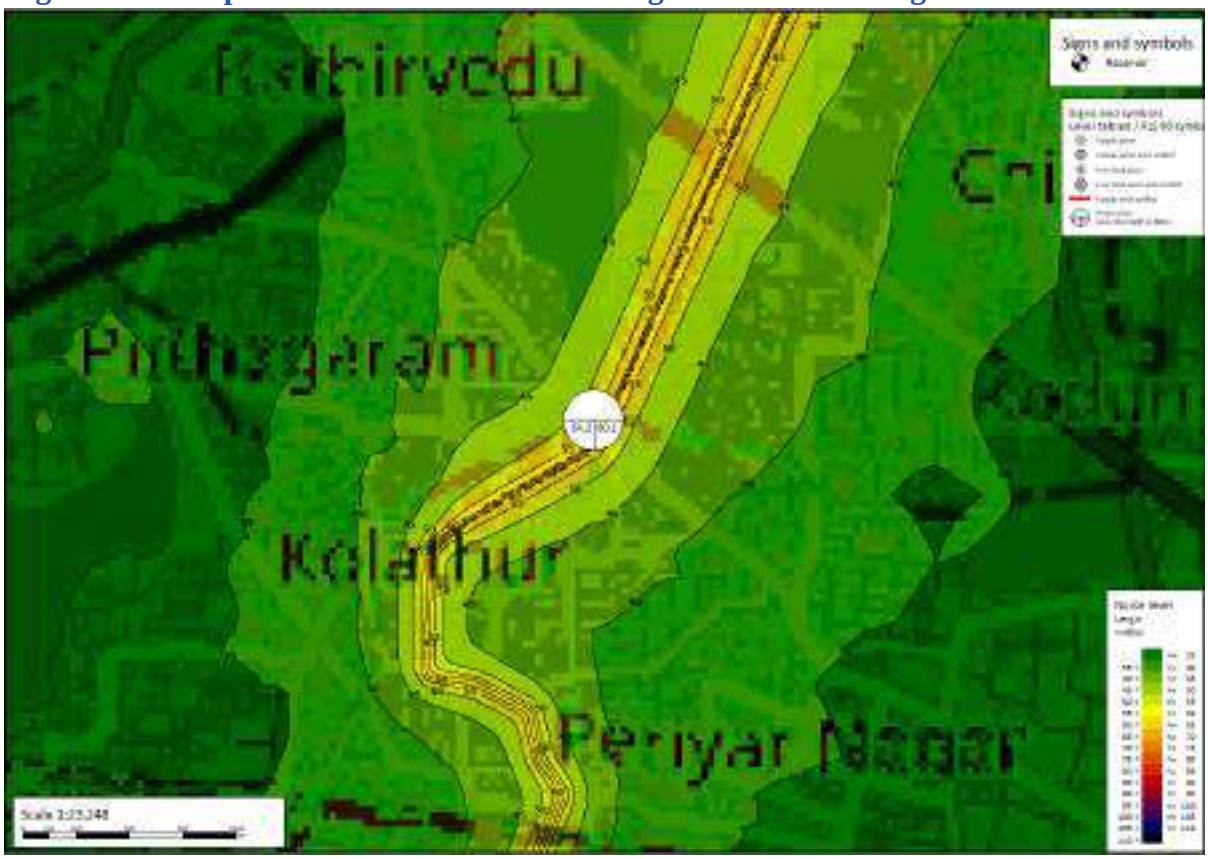


Figure 7-72: Operation Noise at HR-12– Day Time- with Mitigation

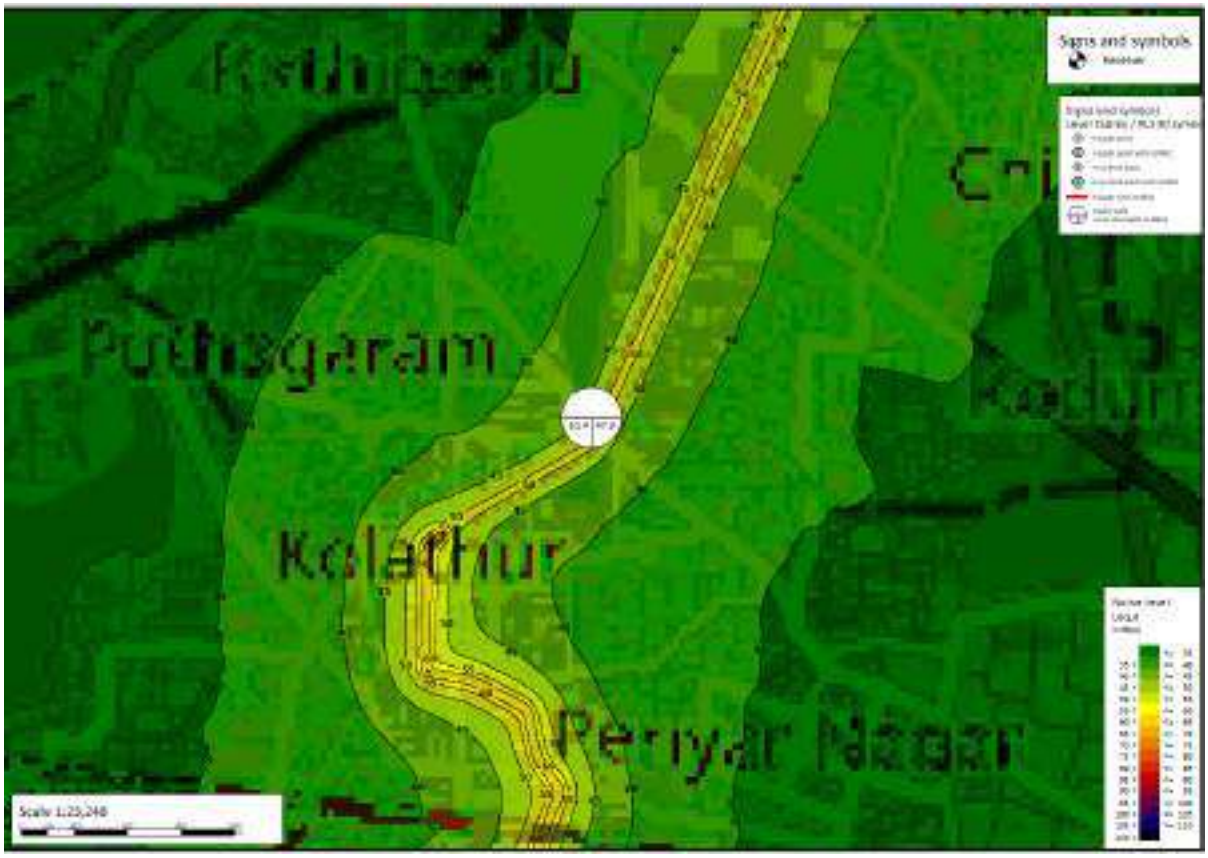


Figure 7-73: Operation Noise at HR-12– Night-time- with Mitigation

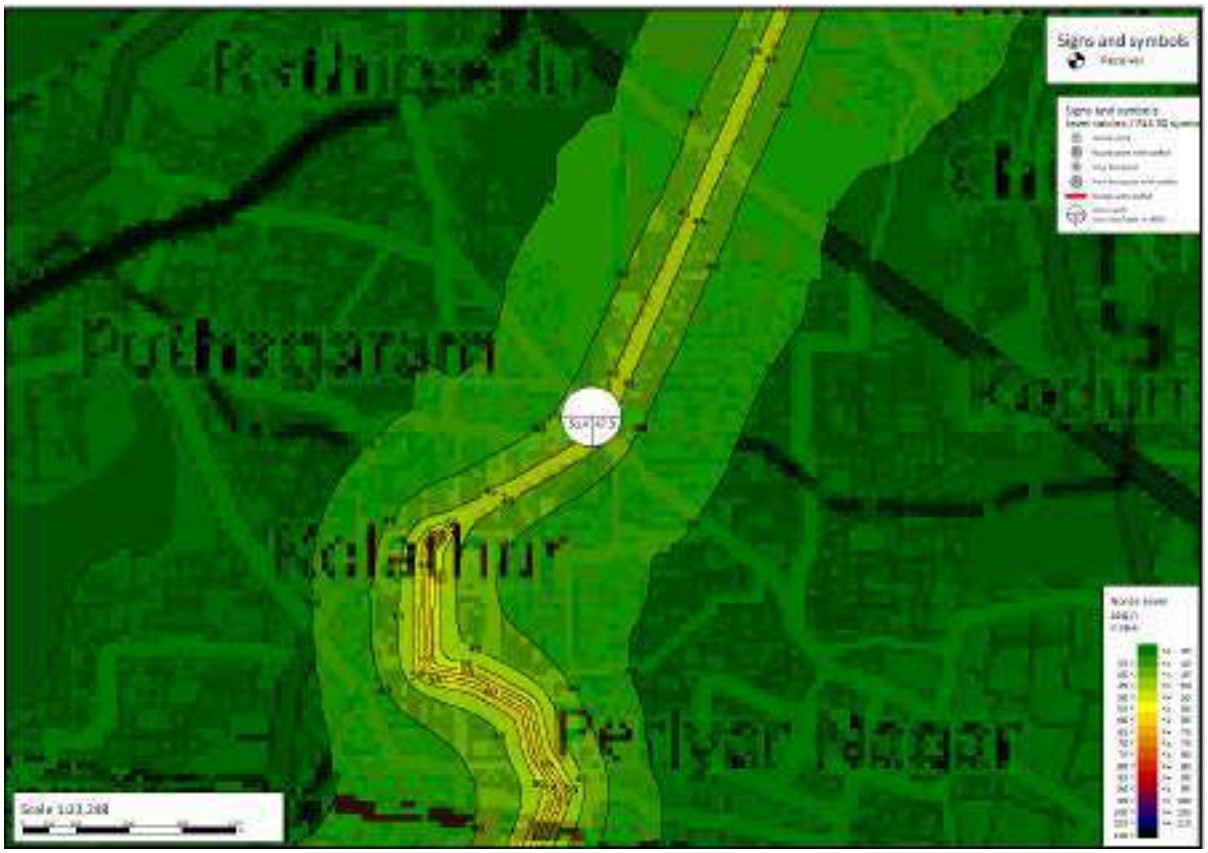

Signs and symbols
Puthagaram
Kadattur
Perlyar Nagar

Table 7-20: Summary of noise assessment at residential receptors

ID	HR1										HR2									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall				Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise				Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	71	65	60	58	71	66	49	46	71	65	69	61	62	59	69	63	50	47	69	61
Floor																				
1st	65	57	60	58	66	62	49	46	65	57	64	54	62	59	66	63	50	47	64	55
2nd	61	57	61	58	64	62	48	45	61	57	66	56	63	60	67	63	49	47	66	57
3rd	60	53	62	59	64	62	48	45	60	53	62	54	63	60	66	64	49	46	62	55
4th	62	56	62	59	65	63	47	45	62	56	61	54	64	61	65	64	49	46	61	55
5th	64	59	62	59	66	64	47	44	64	59	63	57	64	61	67	65	49	46	63	58
6th											62	54	64	61	66	64	49	46	62	55
7th											63	54	64	61	67	64	49	46	64	55
8th											62	54	64	61	66	64	49	46	63	55
9th											64	54	64	61	67	64	49	46	64	55
10th											62	56	63	61	66	64	48	46	62	56
11th											64	54	63	60	67	64	48	45	64	55
12th											63	56	63	60	66	64	48	45	63	56
13th											61	55	63	60	65	63	48	45	61	56

ID	HR3										HR4									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall				Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise				Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact					No-Impact	Impact			No-Impact	No-Impact
Noise Level	66	60	59	56	67	61	51	48	66	60	63	56	60	57	65	60	47	45	63	57
Floor																				
1st	68	58	59	56	68	62	51	48	68	56	60	50	60	57	63	60	47	45	60	55
2nd	64	58	60	57	66	62	51	48	64	57	62	52	61	58	64	61	47	44	62	56
3rd	66	58	60	58	67	62	52	49	66	56	63	52	61	58	65	62	46	44	63	55
4th	62	56	61	58	65	62	52	50	62	56	62	52	61	58	65	62	46	44	63	55
5th											63	53	61	59	65	62	46	44	63	57
6th																				
7th																				
8th																				
9th																				
10th																				
11th																				
12th																				
13th																				

ID	HR5										HR-6									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall				Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise				Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	66	61	55	53	67	61	46	43	66	61	67	64	60	58	68	65	49	46	67	64
Floor																				
1st	64	57	55	53	64	59	46	43	64	55	63	55	60	58	65	61	49	46	63	55
2nd	64	58	56	53	64	60	45	42	64	56	67	57	61	58	68	62	49	46	67	56
3rd	64	58	56	53	65	60	44	41	64	54										
4th																				
5th																				
6th																				
7th																				
8th																				
9th																				
10th																				
11th																				
12th																				
13th																				

ID	HR-7										HR8									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall				Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise				Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	69	63	59	56	70	64	48	45	69	63	65	61	61	58	66	63	49	46	65	61
Floor																				
1st	61	54	59	56	63	60	48	45	61	57	61	57	61	58	64	62	49	46	61	57
2nd	59	53	60	57	62	61	48	45	59	58	62	57	62	59	65	63	49	46	62	58
3rd	62	53	60	58	64	61	47	44	62	61	61	61	62	59	65	64	48	46	61	61
4th	61	56	61	58	64	62	46	44	61	57	61	56	63	60	65	63	48	45	61	57
5th	66	58	61	58	67	63	46	43	66	58	61	58	63	60	65	64	48	45	61	58
6th	65	57	61	58	66	62	46	43	65	58	62	58	63	60	65	64	48	45	62	58
7th	65	58	61	58	67	63	46	43	65	59	63	59	63	60	66	64	48	46	64	59
8th	65	58	61	58	67	63	46	43	65	60	65	60	63	60	67	64	48	46	65	60
9th											64	61	63	60	67	65	48	46	64	61
10th											63	61	62	60	66	65	48	45	63	61
11th											62	57	62	60	65	64	48	45	62	58
12th											61	57	62	59	65	63	48	45	61	57
13th																				
14th																				
15th																				

ID	HR9										HR10									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall				Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise				Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	No-Impact			No-Impact	No-Impact					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	68	63	61	59	69	64	48	45	68	63	68	60	58	55	69	61	46	43	68	60
Floor																				
1st	69	58	61	59	69	63	48	45	69	57	67	56	58	55	68	60	46	43	67	57
2nd	67	60	62	60	68	64	48	45	67	58	66	55	58	56	66	60	45	42	66	57
3rd	68	60	63	60	70	65	48	45	68	61	67	55	59	56	67	60	44	41	67	61
4th	69	60	63	61	70	65	48	46	69	57	68	55	59	56	69	60	44	41	68	57
5th											68	56	59	56	69	61	44	41	68	58
6th											68	56	59	56	69	61	44	41	68	58
7th											69	55	59	56	70	60	44	41	69	59
8th											69	55	59	56	69	60	44	42	69	60
9th											68	56	59	56	68	61	45	42	68	61
10th											67	55	59	56	68	60	45	42	67	61
11th											68	56	59	56	68	61	45	42	68	58
12th											67	57	59	56	68	61	45	42	67	57
13th											63	57	59	56	64	61	45	42	63	45
14th											66	56	59	56	67	61	45	42	66	45
15th											67	55	59	56	68	60	45	42	67	45

ID	HR11										HR12									
	Ambient Noise		Operation - No Mitigation				Operation - With Wall				Ambient Noise		Operation - No Mitigation				Operation - With Wall			
			Predicted		Final Noise		Predicted		Final Noise				Predicted		Final Noise		Predicted		Final Noise	
	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN	Leqd	LeqN
Status					No-Impact	Impact			No-Impact	Impact					No-Impact	No-Impact			No-Impact	No-Impact
Noise Level	61	55	58	56	63	58	58	55	63	58	67	61	58	55	67	62	47	45	67	61
Floor																				
1st	62	55	58	56	64	60	58	55	64	60	64	57	58	55	65	60	47	45	64	57
2nd	63	56	58	56	64	60	58	56	64	61	64	56	59	56	65	60	47	44	64	57
3rd	63	57	59	56	64	61	59	56	64	63	63	56	59	57	65	61	46	43	63	61
4th											63	54	60	57	65	61	45	43	63	57
5th											64	57	60	57	65	62	46	43	64	58
6th											64	54	60	57	65	61	46	43	64	58
7th											66	60	60	57	67	63	46	43	66	59
8th											66	57	60	57	67	62	46	44	66	60
9th											65	59	60	57	66	63	47	44	65	61
10th																				
11th																				
12th																				
13th																				
14th																				
15th																				

Table 7-21 Summary of Noise level db(A) during operation phase at sensitive receptors

No	Name of the Sensitive Receptors	Distance (m)	Operation													
			Without Barrier								With Barrier					
			Baseline Noise levels db(A)		Predicted Noise levels db(A)		Final Noise		Remarks	Remarks	Predicted Noise levels db(A)		Final Mitigated Noise		Status	
			L_{eq},d	L_{eq},n	L_{eq},d	L_{eq},n	Leq,d	Leq,n			L_{eq},d	L_{eq},n	L_{eq},d	L_{eq},n	L_{eq},d	L_{eq},n
1	MM hospital	10	75	66	62	60	75	67	No-Impact	No-Impact	54	52	75	66	No-Impact	No-Impact
2	Government boys high school, porur	78	76	62	65	64	77	66	No-Impact	Impact	54	52	76	63	No-Impact	No-Impact
3	St. joseph hospital	48	66	63	66	65	69	67	No-Impact	Impact	55	53	66	64	No-Impact	No-Impact
4	Kalpana hospital	30	61	51	64	63	66	63	Impact	Impact	60	59	64	53	No-Impact	Impact
5	Cantonment board high school	100	66	61	60	59	67	63	No-Impact	No-Impact	52	50	66	61	No-Impact	No-Impact
6	Anjakha hospital	30	66	62	65	63	69	65	No-Impact	Impact	54	51	66	63	No-Impact	No-Impact
7	St. joseph school	70	76	66	66	65	77	68	No-Impact	No-Impact	55	53	76	66	No-Impact	No-Impact
8	Ravindra bharathi global school	42	69	63	64	62	70	65	No-Impact	No-Impact	54	51	69	63	No-Impact	No-Impact
9	National school	160	74	67	55	54	74	67	No-Impact	No-Impact	50	49	74	67	No-Impact	No-Impact
10	Sri varasidhi vinayagar temple	45	60	55	65	64	66	64	Impact	Impact	56	55	62	58	No-Impact	No-Impact

Note:

- Rail without barrier wall - 2 and 3 Locations recorded an impact during daytime and night time respectively
- Upon applying mitigation measure such as barrier greatly reduces the impact and none of the location predicted any impact except for Kalpana Hospital, which recorded a baseline noise of 51 dBA.

7.5 TRAFFIC IMPACT ON THE NOISE MONITORING AND ANALYSIS

- Noise level profiles at all 12 locations depicted continuous and fluctuating noise profiles which indicates the principal noise source is traffic along the main road along the noise monitoring site.
- Based on the TNM-2.5 guideline, the predicted noise level for an average traffic volume of 7000 vehicle per hour at 40 kmph speed would be 86.5 dBA at a distance 15 m. The maximum recorded noise level during the monitoring session was 76.3 dBA during the day at porur junction which has an maximum PCU's of 110,000. The maximum recorded noise during night was 66.8 dBA at National School at Alandur.

Table 7-22: Traffic Data along the main stretch of Corridor 5

Loc.no	Name of Location	Total Vehicles	Total PCU's
1	Devraj Nagar	98,106	113,220
2	Meddavakkam Koot Road Junction	89,822	69,894
3	Eachangadu Junction	109,620	84,957
4	Army Officer Training Academy	112,355	93,314
5	Vanuvam Pettai Signal	120,746	124,047
6	Pallikarnai Junction	132,713	108,232
7	Sabari Salai (Nr. UTI Bus Stop)	51,881	55,356
8	Dr Kamakshi Hospital	156,412	170,356
9	Ramavaram Signal	175,412	143,805
10	Bharathi Dasan Colony	65,122	50,672
11	Koyambed Market Junction	172,999	149,832
12	Nerkundram Junction	91,282	88,611
13	Mogappair	82,667	67,019
14	Thiru Manglam Junction	97,186	89,602
15	Retteri Junction	115,026	106,490
16	Anna Nagar Junction Nr. Govt. Peripheral Hospital	53,996	54,405
17	Porur Junction	127,338	110,583
18	Avadi Road Jn.	58,338	57,637
	Max		170,356
	Average		96,557

Figure 7-74: Traffic Data Locations

Based on the traffic data, the noise predicted was modelled along with the noise monitoring data, any deviation from the traffic and noise monitoring was used to analyse if there is a significant difference from the noise monitoring to the noise modelled. It is to be noted that the traffic noise modelled was assuming the peak traffic flow recorded through the day.

The noise monitoring includes the traffic noise which was recorded on the day of monitoring and since the monitoring location is very close to the main traffic road, it is assumed to be conclusive that noise monitoring includes the traffic as a noise source. The other location monitored have a very little variation from the maximum traffic noise data.

It is therefore concluded that there would be no impact due to the operation of the metro rail with barrier wall in place.

8 OPERATION PHASE MITIGATION MEASURES

In addition to the structural and engineer practice measures to control noise, good communication with affected communities is often the most effective way to manage potential operational noise impacts. All noise complaints should be effectively recorded, investigated, and addressed.

In addition, the Contractor will observe general good working practices including the following which are particularly relevant to rail operation:

- Provision of noise barriers. Specifications for installation of noise protection devices clearly indicating the location, design and material, and also provide for future maintenance requirements
- Environmental specifications for contractors should cover the required safeguards during the design and construction stage

Note that noise barriers are the only form of mitigation available in a General Noise Assessment. The other mitigation measures are available for a Detailed Noise Analysis with details on the actual structural and complete site assessment studies during the finalization of the design stage. The approximate noise barrier lengths and locations based on the FTA guideline is provided below. It was identified that the barrier of 3m is found to be appropriate and would reduce the impact. In order to identify the height of the common barrier, the maximum ambient noise recorded at HR- 4 which recorded 67.2 dBA and 63.2 dBA during daytime and night respectively.

Mitigation of noise impact from metro rail may involve treatments at the three fundamental components noise problem:

- noise source treatment,
- source-to-receiver propagation path, and
- receiver.

Generally Receiver treatment shall be considered as a last resort for applying mitigation measure.

8.1 SOURCE TREATMENT:

The most effective noise mitigation treatments are applied at the noise source. This is the preferred approach to mitigation when possible. Common source treatments and their estimated acoustical effectiveness. Due to insufficient data on the type of rail and its specification, the listed items were not verified against the train specifications.

Table 8-1: noise reduction during source treatment

Mitigation Measure	Effectiveness
Stringent Vehicle & Equipment Noise Specifications	Varied
Operational Restrictions	Varied

Resilient or Damped Wheels	For rolling noise on tangent track:	2 dB
	For wheel squeal on curved track:	10-20 dB
Vehicle Skirts		6-10 dB
Undercar Absorption		5 dB
Quiet Fan Design and Fan Placement		Varied
Preventative Maintenance on Rail Systems		Varied
Turn Radii Greater than 1000 ft		Avoids Squeal
Rail Lubrication on Sharp Curves		Reduces Squeal
Movable-Point Frogs (reduce rail gaps at crossovers)		Reduces Impact Noise
Engine Compartment Treatments		6-10 dB

8.1.1 STRINGENT VEHICLE AND EQUIPMENT NOISE SPECIFICATIONS

noise control during the specification and design of the metro rail based on the site conditions. By developing and enforcing stringent but achievable noise specifications.

8.1.2 OPERATIONAL RESTRICTIONS

- **lowering of speed**, the reduction of nighttime (10 p.m. to 7 a.m.) operations, and reduction of warning horns and signals.
- **Speed reduction** – Because noise from most transit vehicles is dependent on speed, a reduction of speed results in lower noise levels. The effect can be considerable.
- **Reduction of nighttime operations** – Complete elimination of nighttime operations has a strong effect on reducing the nighttime values.
- **Reduction of warning horns and signals** – Minimizing or eliminating horns and other warning signals at gate crossings can reduce noise impact

8.1.3 WHEEL TREATMENTS (RAIL) –

A major source of noise from steel-wheel and steel-rail systems is the wheel/rail interaction that can produce three distinctive sounds: roar, impact, and squeal.

- Roar is the rolling noise caused by small-scale roughness on the wheel tread and rail running surface.
- Impacts are caused by discontinuities in the running surface of the rail or by a flat spot on the wheels.
- Squeal occurs when a steel-wheel tread or its flange rubs across the rail, resulting in resonant vibrations in the wheel that creates a screeching sound. Various wheel designs and other mitigation measures exist to reduce the noise from each of these three mechanisms.

Resilient wheels – Resilient wheels are effective in eliminating wheel squeal on tight turns with reductions of 10 to 20 dB in the high- frequency range where squeal noise occurs.

Damped wheels – Damped wheels, like resilient wheels, are effective in eliminating wheel squeal on tight turns with reductions of 5 to 15 dB in the high-frequency range where squeal occurs. Rolling noise is also slightly reduced by approximately 2 dB on tangent track. This treatment involves attaching vibration absorbers to standard steel wheels.

Preventative Maintenance (Rail) – Preventative maintenance is the best strategy to minimize rail and wheel deterioration.

Spin-slide control systems – Similar to anti-locking brake systems(ABS) on automobiles, spin-slide control systems reduce the incidence of wheel flats, a major contributor of impact noise. Trains with smooth wheel treads can be up to 20 dB quieter than those with wheel flats. To be effective, the anti-locking feature should be in operation during all braking

phases, including emergency braking. Wheel flats are more likely to occur during emergency braking than during dynamic braking.

Maintenance program – Clearly defined maintenance specifications should be developed during design phase of the project. The specifications should define rail and wheel profiles, include detailed guidance for grinding, rail-wheel interface, periodic monitoring of wheel and rail condition and compliance verification.

8.2 PATH TREATMENTS –

When noise mitigation treatments cannot be applied at the noise source or additional mitigation is required after treating the source, the next preferred placement of noise mitigation is along the noise propagation path between the source and receiver. Common path treatments and their estimated acoustical effectiveness are included in Table below.

Table 8-2: Noise Mitigation Measures – Path Treatments

Mitigation Measure	Effectiveness
Noise barriers close to vehicles	6-15 dB
Noise barriers at row line	3-15 dB
Alteration of horizontal & vertical alignments	Varied
Wayside horns	Varied
Acquisition of buffer zones	Varied
Ballast on at-grade guideway	3 dB
Ballast on aerial guideway	5 dB
Resilient track support on aerial guideway	Varied
Vegetation and trees	Varied

8.2.1 NOISE BARRIERS

All barrier effectiveness can be increased by as much as 5 dB by applying sound-absorbing material to the inner surface of the barrier. The length of the barrier wall is also important to its effectiveness. The barrier must be long enough to block noise from a moving train along most of its visible path. This is necessary so that train noise from beyond the ends of the barrier will not severely compromise noise-barrier performance at noise-sensitive locations. The barrier length can be refined in the engineering phase, closely examining the predicted sound level exceedances at specific receivers, site geometries, and the contribution of barrier flanking noise, then adjusting the length as appropriate.

Noise barriers can be made of any outdoor weather-resistant solid material that meets the minimum sound transmission loss required by the project. Materials that are commonly used for noise barriers include 16-gauge steel, 1-inch thick plywood, and any reasonable thickness of concrete. Typically, a surface density of 0.3 kg/cm2 shall be applied. Areas with strong winds may require more stringent structural requirements. It is critical to seal any gaps between barrier panels and between the barrier and the ground or elevated guideway deck for maximum performance.

It is to be noted that if the barriers are not designed and sited carefully, they can reduce visibility of trains for pedestrians and motorists, which causes safety concerns. It is important to consult with safety experts in choosing and siting a noise barrier.

8.2.2 GROUND ABSORPTION – BALLAST ON GUIDEWAYS –

Propagation of noise over ground is affected by whether the ground surface is absorptive or reflective. Noise from vehicles on the surface is strongly affected by the character of the ground in the immediate vicinity of the vehicle. Ground at the side of the rail has a substantial effect on the propagation of noise to greater distance. Guideways for rail systems

can be either reflective or absorptive, depending on whether they are concrete or ballast. Ballast on a guideway can reduce train noise 3 dB at-grade and up to 5 dB on an aerial structure.

8.2.3 OTHER MITIGATION MEASURES

There will be an increase in noise level in the tunnel and nearby ambient air due to operation of the metro corridors. However, noise levels in the core city area are expected to go down. The increase in levels are marginal; hence local population will not be adversely affected. However, the exposure of workers to high noise levels especially, near the engine, vent shaft etc. need to be minimized. This could be achieved by: ¬

- Job rotation,
- Automation,
- Construction of permanent and temporary noise barriers,
- Use electric instead of diesel powered equipment,
- Use hydraulic tools instead of pneumatic tools,
- Acoustic enclosures should be provided for individual noise generating construction equipment like DG sets,
- Scheduling truck loading, unloading and hauling operation,
- Schedule work to avoid simultaneous activities that both generated high noise levels,
- Anti drumming floor and noise absorption material,
- Low speed compressor, blower and air conditioner,
- Mounting of under frame equipments on anti-vibration pad,
- Smooth and gradual control of door,
- Provision of GRP baffle on the via-duct for elimination of noise transmission,
- Provision of sound absorbing material in the supply duct and return grill of air conditioner,
- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes, and
- Soundproof compartments control rooms etc.

The workers employed in high noise level area could be employed in low noise level areas and vice-versa from time to time. Automation of equipment and machineries, wherever possible, should be done to avoid continuous exposure of workers to noise. At work places, where automation of machineries is not possible or feasible, the workers exposed to noise should be provided with protective devices. Special acoustic enclosures should be provided for individual noise generating equipments, wherever possible. Workers in those sections where periodic adjustment of equipment/machinery is necessary, should be provided with sound proof control rooms so that exposure to higher noise level is reduced. Suitable noise barriers can reduce the noise levels.

The concept of a “low-noise” electric locomotive must be adopted and must be followed up with detailed work throughout the project execution and operation.

In addition, baffle walls as parapets shall be constructed at up to the rail level so as to reduce sound levels. In addition, it is proposed to provide skirting of coach shell covering the wheel which will screen any noise coming from the rail wheel interaction as of propagating beyond the viaduct.

In sensitive areas, track can be suitably designed so as to avoid propagation of noise to adjacent structures. Additional screening of noise can be arranged by providing parabolic noise reflecting walls on each side of the track.

In the operational stage, there may be issues of noise at sensitive receptors near the elevated track. At the viaduct, reflective type sturdy and weather resistant noise barriers shall be proposed near such sensitive receptors.

9 CONCLUSION

The baseline noise study was carried out at 12 residential locations along the alignment of CMRL phase 2 corridor- 5.

- The noise to be generated during construction and operation phase of CMRL corridors were modelled using SOUNDPLAN v8.2 software.
- The results of noise modelling revealed that, in most case the predicted noise levels were within the baseline noise levels and certain locations will have marginal impacts due to increase in noise levels due to proposed activities.
- Mitigation measures are provided to minimise and control the marginal impacts
- Construction noise is expected to create an impact and appropriate mitigation measures shall be taken as per the criteria and impact shall be reduced.
- As per the CMRL SHE manual and Detailed Project report, there would be no construction activity that would take place during night.

10 APPENDIX

10.1 DEFINITIONS

Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise. All sound levels in this report are A-weighted, unless reported otherwise.
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is sometimes described using the L_{90} descriptor.
Ballast	Granular material placed on the track bed for the purpose of holding the track in line and at surface
Ballast mat	A 2-to 3-inch-thick elastomer mat placed under the normal track ballast on top of a rigid slab or packed sub-grade.
Continuous Noise	The level of continuous sound pressure at the workplace over a period of 10 minutes minimum time in dB(A) with reference sound pressure of 20 micro pascal.
dB (A) (decibel A)	Unit used for 'A-weighted' sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear.
dB(A)	A unit for measuring the volume of normal sound pressure. Sound level in decibels read on the "A"-scale of a sound level meter. The "A"-scale weighting best approximates the response of the human ear to sound
dB(C)	A unit for measuring the volume of high sound pressure. 'C' Weighting is a standard weighting of the audible frequencies commonly used for the measurement of Peak Sound Pressure level; with more emphasis to low frequency sounds.
Decibel (dB)	A unit for measuring the volume of sound pressure perceived by the human ear. Standard unit of sound level measurement.
Employee Daily Noise Exposure	The level of eight-hour daily noise exposure of an employee, considering the effect of ear protectors.
Equivalent Sound Level,	The steady A-weighted sound level over any specified period (not necessarily 24 hours) that has the same acoustic energy as the fluctuating noise during that period (with no consideration of night-time weighting). It is a measure of cumulative

	acoustical energy.
Frequency, Hz	The number of complete pressure fluctuations per second above and below atmospheric pressure.
Guideway	Supporting structure to form a track for rolling or magnetically-levitated vehicles
L_{10}, L_{50}, L_{90}	The A-weighted noise levels that are exceeded 10%, 50%, and 90% of the time during the measurement time.
LAeq	Equivalent A weighted continuous sound pressure
LAmax	Maximum A - weighted sound pressure level in decibels recorded over the period stated.
LEP,d	Daily personal noise exposure
Noise	Sound, which is unwanted, either because of its effect on humans, its effect on fatigue or malfunction of physical equipment, or its interference with the perception or detection of other sounds.
Noise Attenuation	Noise reduction. The ability of a material, substance or medium to reduce the noise level from one place to another or between one room and another. Noise attenuation is specified in decibels.
Noise Exposure	Cumulative acoustic stimulation which reaches the ear of a person over a specified time-period such as a work shift, a day, a working life, or a lifetime.
Receiver	The location at which noise levels are computed and analysed. Also referred to as the observer.
Sound Level Meter	An instrument designed and calibrated to respond to sound and to give objective, reproducible measurements of sound pressure level. It normally has several features that would enable its frequency response and average times to be changed to make it suitable to simulate the response of the human ear.
Sound Power Level (PWL)	The quantity indicating the total emission of sound power in in all directions.
Sound Pressure Level (SPL)	The SPL is a function of the distance between the point of measurement and the considered noise source. The SPL decreases at the increasing of the distance between the measurement point and the noise source.

10.2 ABBREVIATIONS

dB	Decibels
dB(A)	A Weighted Decibels
LAeq	is the A-weighted equivalent continuous sound level in decibels measured over a stated period of time.
LEP,d	Daily personal noise exposure
LAmax	is the maximum A - weighted sound pressure level in decibels recorded over the period stated.
PWL	Sound Power Level (dB), decibel
SPL	Sound Pressure Level

10.3 REFERENCE, CODES AND STANDARDS

1. Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration (FTA), U.S. Department of Transportation, Report No. 0123, 2018.
2. International Financial Corporation (IFC) Environmental, Health, And Safety Guidelines-Noise management, April 2007
3. ISO 9613 ‘Acoustics – Attenuation of Sound during Propagation Outdoors – Part 2: General Calculation Method’ (ISO, 1996)
4. ISO 1996-2 2007 Acoustics — Description, measurement and assessment of environmental noise
5. CPCB Noise guidelines, The Noise Pollution (Regulation and Control) Rules, 2000, http://cpcbenvis.nic.in/noisepollution/noise_rules_2000.pdf

6. Indian Factories Act (1948), http://dgfasli.nic.in/html/modelrules/modelrules1/sch_24.htm
7. Guidelines for Noise & Vibrations, Metro Rail Transit system. Ministry of Railways, India **2015**

Updated Environmental Impact Assessment

April 2024
Revision 01

India: Chennai Metro Rail Investment Project
Balance Corridor 5

Annexure 12

Prepared by the Chennai Metro Rail Limited (CMRL) for the Project Lenders.

VIBRATION LEVEL FORECASTING IN THE PROPOSED CHENNAI METRO RAIL PHASE II – CORRIDOR 3, CORRIDOR 4 AND CORRIDOR 5 DURING CONSTRUCTION AND OPERATION PHASES

DRAFT VIBRATION FORECASTING REPORT FOR CORRIDOR 5

	Name
Produced by	Behshad Noori
Approved by	Joan Cardona

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TABLE OF CONTENTS

1.- List of revisions

Revision	Date	Scope of revision	Author	Checked
1	01/06/2021	Document creation	Behshad Noori	Joan Cardona

2.- Introduction

2.1.- Background

Metro Chennai Rail Phase II corridors C3, C4 and C5 comprises an area covering Chennai City, 16 Municipalities, 20 Town Panchayats and 214 Village Panchayats known as Chennai Metropolitan Area, CMA. See Figure 2.1.

According to 2011 census, Chennai Metropolitan Area population is 89.2 lakh and Chennai City population is 46.8 lakh, with about 48 lakh vehicles as per Tamil Nadu government statistics. This significant number of vehicles means that private mode is increasing unabated mainly due to inadequate public transport facilities.

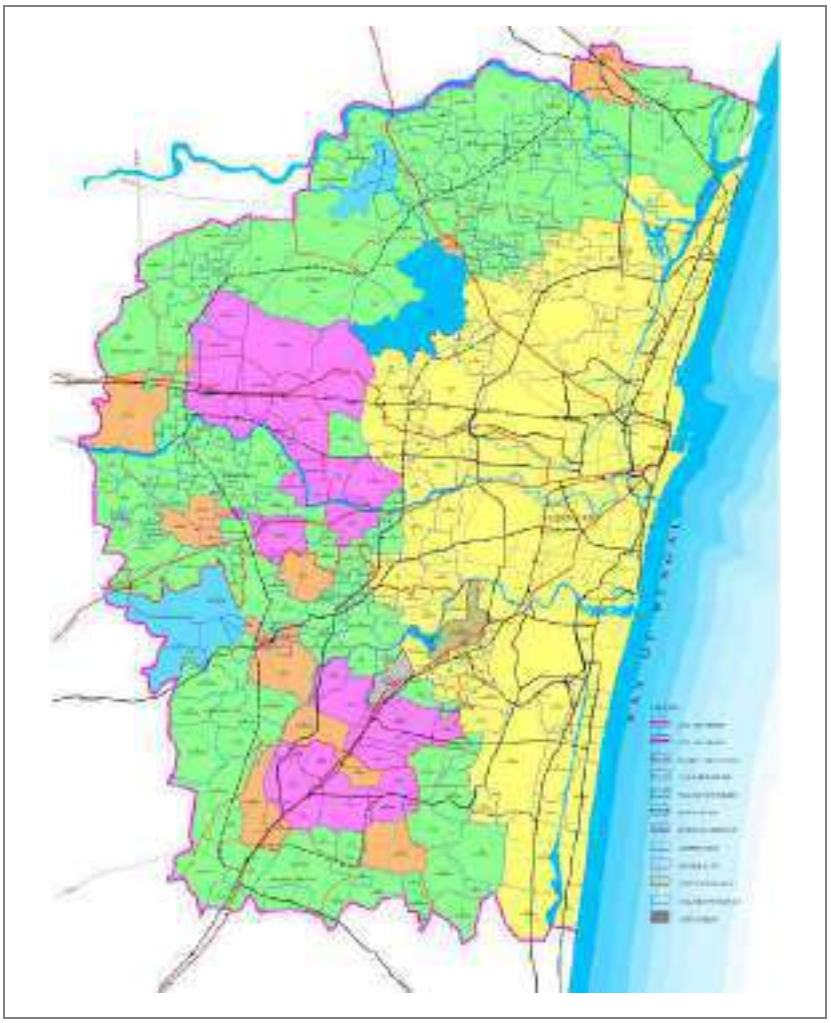

Figure 2.1. Chennai Metropolitan Area.

To face this lack of public transport facilities, Phase-I of Chennai Metro was designed and constructed and became operational by the end of 2016. Phase-I of Chennai Metro covers 54 km in two corridors:

- Corridor 1: Wimco Nagar - Washermenpet - Airport, with a total length of 32.085 km
- Corridor 2: Chennai Central to St. Thomas Mount, with a total length of 21.96 km plus a 10.7 km stretch from Koyambedu to Alandur

In addition to this Phase-I of Chennai Metro as well as to other existing public transportation network, and to develop effective and efficient mass transit system in Chennai Metropolitan Area, Phase-II corridors C3, C4 and C5 of Metro Chennai with a total length of 118.9 km are now under study. In Table 2.1 Phase-II total length is divided into each corridor partial length. This table also shows that each corridor has an elevated and an underground part.

Corridors	Elevated (Km)	Underground (Km)	Total Length (Km)
C-3 Madhavaram to SIPCOT	19.1	26.7	45.8
C-4 Lighthouse to Poonamallee Bypass	16.0	10.1	26.1
C-5 Madhavaram to Sholinganallur	41.2	5.8	47.0
		Total	**118.9**

Table 2.1. Route length of each corridor of Metro Chennai Phase-II.

Figure 2.2 shows a general view of corridor C3, corridor C4 and corridor C5 alignment as well as all stations planned in each of these corridors.

A travel demand assessment was carried out and its results are shown in Table 2.2.

Year	Max. PHPDT			Daily Boardings (in Lakh)			
	C3	C4	C5	C3	C4	C5	Total
2025	16,289	11,707	17,539	6.6	5.5	7.2	**19.2**
2035	22,115	18,944	24,528	10.1	9.3	13.2	**32.6**
2045	24,301	23,816	29,441	11.8	10.3	15.6	**37.7**
2055	27,361	29,940	35,714	13.6	11.4	18.5	**43.5**

Table 2.2. Travel demand projections for corridors C3, C4 and C5.

Figure 2.2. Chennai Metro Phase-II corridors C3, C4 and C5.

The proposed alignment of corridor C5 starts from Madharavam Milk Colony as underground and heads in south direction up to Sholinganallur with a total length of 47.00 km including 41.17 km as elevated section and 5.83 km as underground section. See Table 2.3.

Alignment Type	From (m)	To (m)	Length (m)
Underground	-386	356	742
Switch over Ramp (-)8.0m to 0.0m	356	573	217
At-grade	573	1150	577
Elevated	1150	6653	5503
Switch over Ramp (+)7.5m to (-)8.0m	6653	7049	396
Underground	7049	11530	4481
Switch over Ramp (-)8.0m to (+)7.5m	11530	11920	390
Elevated	11920	46623	34703
Total			**47009**

Table 2.3. Corridor C5 alignment summary.

Train operation plan for Chennai Metro Phase-II corridors considers running of services for 19 hours a day, from 05:00h to 00:00, with a station dwell time of 30 seconds and a scheduled speed of 32 km/h.

This train operation plan is envisaged with the combination of 3 car and 6 car rake composition in the inception year 2025 and 6 car rake composition in the design year 2055. Based on traffic demand assessment, a circular train operation is envisaged between corridor C3 and corridor C5 whereas corridor C4 is proposed to have independent train operation. Table 2.4 collects the rolling stock main features.

S. No.	Parameter	Rolling Stock
1	Basic Unit	3 Car basic unit 2 DMC and 1 TC. Every coach should be fully interchangeable with any other coach of same type.
2	Train Composition	3- Car: DMC + TC + DMC 6- Car: DMC + TC + MC + MC + TC + DMC Capable of GoA4 operation
3	Coach Dimensions	L= 22.6m, W=2.9m, H= 3.9m
4	Coach construction	Light weight Stainless Steel / Aluminum body
5	Axle load	≤16 T

Table 2.4. Rolling stock main features.

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

noise and vibration caused primarily by construction work but also during operation phase.

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

2.2.- Aim of the project

The aim of the project is to carry out a predictive calculation of ground-borne vibration induced into 9 buildings of corridor C5 during the construction phase as well as during the operational phase of this corridor.

Existing vibration levels at these 9 locations before corridor's construction and operation are also assessed, based on results from a previous study.

2.3.- Scope of the work

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

1. Baseline vibration assessment: Vibration measurements were carried out in the frame of previous work at 9 locations under study along the alignment of the future corridor C5 metro infrastructure. These locations were selected accordingly to final client, considering covering different scenarios. Peak Particle Velocity (PPV) were measured and calculated as it is the indicator that is widely used to evaluate the strength of vibration.

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

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

3.- Applicable regulations

3.1.- Quality procedures

AV Ingenieros' procedures according to quality management system ISO 9001:2015 are followed to develop this project. Quality procedures are the following ones:

- Procedure P1.1. Vibroacoustic projects' management
- Procedure S1.1. Projects' technical management

3.2.- Mandatory regulations

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

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

Vibration limits are presented in Table 3.1 and Table 3.2 for Chennai Metro operation phase, and in Table 3.3 as construction vibration damage criteria for Chennai Metro construction phase.

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

Table 3.1. Vibration limits into buildings.

There are some buildings such as concert hall, TV and recording studios and theatres that can be very sensitive to vibration and noise but do not fit into any of the three categories of Table 3.1. Table 3.2 recommends criteria for acceptable ground-borne vibration levels into different types of such buildings.

Land use category	Ground-borne vibration limit [VdB ref = 25.4 μmm/s]
Concert Halls	65 VdB
TV Studios	65 VdB
Recording Studios	65 VdB
Auditoriums	72 VdB
Theatres	72 VdB

Table 3.2. Recommended criteria for ground-borne vibration into special buildings.

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

Table 3.3. Construction vibration damage criteria.

4.- Infrastructure description

Main characteristics of the infrastructure which is being studied are described in the following sub-sections.

4.1.- Alignment

Corridor C5 alignment starts from Madhavaram Milk Colony Metro Station as underground section with a rail level kept at -15 m below ground level, and heads in South direction up to Sholinganallur Metro Station which is proposed as elevated section with a rail level kept at +24 m above ground level. This station is common to corridors 3 and 5. Corridor C5 total length is 47.00 km including 41.17 km as elevated infrastructure and 5.83 km as underground section in two different locations. See Figure 4.1.

Switch over Ramp (SWR) is required to provide transition from underground section to at-grade section at Venugopal Nagar (Ch: 1150 m), where the alignment comes on centre of Jawaharlal Nehru Road and runs elevated up to Retteri (Ch: 6653 m). Here another SWR is required to provide transition from elevated section to underground section, which is the used section type from Ch: 7049 m to Ch: 11530 m, where a final SWR is required again to provide transition from this underground section to the final elevated alignment from Ch: 11920 m to Ch: 46623 m.

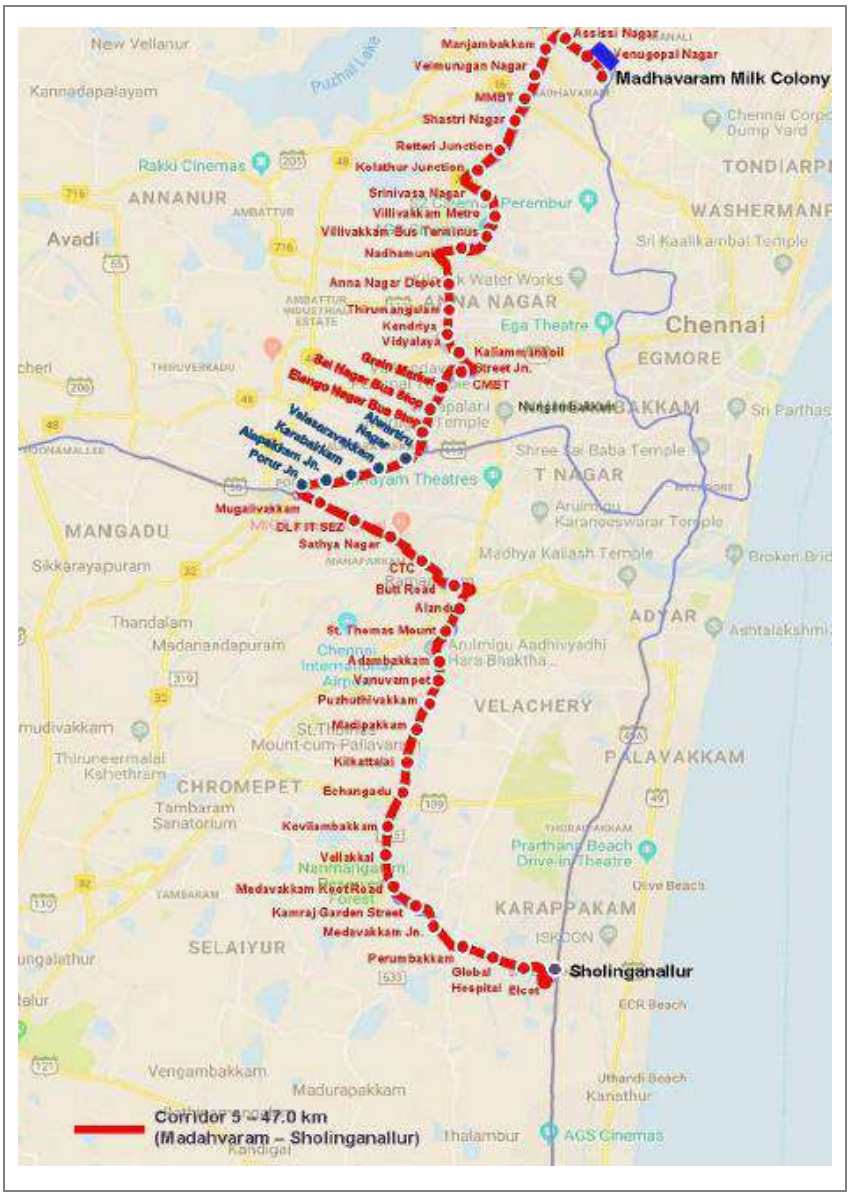

Figure 4.1. Corridor C5 alignment.

Alignment Type	From (m)	To (m)	Length (m)
Underground	-386	356	742
Switch over Ramp (-)8.0m to 0.0m	356	573	217
At-grade	573	1150	577
Elevated	1150	6653	5503
Switch over Ramp (+)7.5m to (-)8.0m	6653	7049	396
Underground	7049	11530	4481
Switch over Ramp (-)8.0m to (+)7.5m	11530	11920	390
Elevated	11920	46623	34703
Total			**47009**

Table 4.1. Alignment summary of Corridor C5.

Corridor C5 includes 48 stations, divided into 1 at-grade station (Venugopal Nagar), 41 elevated stations and 6 underground (UG) stations. Three different characteristic sections can be defined along the whole length of the alignment:

1. Madhavaram Milk Colony to Retteri Station

In his first section the alignment starts as underground but immediately ramps out to ground level with at-grade Venugopal Nagar Station. The alignment comes on centre of Jawaharlal Nehru Road and runs elevated along 4.239 km up to Retteri. The total length is about 6 km and there are 1 UG station, 1 at-grade station and 6 underground stations. Figure 4.2 shows Corridor C5 starting point which is common to corridor C3.

Figure 4.2. Corridor C5 and C3 starting point at Madhavaram Milk Colony.

2. Switch over Ramp from Elevated section Underground section
The ramp is proposed between double height Retteri Junction Station and shallow depth Kolathur Junctions Station from Chainage 6653 m to Chainage 7049 m with rail level dropping from +7.5 m to -8.0 m.

3. Retteri Junction to Nathamuni
The alignment in this section runs underground below dense residential areas of Kolathur and Srinivasa Nagar and have a total length of 4.876 km with 5 UG stations.

The alignment crosses railway tracks at Villivakkam Railway Station with clear cushion of 15.5 m between tunnel top and ground level. See Figure 4.3.

Figure 4.3. Corridor C5 alignment crossing railway tracks at Villivakkam Metro Station.

4. Switch over Ramp from Underground section to Elevated section
Switch over ramp to bring the alignment from underground to elevated is proposed after Nathamuni Station from Chainage 11530 m to Chainage 11920 m with rail level rising from -8.0 m to +7.5 m.

5. Anna Nagar to Sholinganallur
The alignment in this section runs completely elevated and its total length is about 34.907 km with 35 elevated stations.

4.2.- Sensitive locations to be studied

This vibration assessment is carried out in specific locations given by client. These locations are those specified in Table 4.2 and graphically represented on a map using a house symbol in Figure 4.4.

S. No	Location No	Location	Elevated / Underground	Distance from alignment [m]	Location coordinates
1	C5-A	Kolathur Junction/Villivakkam	UG	3	Lat: 13° 6'41.76"N Long: 80°12'40.66"E
2	C5-B	Valasaravakkam Junction	UG	6	Lat: 13° 2'31.76"N Long: 80°10'46.58"E
3	C5-C	Sholinganallur Junction	Elevated	25	Lat: 12°54'1.44"N Long: 80°13'41.32"E
4	C5-D	Kalpana Hospital	Elevated	5	Lat: 12°58'57.28"N Long: 80°11'46.32"E
5	C5-E	MM Hospital	Elevated	16	Lat: 13° 3'10.06"N Long: 80°11'31.17"E
6	C5-F	St. Joseph School	Elevated	98	Lat: 13° 0'43.07"N Long: 80°11'38.37"E
7	C5-G	Ravindra Bharati Global School	Elevated	15	Lat: 12°57'5.27"N Long: 80°11'8.58"E
8	C5-H	DMI St. Joseph Hospital	Elevated	30	Lat: 13° 1'59.86"N Long: 80° 9'40.27"E
9	C5-I	Cantonment Board High School	Elevated	38	Lat: 13° 0'46.44"N Long: 80°11'42.76"E

Table 4.2. List of sensitive receptors to be studied.

As can be seen in Table 4.2:

- Sensitive locations are mostly located along elevated sections rather than along underground tunnel sections: 78% elevated vs 22% underground.
- Three out of nine (33.3%) sensitive buildings are education centres, another three of them (33.3%) are residential areas, and the left three locations (33.3%) are hospitals.

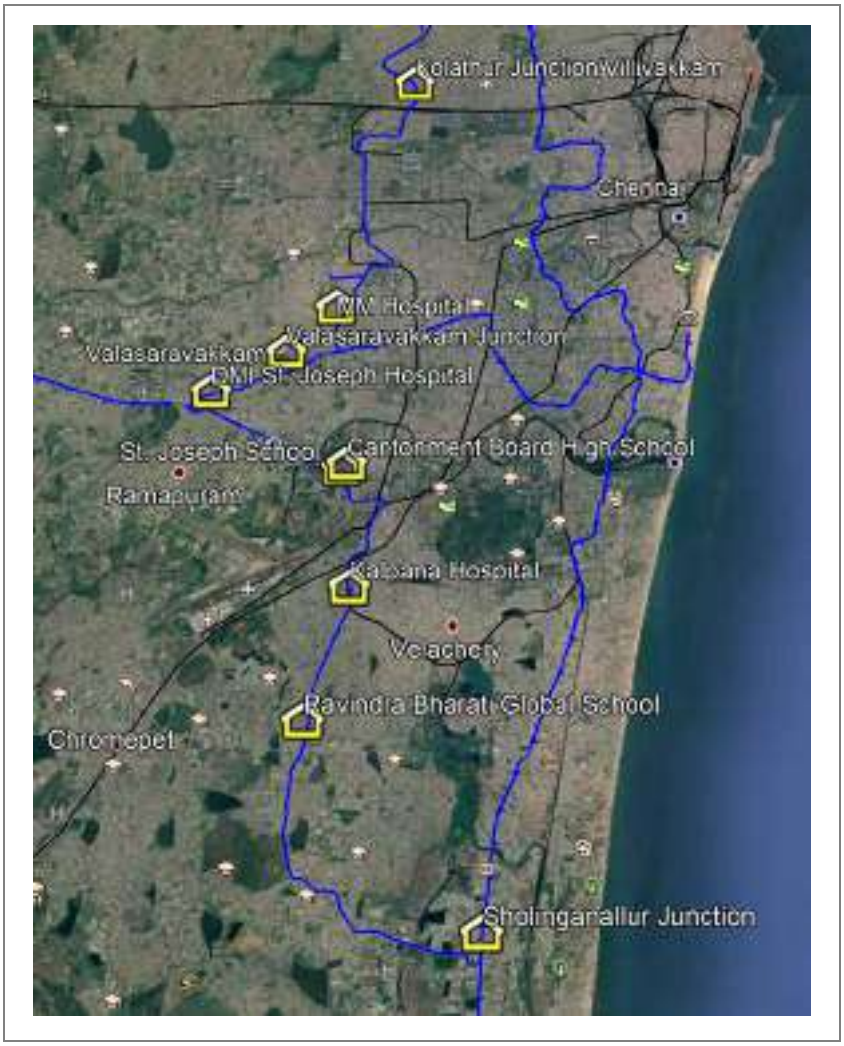

Figure 4.4. Location of nine sensitive buildings to be studied.

4.3.- Railway superstructure

As defined in alignment section, Corridor C5 considers elevated sections and underground sections. In case of elevated sections, three types of superstructures are considered which can be graphically seen in Figure 4.5:

- Precast segmental box girder
  The superstructure shall be constructed span by span sequentially, starting at one end of a continuous stretch and finishing at the other end. Some of the main advantages of precast segmental construction are reduction in structural concrete thickness, good corrosion protection and simplified segment casting.

- Precast U-channel
  Single/doble U type viaduct structure is also a precast construction with 25-28 m span. Some of the main advantages of this type of superstructure are lower the longitudinal profile, saving in construction cycle time and built-in sound barrier.

- Precast I-Girder superstructure
  Pre-cast I-Girders for various span ranges 20-34 m can be designed. Precast, pre-stressed I-Girders are casted in casting yard, transported to site and erected as ¾ I-Girders per span by using road cranes.

Figure 4.5. Three main types of superstructures considered in elevated sections.

In case of underground sections, two twin tunnels arrangement is considered, as can be seen in Figure 4.6. The tunnel excavation diameter will be 6700 mm with an internal useful tunnel diameter of 5800 mm. The Tunnel Boring Machine, TBM, will use 6 rings per segment, with a total thickness of 275 mm and a total weight of 3 T per ring.

Also cut-and-cover tunnel section are considered in specific short length sections. In this method, entire volume required to accommodate structure is first excavated, structures are casted followed by backfilling. Support of excavated sides by way of diaphragm wall/sheet pile/soldier pile/secant pile is done in cut-and-cover method. The support walls are often braced to effectively resist the huge earth pressure.

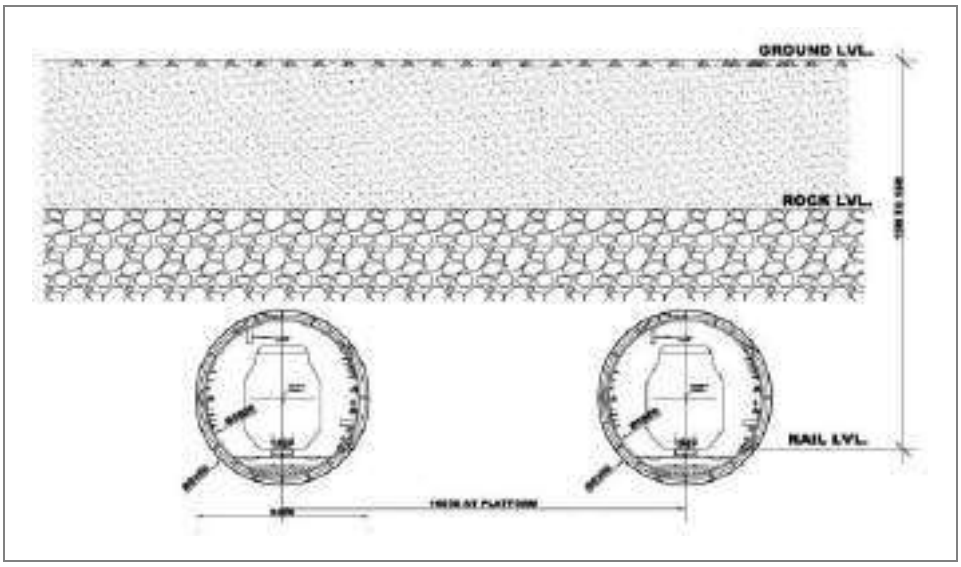

Figure 4.6. Two twin tunnels arrangement considered for underground section.

4.4.- Track structure

To reduce maintenance and renewal efforts, Head Hardened (HH) rails of grade 1080 are proposed for main lines. UIC 60 rail section will be used.

Ballastless track is proposed for elevated and underground stretches and fastening system to be installed will be a direct fixation type selected accordingly to “Procedure for safety certification and technical clearance of Metro System” written in 2015 by Govt. of India, ministry of Railways. Figure 4.7 shows a typical cross section of ballastless track on viaduct.

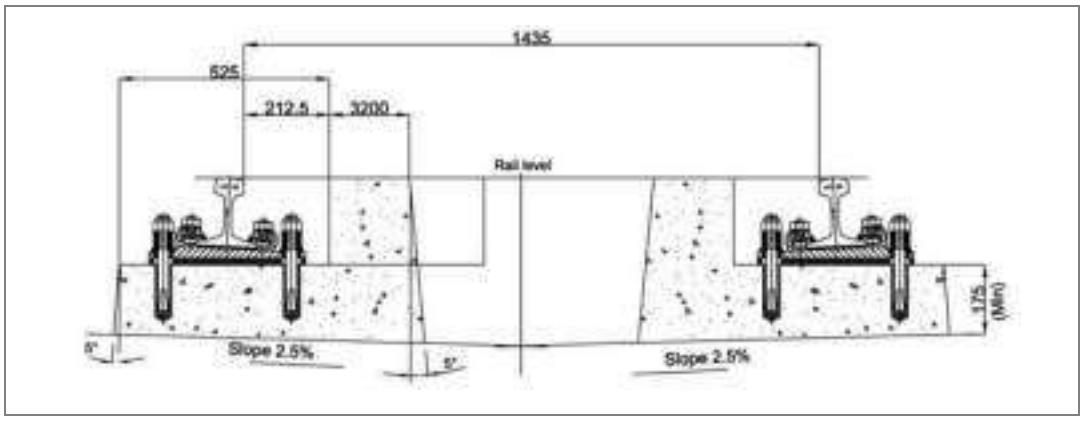

Figure 4.7. Typical cross section of ballastless track on viaduct.

4.5.- Rolling stock

Rolling stock selected to operate Corridor C5 will be based on Table 4.3 specifications.

Parameter	Value
Coach Width	2.9 m wide coaches
Basic Unit	3 car basic unit: 2 DMC and 1 TC
Train Composition	3-car: DMC+TC+DMC 6-car: DMC+TC+MC+MC+TC+DMC
Coach construction	Light weight stainless steel / aluminium body
Axle load	16 T
Breaking System	Regenerative braking
Performance	Max. speed: 90 km/h Max. acceleration: 1 m/s^2 Max. deceleration: 1.1 m/s^2 (normal brake) Max. deceleration: 1.3 m/s^2 (emergency brake)

Table 4.3. Rolling stock main characteristics.

Figure 4.8 shows the simplified velocity – time operation curve to achieve the desired schedule and Figure 4.9 shows a sample of rolling stock that is currently used in other Metro Chennai existing corridors.

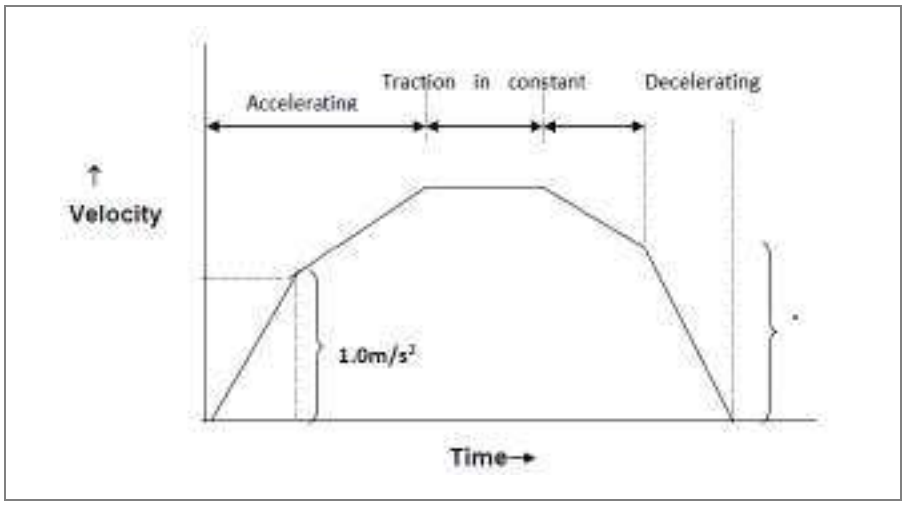

Figure 4.8. Simplified velocity – time operation curve.

Figure 4.9. Sample of Rolling stock used in other Metro Chennai existing corridors.

4.6.- Traffic demand

The underlying operation philosophy is to provide mass rapid transit services at economical cost with fixed Infrastructure and rolling stock planning.

- Frequency of train services shall be optimized to provide sectional capacity commensurate with peak direction traffic demand during peak hours.
- Minimum train service frequency shall be provided during lean period to keep option of this service attractive even during lean period
- The frequency of services shall be regulated to meet the growing traffic demand in horizon years
- Basic unit selected is two motor car and one trailer car

Train operation plan for Corridor C5 will be based on the following salient features:

- Running of normal services for 19 hours of the day (5:00 AM to 00:00 AM i.e., midnight) with average station dwell time of 30 seconds
- Make up time of 5-10% (on tangent track) with 8-12% coasting
- Scheduled average speed for the corridors shall be 32 km/h

Train operation plan for Phase II corridors has been formulated considering PHPDT for different sections of corridors. The PHPDT considered for the preparation of train operation plan is given in Table 4.4.

Corridor	2025	2035	2045	2055
C5 – Madhavaram – Adyar – Sholinganallur	16,289	22,115	24,301	27,361
C5 – Madhavaram – Sholinganallur	17,539	24,528	29,441	35,714

Table 4.4. PHPDT for different horizon years.

Train operation is envisaged with combination of 3 car and 6 car rake composition in the inception year 2025 and 6 rake composition in design year 2055. Th infrastructure is designed considering two different options:

Option 1: circular operation between Corridor C3 and Corridor C5
Trains are proposed to run between the following sections:

- Madhavaram – Adyar – SIPCOT covering a total length of 44.7 km
- Madhavaram – CMBT – Sholinganallur – Adyar - Madhavaram covering a total length of 81.3 km
- MMBT – CMBT – Sholinganallur covering a total length of 42 km

Option 2: independent train operation
Independent operation for Madhavaram to Sholinganallur via CMBT, covering a total length of 46.3 km.

Train operation plan for Madhavaram -Sholinganallur section of the corridor in year 2055 is planed with 6 car rake composition and 212 seconds headway during peak period. The PHPDT capacity of the trains during peak hours will be 26,792 at 6 passengers/m^2 rate of standee area (capacity of 34,068 at 8 passengers/m^2 rate of standee area). The planned PHPDT capacity is less than PHPDT demand of 35,714 passengers in few sections. However, capacity in these sections can be met by carrying standees at 8 passengers/m^2 rate.

Figure 4.10 shows PHPDT demand and capacity provided for Madhavaram – Sholinganallur corridor C5.

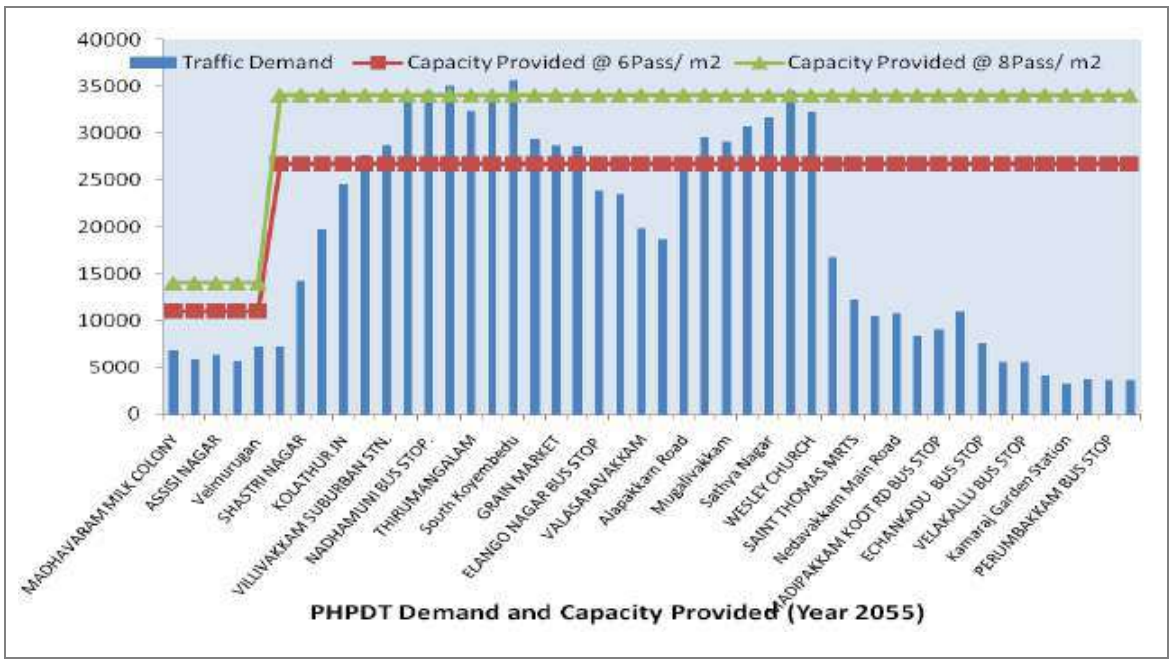

Figure 4.10. PHPDT demand and capacity provided (2055) for Madhavaram-Sholinganallur corridor.

4.7.- Geology

The geology of Chennai comprises of mostly sand deposits, clay, granite, gneiss and traces of shale and sandstone. The city is classified into three regions based on geology i.e., sandy areas, clayey areas, and hard-rock areas.

Sandy areas are found along the riverbanks and the coasts. In sandy areas such as Tiruvanmiyur, Adyar, Kottivakkam, Santhome, George Town, Tondiarpet and the rest of coastal Chennai, rainwater run-off percolates very quickly.

Clayey regions cover most of the city while hard rock areas are Guindy, Velachery, Adambakkam and a part of Saidapet. In clayey and hard rock areas, rainwater percolates slowly, but it is held by the soil for a longer time. The city's clayey areas include T. Nagar, West Mambalam, Anna Nagar, Perambur and Virugambakkam.

Chennai district forms part of coastal plains of Tamil Nadu. Major part of the district is having flat topography with very gentle slope towards east. The altitudes of land surface vary from 10 m above MSL in the west to sea level in the east. Fluvial, marine, and erosional landforms are noticed in the district. Marine transgression and

regressions and neo-tectonic activity during the recent past have influenced the morphology and resulted in various present landforms. Meandering streams with small sand bars are present along the course of Adyar River. The pediment and buried pediment in Guindy area in and around the reserved forest, is the only area where the ecological system is less disturbed, while the other areas are completely disturbed by built up area with largescale human interference and pollution.

The geology of Chennai is shown in Figure 4.11.

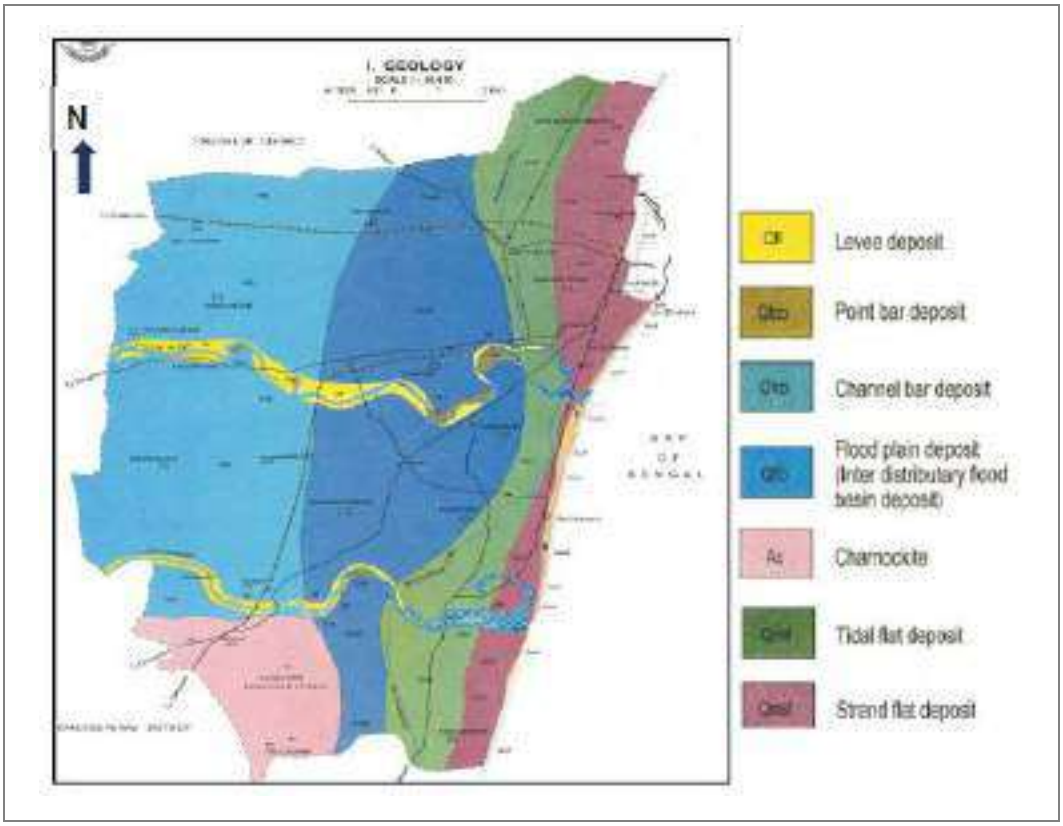

Figure 4.11. Geology of Chennai city and shoutern part.

5.- Prediction methodology

5.1.- Construction phase

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

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

Table 5.1 presents average source levels at 25 ft in terms of PPV and RMS velocity in decibels (L_v), for various types of construction equipment measured under a wide variety of construction activities. Note that although the table gives one level for each piece of equipment, there might be considerable variation in reported ground vibration levels from construction activities. The data in Table 5.1 provide a reasonable estimate for a wide range of soil conditions.

Equipment	PPV (in/sec)	L_v at 25 ft (VdB re 1 micro-in/sec)
Impact Pile Driver: Upper range/Typical range	1.518/0.644	112/104
Sonic Pile Driver: Upper range/Typical range	0.734/0.17	105/93
Clam shovel drop	0.202	94
Hydromill: in soil/ in rock	0.008/0.017	66/75
Vibratory Roller	0210	94
Hoe Ram	0.089	87
Large bulldozer	0.089	87
Caisson drilling	0.089	87
Loaded trucks	0.076	86
Jackhammer	0.035	79
Small bulldozer	0.003	58

Table 5.1. Vibration source levels for construction equipment at 25 ft.

Assess for building damage and for annoyance due to each piece of equipment need to be carried out.

5.1.1.- Building damage assessment

Construction vibration is generally assessed in terms of peak particle velocity (PPV). In this regard, first, the vibration source level (PPV_{ref}) for each piece of equipment at a reference distance of 25 ft is determined using Table 5.1, then Eq. 6.1 is used to apply adjustment to the source reference level to account for the distance from the equipment to the receiver,

$$PPV_{equip} = PPV_{ref} \times \left(\frac{25}{D}\right)^{1.5}; \quad (6.1)$$

where PPV_{equip} is the peak particle velocity of the equipment, PPV_{ref} is the source reference vibration level at 25 ft (Table 5.1) and D is the distance from the equipment to the receiver.

The predicted vibration levels obtained using this quantitative construction vibration assessment is compared with the impact criteria introduced Section 3.2.- to assess the construction vibration damage impact.

5.1.2.- Annoyance assessment

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

$$L_{v,distance} = L_{v,ref} - 30log\left(\frac{D}{25}\right); \quad (6.2)$$

where $L_{v,distance}$ is the RMS velocity level adjusted for distance (in VdB), $L_{v,ref}$ is the source reference vibration level at 25 ft (in VdB) as proposed by FTA in Table 5.1 and D is the distance from the equipment to the receiver.

The predicted vibration levels obtained using this quantitative assessment is compared with the impact criteria introduced in Section 3.2.- for annoyance assessment during the construction phase.

5.2.- Operational phase

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

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

In the following subsections step will be explained in more details.

5.2.1.- Identify sensitive receptors

Identifying the sensitive receptors are mainly defined using two main criteria, type of the project (or type of the source) and land use category; based on which the screening distances for vibration assessments, as shown in Table 5.2, is defined. Regarding Chennai Metro Rail Phase II – Corridor 5, 9 sensitive receptors has been already identified, including 7 sensitive receptors for elevated section and 2 sensitive receptors for the underground section. So, in this report the vibration impact assessment for these 9 receptors is carried out. Table 4.2 shows the list of these receptors along with their distance from the source, which is either elevated or underground.

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

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

Table 5.2. Screening distances for vibration assessments

5.2.2.- Base curve

Three base curves are proposed by FTA guidelines. These based lines categorize the induced vibration level as a function of distance between the source and the receptor for three different type of sources, locomotive-powered passenger or freight curve, rapid transit or light rail vehicles curve and rubber-tired vehicles curve. Considering the type of the characteristics of the rolling stocks used in corridor 5, as explained in 4.5.-, rapid transit or light rail vehicles curve is used in this study as a base curve for ground surface vibration level. Noteworthy, the main base curve proposed by FTA is for the reference train speed of $vt_{ref} = 50$ mph, however, it is expressed that vibration level is approximately proportional to $20log(^{vt}/_{vt_{ref}})$. for Figure 5.1 shows the base ground surface vibration curves for five different train speeds, it can be observed that the faster the train is, the higher induced vibration will be. For corridor 5, the prediction is carried out for both design speed of 49.7 mph (80 kmph) and scheduled speed of 19.9 mph (32 kmph).

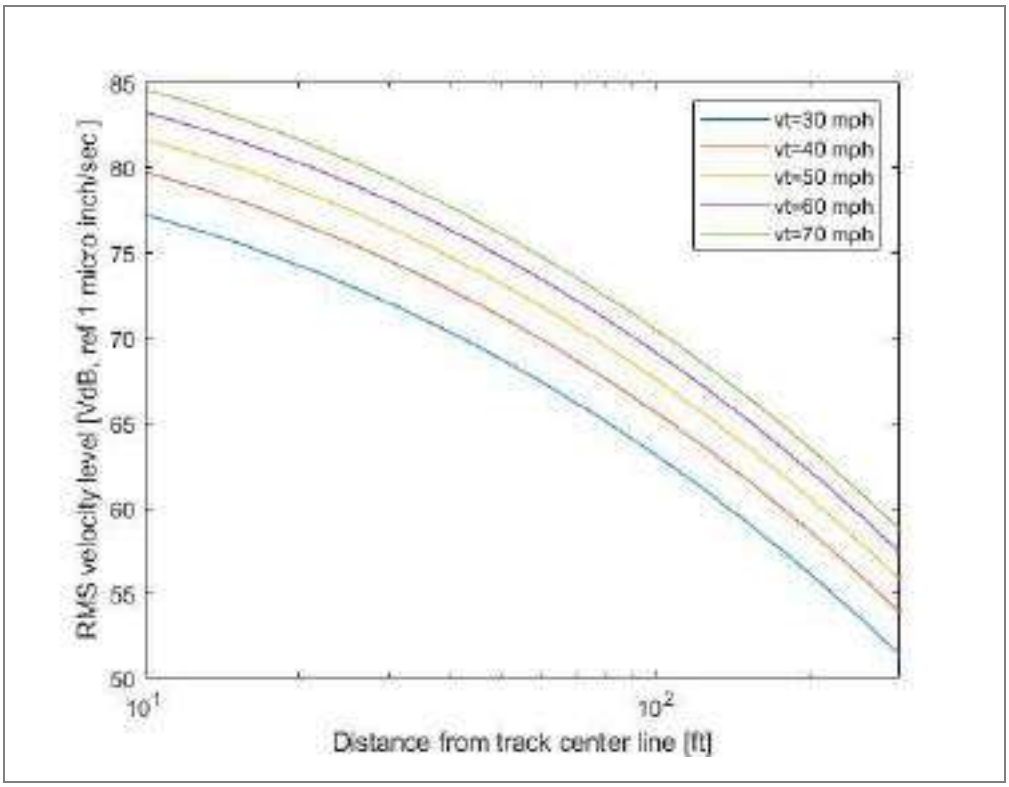

Figure 5.1. Ground surface vibration curves for different train speeds.

5.2.3.- Project-specific adjustments

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

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

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

The most important adjustment factors for the propagation path consist of type of transit structure, geologic conditions and coupling to building foundation. In general, the heavier the structure, the lower the vibration levels; and the heavier the building construction, the greater the coupling loss. The geological condition near the sensitive receptors of corridor 5 shows that the soil type can be associated with efficient vibration propagation. As proposed by FTA guidelines, a conservative approach would be to use for efficient propagation for areas where efficient propagation is likely. This approach is followed in this study.

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

5.2.4.- Vibration impact criteria

The criteria for ground-borne vibration land use categories 1-3 are presented in Table 3.1. The criteria are presented in terms of acceptable indoor ground-borne vibration and noise levels. Impact will occur if these levels are exceeded. Criteria for ground-borne vibration are expressed in terms of rms velocity levels in VdB. The criteria for ground-borne vibration and noise for special land uses are presented in Table 3.2.

5.2.5.- Vibration mitigation measures

The purpose of vibration mitigation is to minimize the adverse effects that the project ground-borne vibration will have on sensitive land uses if the predicted vibration level exceeds the criteria limits. Targeting the mechanisms of ground-borne vibration generation to reduce transmitted forces by the vehicle to the track would be the most efficient approach. Due to high cost of the maintenance actions, countermeasures are necessary to address railway-induced ground-borne vibration problem at a more reasonable cost. Several solutions have been proposed to address the problem of

ground-borne vibration induced by railways. The mitigation measures can be categorized according to the location at where they are applied: i) the source; ii) the receiver and iii) the propagation path.

Mitigation measures at the source mainly target the track and its resiliency to reduce vibration transmission into the ground. An effective measure to reduce the vibration at the point of the emission is using floating-slab and high-resilience fasteners. Damping treatments, localized stiffening or mass addition are some mitigation measures at receivers, that can be used to reduce the post-construction vibration.

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

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

6.- Results

In this section, the methodology explained previously is used to obtain a general overview on vibration level induced during construction and operation phases regarding distance between the source and receptors. Then, the methodology is employed to predict the vibration level during construction and operation phases at 13 identified sensitive receptors.

6.1.- General vibration impact assessment

6.1.1.- Construction phase - Damage impact assessment

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

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

In this figure, all the construction equipment defined by FTA guidelines has been presented regardless of its application in the present project. According to FTA guidelines, different pile drive methods could result in different vibration. Therefore, the upper range is proposed for pile drive. Noteworthy, it can be observed from Figure 7.1 that pile drivers, either impact or sonic, along with clam shovel drop and vibratory roller are among the most problematic equipment. To clarify the effect of this equipment, the distance up to which the equipment can induce the vibration levels higher than the damage criteria are presented Table 6.1.

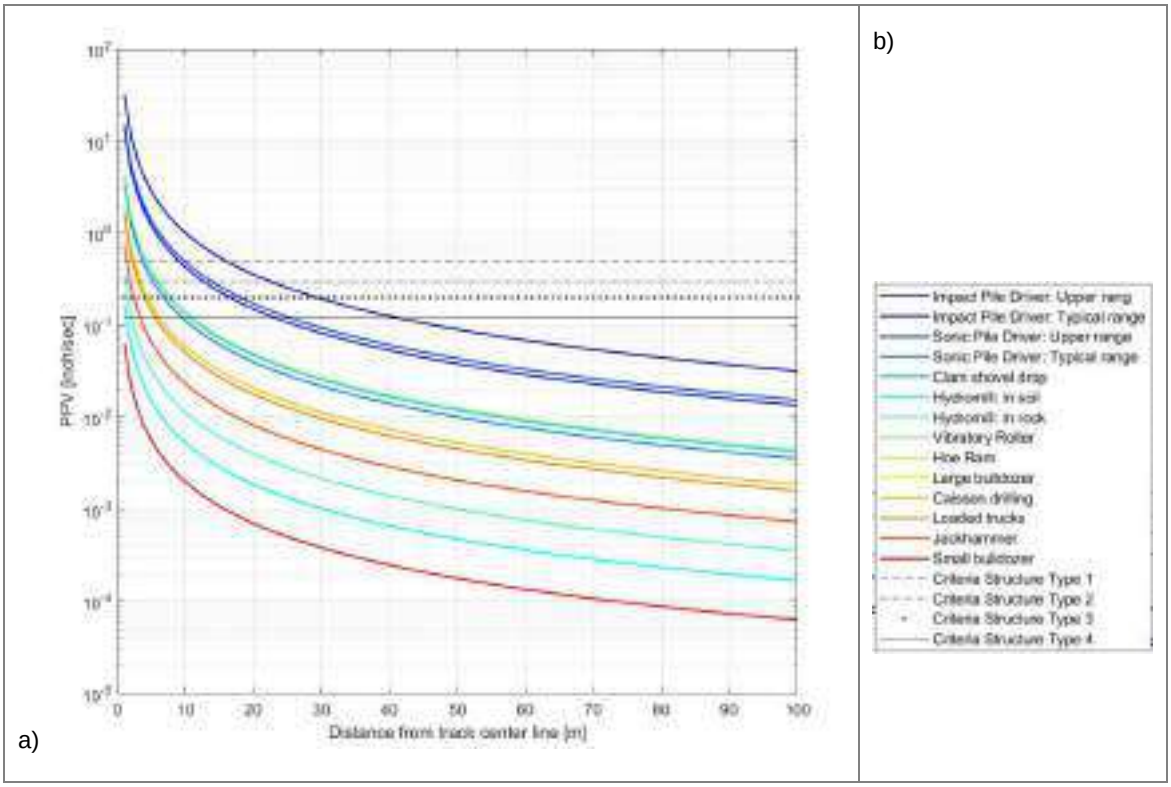

Figure 6.1. a) Predicted vibration level (PPV in inch/sec) for eleven type of construction equipment and impact criteria for four different type of structures and b) figure legend.

Construction equipment	Affected area distance from construction zone (m) – Considering the structure type			
	structure type 1 (0.5 inch/s)	structure type 2 (0.3 inch/s)	structure type 3 (0.2 inch/s)	structure type 4 (0.12 inch/s)
Impact pile drive (upper range)	16 m	23 m	30 m	41 m
Sonic pile drive (upper range)	10 m	14 m	19 m	25 m
Impact pile drive (typical range)	9 m	12 m	16 m	23 m
Clam shovel drop	4 m	6 m	8 m	11 m
Vibratory roller	4 m	6 m	8 m	11 m
Sonic pile drive (typical range)	4 m	6 m	6 m	9 m

Table 6.1. Affected area in construction phase due to five use of five most problematic equipment. Categorized based on four different criteria impact of four type of structures.

6.1.2.- Construction phase - Annoyance impact assessment

The equation (6.2) has been used to predict the induced vibration during the construction phase for different equipment as a function of distance between construction zone and receptor. The results are shown in Figure 6.2. Moreover, the annoyance criteria have been shown in this figure. Three criteria proposed by FTA guidelines based on the land use, as explained in Section 3.2.-, are shown in the figure as well. Noteworthy, here it is considered that the use of construction equipment is considered as a frequent event (used more than 12 event per day). If the frequency event is less between 5 to 12 events per day, the criteria category 3 will not change, but, the criteria categories 3 and 2 will increase 3 dB. In addition, if the frequency event is less than 5 event per day, the criteria category 3 will not change, but, the criteria categories 3 and 2 will increase 8 dB. In this section, the conservative approach, assuming the frequent events, has been considered.

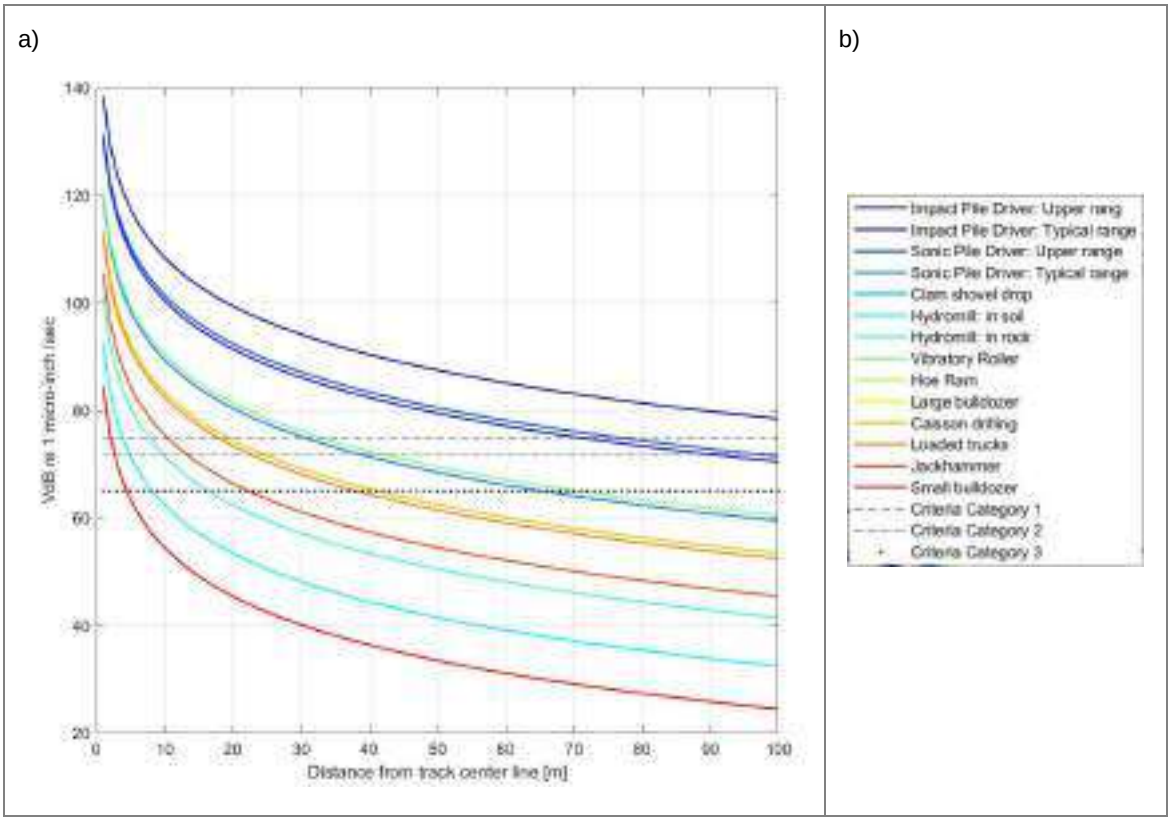

Figure 6.2. Predicted vibration level (VdB ref 1 micro-inch/sec) for eleven type of construction equipment and impact criteria for three different type of land use and b) figure legend.

To clarify the effect of most problematic equipment, the distance up to which the equipment can induce the vibration levels higher than the annoyance criteria are presented in Table 6.2.

Building structure	Affected area distance from track centre (m) – Considering the land use		
	Category 1 (65 VdB)	Category 2 (72 VdB)	Category 3 (75 VdB)
Impact pile drive (upper range)	100 m	100 m	100 m
Sonic pile drive (upper range)	100 m	93 m	76 m
Impact pile drive (typical range)	100 m	89 m	70 m
Clam shovel drop	69 m	41 m	32 m
Vibratory roller	69 m	41 m	32 m
Sonic pile drive (typical range)	64 m	37 m	30 m

Table 6.2. Affected area due to t construction phase due to five use of five most problematic. Categorized based on three different criteria impact of three land use category and the type of the building structure.

6.1.3.- Operation phase – Underground section

The methodology explained in Section 5.2.- has been used to predict the induced vibration due to train pass-by in underground section for both design and scheduled speeds as a function of distance between the centre of track and receptor. The results are shown in Figure 6.3. Moreover, the annoyance criteria have been shown in this figure. Noteworthy, three criteria, proposed by FTA guidelines based on the land use as explained in Section 3.2.-, are shown in the figure as well.

As it can be observed, the type of the building could affect the level of the vibration into the receptor. To clarify the effect of the type of the building foundation and the train speed, the distance up to which the train pass-by can induce the vibration levels higher than the annoyance criteria are presented in Table 6.3 and Table 6.4 for design and schedule speeds, respectively.

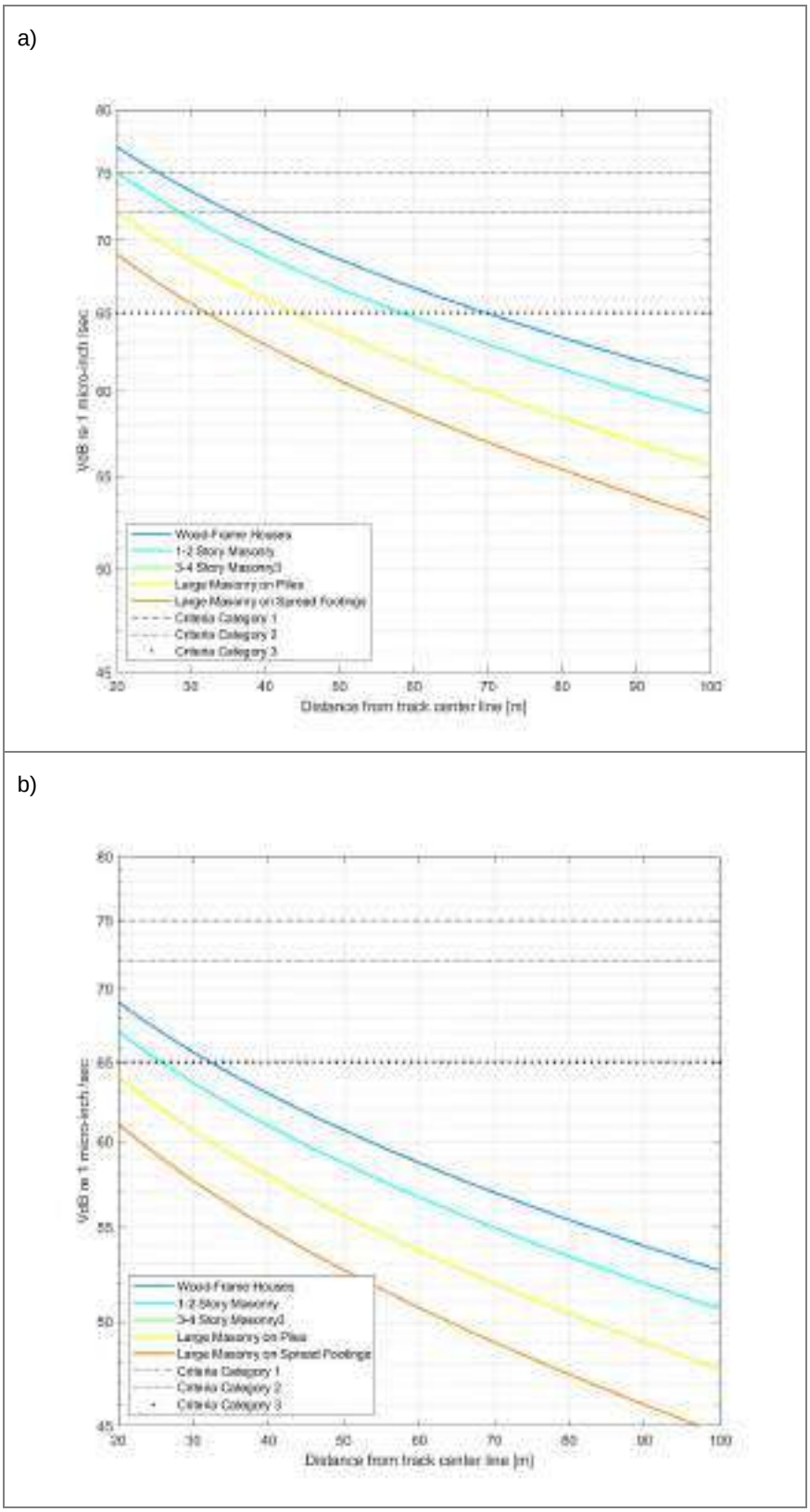

Figure 6.3. Predicted vibration level (VdB ref 1 micro-inch/sec) for 5 different types of buildings induced to train pass-by in underground sections with a) designed speed of 80 kmph and b) with scheduled speed of 32 kmph. Horizontal lines present the criteria impact for 3 different land use.

Design speed 80 kmph

Building structure	Affected area radius from track centre (m) – Considering the land use		
	Category 1 (65 VdB)	Category 2 (72VdB)	Category 3 (75 VdB)
Wood-Frame Houses	70 m	36 m	26 m
1-2 Story Masonry	58 m	29 m	20 m
3-4 Story Masonry/ Large Masonry on Piles	44 m	20 m	13 m
Large Masonry on Spread Footings	32 m	13 m	--

Table 6.3. Affected area due to train-pass by in underground section with designed speed of 80 kmph. Categorized based on three different criteria impact of three land use category and the type of the building structure.

Scheduled speed 32 kmph

Building structure	Affected area radius from track centre (m) – Considering the land use		
	Category 1 (65 VdB)	Category 2 (72VdB)	Category 3 (75 VdB)
Wood-Frame Houses	32 m	14 m	--
1-2 Story Masonry	20 m	10 m	--
3-4 Story Masonry/ Large Masonry on Piles	18 m	--	--
Large Masonry on Spread Footings	12 m	--	--

Table 6.4. Affected area due to train-pass by in underground section with scheduled speed of 32 kmph. Categorized based on three different criteria impact of three land use category and the type of the building structure.

6.1.4.- Operation phase – Elevated section

The methodology explained in Section 5.2.- has been used to predict the induced vibration due to train pass-by in elevated section for both design and scheduled speeds as a function of distance between the centre of track and receptor. The results are shown in Figure 6.4. Like before, the annoyance criteria have been shown in this figure. To clarify the effect of the type of the building foundation and the train speed, the distance up to which the train pass-by can induce the vibration levels higher than the annoyance criteria are presented in Table 6.5 and Table 6.6 for design and schedule speeds, respectively.

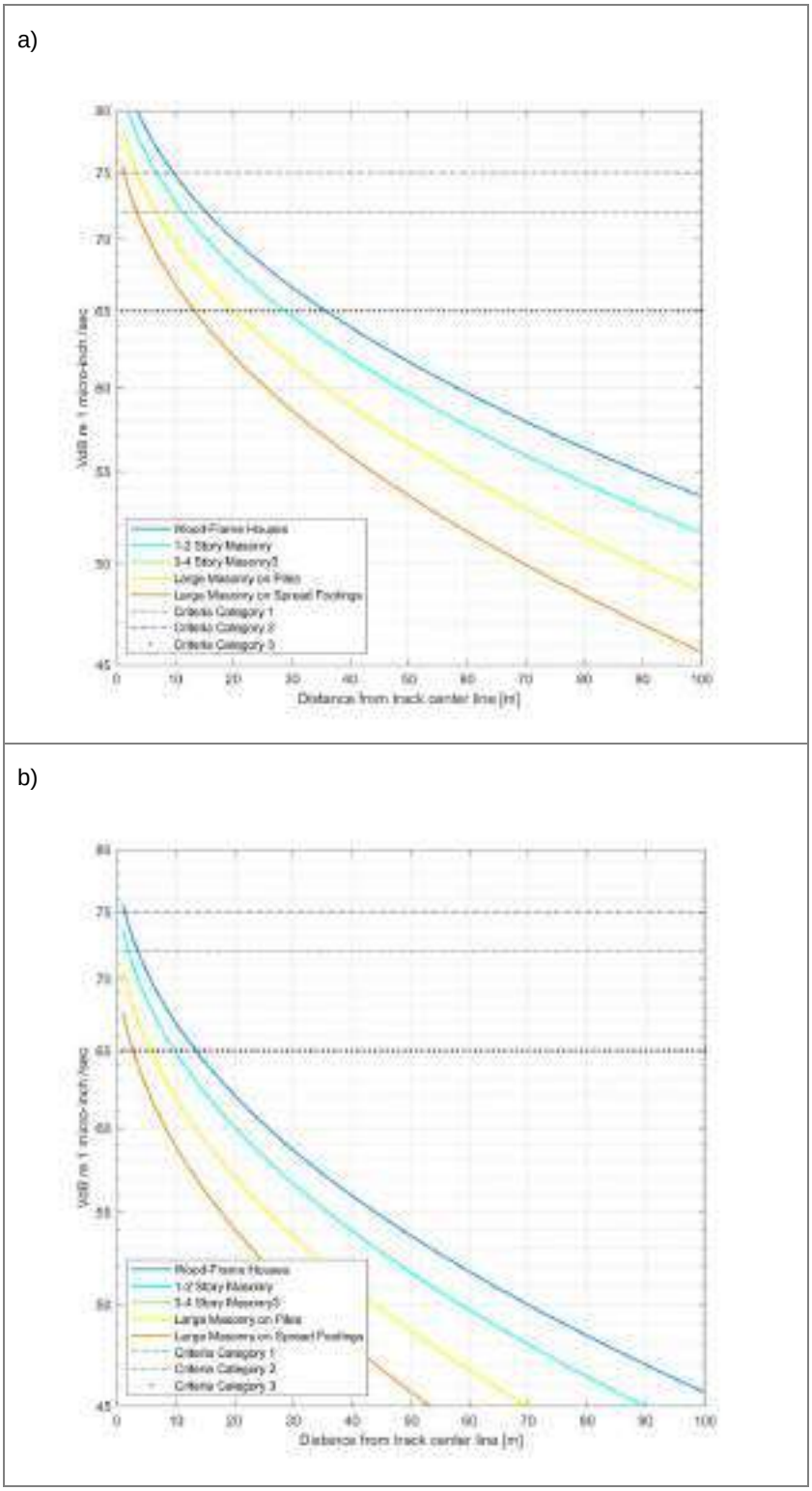

Figure 6.4. Predicted vibration level (VdB ref 1 micro-inch/sec) for 5 different types of buildings induced to train pass-by in elevated sections with a) designed speed of 80 kmph and b) with scheduled speed of 32 kmph. Horizontal lines present the criteria impact for 3 different land use.

Design speed 80 kmph

Building structure	Affected area radius from track centre (m) – Considering the land use		
	Category 1 (65 VdB)	Category 2 (72VdB)	Category 3 (75 VdB)
Wood-Frame Houses	36 m	16 m	10 m
1-2 Story Masonry	29 m	12 m	7 m
3-4 Story Masonry/ Large Masonry on Piles	20 m	7 m	4 m
Large Masonry on Spread Footings	13 m	3 m	2 m

Table 6.5. Affected area due to train-pass by in elevated section with designed speed of 80 kmph. Categorized based on three different criteria impact of three land use category and the type of the building structure.

Scheduled speed 32 kmph

Building structure	Affected area radius from track centre (m) – Considering the land use		
	Category 1 (65 VdB)	Category 2 (72VdB)	Category 3 (75 VdB)
Wood-Frame Houses	14 m	4 m	--
1-2 Story Masonry	10 m	2 m	--
3-4 Story Masonry/ Large Masonry on Piles	5 m	--	--
Large Masonry on Spread Footings	3 m	--	--

Table 6.6. Affected area due to train-pass by in elevated section with scheduled speed of 32 kmph. Categorized based on three different criteria impact of three land use category and the type of the building structure.

6.2.- Vibration impact assessment at 9 receptors

The summary of the predicted results of all 9 sensitive receptors for the construction and operation phase are presented in this section. As explained previously, the building structure, its foundation, land use and frequency of events are important parameters to define the criteria for assessing the vibration impact either in construction phase or operation phase. However, there are three receptors, Kolathur Junction/Villivakkam, Valasaravakkam Junction and Sholinganallur Junction, in which no specific building has been defined. Moreover, there are some receptors which the type of foundation is not clearly defined. Therefore, the following approach has been followed for the criteria:

- For damage assessment during construction phase. if there is uncertainty about the receptor structure, four damage criteria for four different types of structures (St1/St2/St3/St4) as explained in Section 3.2.- are considered.
- For annoyance assessment during construction phase, if there is uncertainty about the frequency of the events, three annoyance criteria associated with frequent event, occasional even and infrequent even (as explained in Section 6.1.2.-) are considered.
- For annoyance assessment during construction phase, if there is uncertainty about the land use three annoyance criteria associated with three different land use (Cat1/Cat2/Cat3) are presented.
- For annoyance assessment during operation phase, if there is uncertainty about the building foundation, several predicted results have been obtained.

6.2.1.- Kolathur Junction/Villivakkam

Kolathur Junction/Villivakkam	Construction phase Damage assessment		Construction phase Annoyance assessment	
	Predicted	Criteria (in/sec) St1/St2/St3/St4	Predicted	Criteria (VdB 1 μ inch/sec) Cat1/Cat2/Cat3
Impact Pile Driver: Upper range	0.51	0.5/0.3/0.2/0.12	102.5	Frequent Event: 65/72/75
Impact Pile Driver: Typical range	0.20		94.5	
Sonic Pile Driver: Upper range	0.25		95.5	
Sonic Pile Driver: Typical range	0.06		83.5	
Clam shovel drop	0.07		84.5	
Hydromill: in soil	0.00		56.5	
Hydromill: in rock	0.01		65.5	Occasional Event: 65/75/78
Vibratory Roller	0.07		84.5	
Hoe Ram	0.03		77.5	Infrequent Event: 65/80/83
Large bulldozer	0.03		77.5	
Caisson drilling	0.03		77.5	
Loaded trucks	0.03		76.5	
Jackhammer	0.01		69.5	
Small bulldozer	0.00		48.5	

Table 6.7. Prediction results for construction phase of Kolathur Junction/Villivakkam receptor.

Kolathur Junction/Villivakkam	Operation phase	
	Predicted (VdB 1 μ inch/sec) Design/Schedule speed	Criteria (VdB 1 μ inch/sec) Cat1/Cat2/Cat3
Wood-Frame Houses	78.8/70.9	65/72/75
1-2 Story Masonry	76.8/68.9	65/72/75
3-4 Story Masonry/ Large Masonry on Piles	73.8/65.9	65/72/75
Large Masonry on Spread Footings	70.8/62.9	65/72/75

Table 6.8. Prediction results for operation phase Kolathur Junction/Villivakkam receptor.

6.2.2.- Valasaravakkam Junction

Valasaravakkam Junction	Construction phase Damage assessment		Construction phase Annoyance assessment	
	Predicted	Criteria (in/sec) St1/St2	Predicted	Criteria (VdB 1 μ inch/sec) Cat3
Impact Pile Driver: Upper range	0.47	0.5/0.3/0.2/0.12	101.8	Frequent Event: 65/72/75
Impact Pile Driver: Typical range	0.20		93.8	
Sonic Pile Driver: Upper range	0.23		94.8	
Sonic Pile Driver: Typical range	0.05		82.8	
Clam shovel drop	0.06		83.8	
Hydromill: in soil	0.00		55.8	
Hydromill: in rock	0.01		64.8	Occasional Event: 65/75/78
Vibratory Roller	0.07		83.8	
Hoe Ram	0.03		76.8	Infrequent Event: 65/80/83
Large bulldozer	0.03		76.8	
Caisson drilling	0.03		76.8	
Loaded trucks	0.02		75.8	
Jackhammer	0.01		68.8	
Small bulldozer	0.00		47.8	

Table 6.9. Prediction results for construction phase of Valasaravakkam Junction receptor.

Valasaravakkam Junction	Operation phase	
	Predicted (VdB 1 μ inch/sec) Design/Schedule speed	Criteria (VdB 1 μ inch/sec) Cat1/Cat2/Cat3
Wood-Frame Houses	78.4/70.5	65/72/75
1-2 Story Masonry	76.4/68.5	65/72/75
3-4 Story Masonry/ Large Masonry on Piles	73.4/65.5	65/72/75
Large Masonry on Spread Footings	70.4/62.5	65/72/75

Table 6.10. Prediction results for operation phase of Valasaravakkam Junction receptor.

6.2.3.- Sholinganallur Junction

Sholinganallur Junction	Construction phase Damage assessment		Construction phase Annoyance assessment	
	Predicted	Criteria (in/sec) St1/St2	Predicted	Criteria (VdB 1 μ inch/sec) Cat3
Impact Pile Driver: Upper range	0.26	0.5/0.3/0.2/0.12	96.5	Frequent Event: 65/72/75
Impact Pile Driver: Typical range	0.11		88.5	
Sonic Pile Driver: Upper range	0.12		89.5	
Sonic Pile Driver: Typical range	0.03		77.5	
Clam shovel drop	0.03		78.5	
Hydromill: in soil	0.00		50.5	
Hydromill: in rock	0.00		59.5	Occasional Event: 65/75/78
Vibratory Roller	0.04		78.5	
Hoe Ram	0.01		71.5	Infrequent Event: 65/80/83
Large bulldozer	0.01		71.5	
Caisson drilling	0.01		71.5	
Loaded trucks	0.01		70.5	
Jackhammer	0.01		63.5	
Small bulldozer	0.00		42.5	

Table 6.11. Prediction results for construction phase of Sholinganallur Junction receptor.

Sholinganallur Junction	Operation phase	
	Predicted (VdB 1 μ inch/sec) Design/Schedule speed	Criteria (VdB 1 μ inch/sec) Cat1/Cat2/Cat3
Wood-Frame Houses	68.2/60.2	65/72/75
1-2 Story Masonry	66.2/58.2	65/72/75
3-4 Story Masonry/ Large Masonry on Piles	63.2/55.2	65/72/75
Large Masonry on Spread Footings	60.2/52.2	65/72/75

Table 6.12. Prediction results for operation phase of Sholinganallur Junction receptor.

6.2.4.- Kalpana Hospital

Kalpana Hospital	Construction phase Damage assessment		Construction phase Annoyance assessment	
	Predicted	Criteria (in/sec) St1/St2	Predicted	Criteria (VdB 1 μ inch/sec) Cat3
Impact Pile Driver: Upper range	2.86	0.5/0.3	117.5	Frequent Event: 65 Occasional Event: 65 Infrequent Event: 65
Impact Pile Driver: Typical range	1.21		109.5	
Sonic Pile Driver: Upper range	1.38		110.5	
Sonic Pile Driver: Typical range	0.32		98.5	
Clam shovel drop	0.38		99.5	
Hydromill: in soil	0.02		71.5	
Hydromill: in rock	0.03		80.5	
Vibratory Roller	0.40		99.5	
Hoe Ram	0.17		92.5	
Large bulldozer	0.17		92.5	
Caisson drilling	0.17		92.5	
Loaded trucks	0.14		91.5	
Jackhammer	0.07		84.5	
Small bulldozer	0.01		63.5	

Table 6.13. Prediction results for construction phase of Kalpana Hospital receptor.

Kalpana Hospital	Operation phase	
	Predicted (VdB 1 μ inch/sec) Design/Schedule speed	Criteria (VdB 1 μ inch/sec) Cat3
1-2 Story Masonry	76.6/68.6	65
3-4 Story Masonry/ Large Masonry on Piles	73.6/65.5	65

Table 6.14. Prediction results for operation phase of Kalpana Hospital receptor.

6.2.5.- MM Hospital

MM Hospital	Construction phase Damage assessment		Construction phase Annoyance assessment	
	Predicted	Criteria (in/sec) St1/St2	Predicted	Criteria (VdB 1 μ inch/sec) Cat3
Impact Pile Driver: Upper range	0.50	0.5/0.3	102.3	Frequent Event: 65 Occasional Event: 65 Infrequent Event: 65
Impact Pile Driver: Typical range	0.21		94.3	
Sonic Pile Driver: Upper range	0.24		95.3	
Sonic Pile Driver: Typical range	0.06		83.3	
Clam shovel drop	0.07		84.3	
Hydromill: in soil	0.00		56.3	
Hydromill: in rock	0.01		65.3	
Vibratory Roller	0.07		84.3	
Hoe Ram	0.03		77.3	
Large bulldozer	0.03		77.3	
Caisson drilling	0.03		77.3	
Loaded trucks	0.02		76.3	
Jackhammer	0.01		69.3	
Small bulldozer	0.00		48.3	

Table 6.15. Prediction results for construction phase of MM Hospital receptor.

MM Hospital	Operation phase	
	Predicted (VdB 1 μ inch/sec) Design/Schedule speed	Criteria (VdB 1 μ inch/sec) Cat3
1-2 Story Masonry	69.7/61.8	65
3-4 Story Masonry/ Large Masonry on Piles	66.7/58.8	65

Table 6.16. Prediction results for operation phase of MM Hospital receptor.

6.2.6.- St. Joseph School

St. Joseph School	Construction phase Damage assessment		Construction phase Annoyance assessment	
	Predicted	Criteria (in/sec) St1/St2	Predicted	Criteria (VdB 1 μ inch/sec) Cat3
Impact Pile Driver: Upper range	0.03	0.5/0.3	78.7	Frequent Event: 75 Occasional Event: 78 Infrequent Event: 83
Impact Pile Driver: Typical range	0.01		70.7	
Sonic Pile Driver: Upper range	0.02		71.7	
Sonic Pile Driver: Typical range	0.00		59.7	
Clam shovel drop	0.00		60.7	
Hydromill: in soil	0.00		32.7	
Hydromill: in rock	0.00		41.7	
Vibratory Roller	0.00		60.7	
Hoe Ram	0.00		53.7	
Large bulldozer	0.00		53.7	
Caisson drilling	0.00		53.7	
Loaded trucks	0.00		52.7	
Jackhammer	0.00		45.7	
Small bulldozer	0.00		24.7	

Table 6.17. Prediction results for construction phase of St. Joseph School receptor.

St. Joseph School	Operation phase	
	Predicted (VdB 1 μ inch/sec) Design/Schedule speed	Criteria (VdB 1 μ inch/sec) Cat3
1-2 Story Masonry	51.9/43.9	75
3-4 Story Masonry/ Large Masonry on Piles	48.9/40.9	75

Table 6.18. Prediction results for operation phase of St. Joseph School receptor.

6.2.7.- Ravindra Bharati Global School

Ravindra Bharati Global School	Construction phase Damage assessment		Construction phase Annoyance assessment	
	Predicted	Criteria (in/sec) St1/St2	Predicted	Criteria (VdB 1 μ inch/sec) Cat3
Impact Pile Driver: Upper range	0.55	0.5/0.3	103.2	Frequent Event: 75 Occasional Event: 78 Infrequent Event: 83
Impact Pile Driver: Typical range	0.23		95.2	
Sonic Pile Driver: Upper range	0.27		96.2	
Sonic Pile Driver: Typical range	0.06		84.2	
Clam shovel drop	0.07		85.2	
Hydromill: in soil	0.00		57.2	
Hydromill: in rock	0.01		66.2	
Vibratory Roller	0.08		85.2	
Hoe Ram	0.03		78.2	
Large bulldozer	0.03		78.2	
Caisson drilling	0.03		78.2	
Loaded trucks	0.03		77.2	
Jackhammer	0.01		70.2	
Small bulldozer	0.00		49.2	

Table 6.19. Prediction results for construction phase of Ravindra Bharati Global School receptor.

Ravindra Bharati Global School	Operation phase	
	Predicted (VdB 1 μ inch/sec) Design/Schedule speed	Criteria (VdB 1 μ inch/sec) Cat3
3-4 Story Masonry/ Large Masonry on Piles	62.1/54.2	75

Table 6.20. Prediction results for operation phase of Ravindra Bharati Global School receptor.

6.2.8.- DMI St. Joseph Hospital

DMI St. Joseph Hospital	Construction phase Damage assessment		Construction phase Annoyance assessment	
	Predicted	Criteria (in/sec) St1/St2	Predicted	Criteria (VdB 1 μ inch/sec) Cat3
Impact Pile Driver: Upper range	0.19	0.5/0.3	94.1	Frequent Event: 65 Occasional Event: 65 Infrequent Event: 65
Impact Pile Driver: Typical range	0.08		86.1	
Sonic Pile Driver: Upper range	0.09		87.1	
Sonic Pile Driver: Typical range	0.02		75.1	
Clam shovel drop	0.03		76.1	
Hydromill: in soil	0.00		48.1	
Hydromill: in rock	0.00		57.1	
Vibratory Roller	0.03		76.1	
Hoe Ram	0.01		69.1	
Large bulldozer	0.01		69.1	
Caisson drilling	0.01		69.1	
Loaded trucks	0.01		68.1	
Jackhammer	0.00		61.1	
Small bulldozer	0.00		40.1	

Table 6.21. Prediction results for construction phase of DMI St. Joseph Hospital receptor.

DMI St. Joseph Hospital	Operation phase	
	Predicted (VdB 1 μ inch/sec) Design/Schedule speed	Criteria (VdB 1 μ inch/sec) Cat3
1-2 Story Masonry	58.5/50.6	65
3-4 Story Masonry/ Large Masonry on Piles	55.5/47.6	65

Table 6.22. Prediction results for operation phase of DMI St. Joseph Hospital receptor.

6.2.9.- Cantonment Board High School

Cantonment Board High School	Construction phase Damage assessment		Construction phase Annoyance assessment	
	Predicted	Criteria (in/sec) St1/St2	Predicted	Criteria (VdB 1 μ inch/sec) Cat3
Impact Pile Driver: Upper range	0.14	0.5/0.3	91.1	Frequent Event: 75 Occasional Event: 78 Infrequent Event: 83
Impact Pile Driver: Typical range	0.06		83.0.	
Sonic Pile Driver: Upper range	0.07		84.1	
Sonic Pile Driver: Typical range	0.02		72.1	
Clam shovel drop	0.02		73.1	
Hydromill: in soil	0.00		45.1	
Hydromill: in rock	0.00		54.1	
Vibratory Roller	0.02		73.1	
Hoe Ram	0.01		66.1	
Large bulldozer	0.01		66.1	
Caisson drilling	0.01		66.1	
Loaded trucks	0.01		65.1	
Jackhammer	0.00		58.1	
Small bulldozer	0.00		37.1	

Table 6.23. Prediction results for construction phase of Cantonment Board High School receptor.

Cantonment Board High School	Operation phase	
	Predicted (VdB 1 μ inch/sec) Design/Schedule speed	Criteria (VdB 1 μ inch/sec) Cat3
1-2 Story Masonry	57.3/49.4	75

Table 6.24. Prediction results for operation phase of Cantonment Board High School receptor.

7.- Conclusions & recommendations

The conclusions after the assessment of vibration levels to be induced along the alignment of Chennai Metro Rail Corridor C5 during its constructions phase as well as during its operation phase, are the following ones:

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

2. FTA Manual prediction methodology is implemented into a Matlab-based code to assess the vibration levels induced during Corridor C5 construction phase as well as during its operation phase.

3. Regarding Chennai Metro Rail Corridor C5 construction phase:
    a. Pile drivers (impact or sonic), clam shovel drop, and vibratory roller are among the most problematic equipment.
    b. Distance up to which this equipment can induce vibration levels higher than the damage criteria are presented in Table 6.1. Depending on the building structure type, impact pile driving can affect up to 40 m distance.
    c. And distance up to which this equipment can induce vibration levels higher than the annoyance criteria are presented in Table 6.2. Depending on the land use category, impact pile driving can affect up to 100 m distance.

4. Regarding Chennai Metro Rail Corridor C5 operation phase:
    a. Induced vibration due to train pass-by in underground and elevated sections for both design and scheduled speeds as a function of distance between the centre of track and receptor has been assessed.
    b. For underground sections, a maximum distance of 58 m will be affected if 80 kmph design speed and masonry building structure are considered. This distance will be reduced to 20 m if 32 kmph scheduled speed is considered.
    c. For elevated sections, a maximum distance of 29 m will be affected if 80 kmph design speed and masonry building structure are considered. This distance will be reduced to 10 m if 32 kmph scheduled speed is considered

5. The assessment of the vibration level into nine (9) specific buildings carefully selected due to its sensitive use, leads to the following results:
    a. Typical range impact pile driving during Chennai Metro Rail Corridor C5 construction will induce vibration levels higher than damage criteria in 1 out of 9 sensitive locations, a 11.1 %, while this equipment will cause vibration levels higher than annoyance criteria in 7 out of 9 sensitive locations, a 77.8 %.
    b. No effective abatement solutions can be installed or applied to the construction phase, but a continuous vibration monitoring survey can be design and implemented to control the evolution of the vibration levels induced during the construction phase.
    This continuous vibration monitoring survey will be complemented with in situ examination of all affected buildings prior the commencement, during and after the completion of the construction phase, to detect possible damages due to the construction phase.
    c. Chennai Metro Rail Corridor C5 operation phase will induce vibration levels higher than vibration limits into buildings in 3 out of 9 sensitive locations, a 33.3 %, if scheduled speed is considered. These locations are Kolathur Junction/Villivakkam, Valasaravakkam Junction and Kalpana Hospital.
    d. There are two main possible and world-wide used vibration abatement solutions to reduce ground-borne vibration into the affected sensitive buildings: floating slabs and high-resilient fastening systems. These to solutions can reduce vibration levels up to 10 VdB and 5 VdB, respectively.

The authors of the project:

Behshad Noori

Joan Cardona

St. Cugat del Vallès, Barcelona, Spain
the 1st of June 2021

8.- References

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

[2] Comprehensive Detailed Project Report for Chennai Metro Phase-II, December 2018.

Updated Environmental Impact Assessment

April 2024
Revision 01

India: Chennai Metro Rail Investment Project

Balance Corridor 5

Annexure 13

Prepared by the Chennai Metro Rail Limited (CMRL) for the Project Lenders.

भारतसरकार
GOVERNMENT OF INDIA
पर्यावरण ,वनएवंजलवायुपरिवर्तनमंत्रालय
MINISTRY OF ENVIRONMENT, FORESTS & CLIMATE CHANGE
Integrated Regional Office
1st Floor Additional Office Block for GPOA, Shastri Bhawan,
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F.No.4-TNB080/2022-CHN/ 267
Date: 029 March, 2023

To,

The Additional Chief Secretary to the Government of Tamil Nadu,
Environment & Forests Department,
Secretariat, Fort St. George, Chennai – 600 009.

Subject: Diversion of 1.569 ha of forest land in Nanmangalam RF for Chennai Metro Rail Limited Phase II C5-06 Madhavaram to Sholinganallur corridor in Nanmangalam forest land for elevated Metro station in Chengalpattu District in Chennai Forest Division area in favour of Chennai Metro Rail Limited, Chennai Admin Building, Poonamalle High road, Koyambedu, Chennai-Reg.

Madam,

Please refer to the State Government letter Nos.22539/FR.10/2021-2 dated 08.02.2022 and 22539/FR.10/2021-5 dated 24.06.2022 and online proposal No. FP/TN/RAIL/141594/2021 seeking prior approval of the Government of India in accordance with Section'2' of Forest (Conservation) Act, 1980 for the above mentioned project. The project was accorded in-principle approval (Stage-I) by the Central Government vide letter dated 27.07.2022. The State Government letter No.1486/Section.II/2022(1764447) dated27.01.2023 have reported compliance to the conditions stipulated in the in-principle approval;

After careful consideration of the compliance report submitted by the State Government, I am directed to convey the Central Government's **final approval** ***(Stage-II)*** under Section '2' of Forest (Conservation) Act, 1980 for diversion of **1.569 ha** of forest land in Nanmangalam RF for Chennai Metro Rail Limited Phase II C5-06 Madhavaram to Sholinganallur corridor in Nanmangalam forest land for elevated Metro station in Chengalpattu District in Chennai Forest Division area in favour of Chennai Metro Rail Limited, Chennai Admin Building, Poonamalle High road, Koyambedu, Chennai, **for a period of 30 years**, subject to the following conditions:-

1. The legal status of forest land shall remain unchanged;
2. Demarcation of the proposed forest area shall be carried out by erecting 4 feet high cement concrete pillars duly numbered at an interval of 20 meters and maintained at the cost of user agency;

3. The Compensatory Afforestation (CA) shall be raised and maintained by the State Forest Department over **3.14 ha** of degraded forest area in Kumili RF of Tambaram Range, from the amount already been realized from the user agency;

4. Additional amount of the Net Present Value (NPV) of the diverted forest land if any, becoming due after revision of the same by the Hon'ble Supreme Court of India in future, shall be charged by the State Government from the User Agency;

5. Pre-fabricated structures should be used to the maximum possible extent to reduce the extent of disturbance in the habitat;

6. The debris / earth excavated during the track laying work should be disposed off or reused suitably so that the natural drainage of the area is not blocked. Materials to be used for construction of new tracks should be brought from outsides the forest area;

7. Disturbance shall be kept minimum by creating labour camps outside the forest area as far as possible;

8. All mitigation measures as recommended / suggested in the **"Biodiversity Assessment and Biodiversity Management Plan"** for Nanmangalam RF, shall be implemented from the amount already been realized from the User Agency;

9. Felling shall be restricted to removal of trees only where it is necessary with strict supervision of State Forest Department. Trees of **spontaneous growth origin shall not be felled, if any;**

10. Trees/bushes standing in the diverted area shall be felled / cleared strictly as per requirement and with prior permission of the Divisional Forest Officer concerned;

11. The user agency shall obtain Environmental Clearance, if required;

12. The forest land proposed for diversion shall under no circumstances be transferred or sublet to any other agency, department or person without the prior approval of the Central Government;

13. The total forest area utilized for the project shall not exceed **1.569 ha** and the forest area diverted shall not be used for any purpose other than those shown in the diversion proposal;

14. The layout plan of the proposal shall not be changed without the prior approval of the Central Government;

15. The user agency and the State Government shall ensure compliance to the all Acts, Rules, Regulation, Guidelines of the Ministry for the time being in force, as applicable to the railway line projects and Court Orders, if any, in specific to the subject project shall be complied with;

16. Any other conditions that the Central Government or Regional Officer (Central) of Integrated Regional Office, Chennai may impose from time to time in the interest of afforestation, conservation and management of flora and fauna in the area, shall be complied by the User Agency;

17. In the event of failure to comply with any of the above conditions the User Agency is liable for penal action as per the provisions under rules / guidelines issued under FCA, 1980.

Yours faithfully,

2/3/2023

(K.Karthikeyan)
Assistant Inspector General of Forests (Central)

Copy to:-

1. The Principal Chief Conservator of Forests, Govt. of Tamil Nadu, Forest Department, Guindy Velachery Main Road, Guindy, Chennai - 32
2. The Additional Principal Chief Conservator of Forests/Nodal Officer (FCA), Office of the Principal Chief Conservator of Forests, Govt. of Tamil Nadu, Forest Department, Guindy Velachery Main Road, Guindy, Chennai - 32
3. IGF, ROHQ, MoEF&CC, New Delhi -110003 for information please
4. CMRL, Admin Building Poonamalle High Road Koyambedu,Chennai Tamil Nadu-600107premnath.m@cmrl.in
5. Guard File.

2/3/2023

(K.Karthikeyan)
Assistant Inspector General of Forests (Central)

Updated Environmental Impact Assessment

April 2024
Revision 01

India: Chennai Metro Rail Investment Project

Balance Corridor 5

Annexure 14

Prepared by the Chennai Metro Rail Limited (CMRL) for the Project Lenders.

ABSTRACT

Announcement - Highways and Minor Ports – "Construction of Multi level Grade Separator on Mount - Poonamallee - Avadi Road from MIOT Hospital to Mugalivakkam via Ramapuram, L&T and DLF" – Integrated with Chennai Metro Rail Limited (CMRL) Proposal – Administrative and Financial Sanction – Accorded – Orders – Issued.

Highways and Minor Ports (HW2) Department

G.O.(Ms) No.136 **Dated: 20.12.2021**

பிலவ, மார்கழி–5, திருவள்ளுவராண்டு 2052

Read:

1. G.O.(D) No.20, Highways and Minor Ports (HW2) Department, dated 08.02.2018
2. G.O.(Ms) No.24, Highways and Minor Ports (HW1) Department, dated 28.01.2020
3. Government Letter No.10999/HW2/2020-1, dated 22.12.2020
4. From the Chief Engineer (H) (FAC), Metro Letter No. 3075/ 2018/ AE-III, dated:17.08.2021

ORDER:

In the Government Order first read above, among other orders, Government have accorded Administrative Sanction for a sum of Rs.90.00 lakh for preparing the Detailed Project Report (DPR) for the "Construction of Multi level Grade Separator on Mount - Poonamallee - Avadi Road from MIOT Hospital to Mugalivakkam via Ramapuram, L&T and DLF".

2. In the Government Order second read above, among other orders, Government have accorded Administrative Sanction for Land Acquisition for the sum of Rs.33.60 crore for the work of "Construction of Multi level Grade Separator on Mount - Poonamallee - Avadi Road from MIOT Hospital to Mugalivakkam via Ramapuram, L&T and DLF".

3. The Hon'ble Minister for Public Works (Building, Highways and Minor Ports) has made the following announcement on 27.08.2021 in the floor of the assembly during the budget demand of Highways and Minor Ports Department during the year 2021-2022.

சென்னை பெருநகர பகுதியில் போக்குவரத்து நெரிசலைக் குறைப்பதற்காக பல பணிகளில் "மவுண்ட் பூந்தமல்லி ஆவடி சாலையில் இராமபுரம் மற்றும் முகலிவாக்கம் சந்திப்புகளில் 3.14 கி.மீ. நீளத்திற்கு உயர் மட்ட சாலை மற்றும்

மவுண்ட் மேடவாக்கம் சாலை மற்றும் உள்வட்ட சாலை சந்திப்பில் கீழ்பாலம்" அமைக்க இரு பணிகள் ரூ.403 கோடி மதிப்பில் சென்னை மெட்ரோ இரயில் நிறுவனத்து ன் ஒருங்கிணைந்து மேற்கொள்ளப்படும்.

4. In the letter fourth read above, the Chief Engineer (H) (FAC), Metro has stated that the CMRL proposal of Elevated Metro Line overlaps with the above Grade Separator proposal for the entire length, the Steering Committee decided that CMRL would prepare the comprehensive DPR integrating both the Highways and Metro Rail projects and also CMRL shall take up the construction of the above Grade Separator integrated with CMRL projects.

5. The Chief Engineer (H) (FAC), Metro has stated that the Land Acquisition for the above work will be done by Highways Department. Meanwhile, the CMRL has requested to deposit the cost for construction of Highway Grade Separator portion, so as to enable them to proceed with the tendering process.

6. The Government has convened "in principle approval" for multi level grade separator and also requested CMRL to send the exact cost to be borne by the State and it would be deposited at the appropriate time vide Government letter third read above.

7. The Chief Engineer (H) (FAC), Metro has also stated that integrated proposal for the Metro Rail and Grade Separator has been prepared by the CMRL incorporating the Highways requirements. The Grade Separator Viaduct is proposed in Level -1 and the Metro Rail Viaduct is proposed in Level-2. The features of the Grade separator are as follows:

- The Grade Separator Ramp starts at km 2/729 and ends at Km 5/869 of Mount - Poonamallee - Avadi Road. **The total length of Grade separator is 3140 m.**
- The Grade Separator consists of 4 lanes with dual two lane 7.5m carriageway and 0.5m crash barrier on either side of the Single pier.
- The vertical clearance for the Grade Separator proposed is a minimum of 5.50m from the bottom of pier cap to existing road level duly taking into consideration of future strengthening of the existing road. The level-1 Grade Separator portion is also having a minimum vertical clearance of 5.50m from bottom of Metro pier-caps.
- 3 lane dual carriageway at grade is ensured in via duct portion and in approach portions 7.5 m carriageway at grade is proposed.

8. The Chief Engineer (H) (FAC), Metro has stated that the Highways Component has been worked out by CMRL, based on the contribution of that component in the integrated proposal excluding Land Acquisition. Wherever there is only a Grade Separator item, 100% has been attributed to Grade Separator and vice-versa to CMRL Viaduct. The overall cost of the Integrated project of both CMRL and

Highways has been arrived as Rs.565,91,91,141/- by CMRL. The abstract cost given by CMRL for Highways Grade Separator portion, is as follows:-

Description	Amount (in Rupees)
Civil Cost	**268,69,79,873**
Contingencies 2.5%	6,71,74,497
Shifting of Utilities 2%	5,37,39,597
Department and Supervision charges 12.5%	33,58,72,484
TOTAL CIVIL COST	**314,37,66,451**
GST 12%	37,72,51,974
TOTAL COST	**352,10,18,425**

9. The Chief Engineer (H) (FAC), Metro has therefore requested the Government to accord Administrative Sanction for a sum of Rs.352,10,18,425/- for the work of "Construction of Multi level Grade Separator on Mount - Poonamallee - Avadi Road from MIOT Hospital to Mugalivakkam via Ramapuram, L&T and DLF" so as to deposit the cost of the Highways Grade Separator component to CMRL at the appropriate time as and when required by CMRL.

10. The Government after careful examination, accept the proposal of Chief Engineer (H) (FAC), Metro and accord Administrative Sanction and Financial Sanction at a cost of Rs.314,48,41,243/- (Rupees Three hundred and fourteen crore forty eight lakh forty one thousand two hundred and forty three only) for the work of "Construction of Multi level Grade Separator on Mount - Poonamallee - Avadi Road from MIOT Hospital to Mugalivakkam via Ramapuram, L&T and DLF" as detailed below and also the Chief Engineer (H) (FAC), Metro is requested to deposit the same to the CMRL at appropriate time as and when required by CMRL.

Description	Sanctioned Amount (in Rupees)
Civil Cost	**268,69,79,873**
Contingencies 2.5%	6,71,74,497
Shifting of Utilities 2%	5,37,39,597
Department and Supervision charges 12.5%	NIL
TOTAL CIVIL COST	**2,80,78,93,967**
GST 12%	33,69,47,276
TOTAL COST	**314,48,41,243**

11. The expenditure sanctioned in para-10, above shall be debited to the following head of account:-

"5054 – Capital Outlay on Roads and Bridges – 80 General – 800 – Other Expenditure – States Expenditure – JW – Chennai Metropolitan

Development Plan – Traffic and Transport Improvement in Chennai City – 416 Major works – 01. Major Works."

IFHRMS (DP code: 5054-80-800-JW-41601)

12. The Chief Engineer (H) (FAC), Metro is authorized to incur the expenditure sanctioned in para-10 above.

13. The expenditure sanctioned in Para 10 above shall constitute an item of "New Instrument of Service" and approval of the Legislature will be obtained in due course. Pending approval of the Legislature, the expenditure will be initially met by an advance from the Contingency Fund. The Chief Engineer (Metro) (FAC), Highways Department is directed to calculate the actual amount required for the period upto next Supplementary Estimates and apply for sanction of the same as advance from the Contingency Fund to Finance (B.G-I) Department directly in Form 'A' appended to the Tamil Nadu Contingency Fund Rules, 1963 along with a copy of this order. Orders for sanction of an advance from the Contingency Fund will be issued from Finance (B.G-I) Department. The Chief Engineer (Metro) (FAC), Highways Department is also directed to send a draft explanatory notes for inclusion the above expenditure in the Supplementary Estimates 2021-2022 to Finance (BG-I/PW-I) Department without fail

14. This order issues with the concurrence of Finance Department vide its U.O.No.54903/PW-I/2021 dated: 16.12.2021 and Additional Sanction Ledger No.1181 (One thousand one hundred and eighty one).

(By Order of the Governor)

Dheeraj Kumar
Principal Secretary to Government

To
The Chief Engineer (H) (FAC), Metro, Chennai-25
The Managing Director, Chennai Metro Rail Limited,
Koyambedu, Chennai-107
The Accountant General, Chennai-18
The Pay & Accounts Officer (South), Chennai-35

Copy to:
The Office of the Hon'ble Chief Minister, Chennai-9
The Special Personal Assistant to Minister for Public Works
(Buildings, Highways and Minor Ports), Chennai-9
The Private Secretary to the Principal Secretary to Government,
Highways & Minor Ports Department, Chennai-9
The Finance (PW-I/ BG-I/II/W.M-I) Department, Chennai-9
All Sections of Highways and Minor Ports Department, Chennai-9
C.No.10473/HW2/2021
SF/SC

//Forwarded By Order//

20.12.2021

(A.Ganesh Kumar)
Under Secretary to Government