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(A*n Autonomous body constituted by the Revenue Department, Govt of Kerala*)
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ILDM/210/2023-E1 03-02-2024

From
Executive Director
ILDM
Thiruvananthapuram

To
Commissioner
Land Revenue Department

District Collector
Malappuram

Sir,

Sub: Publishing of Final District Survey Report (DSR) of

Malappuram-Reg.

Ref: 1. G.O (Ms)No.694/2022/RD dated 14.02.2022
2.Minutes of the 135th Meeting of SEIAA held on 22.12.2023 & 23.12.2023
3. Letter No. 3162/A1/2021/SEIAA dated 10.01.2024
4. Email from CSIR-NIIST dated 26.01.2024 & 27.01.2024

Kind attention is invited to the reference cited above. The 135th meeting of the State Environment Impact Assessment Authority (SEIAA) held on 22nd and 23rd December 2023 has approved the District Survey Report (River sand mining) of Malappuram District as per reference 2nd cited. The Authority has also directed ILDM, the nodal agency for the preparation of District Survey Reports for river sand mining to publish the final document on the website of all concerned departments / agencies as per reference 3rd cited.

CSIR-NIIST has submitted the final copy (Soft copy) of the DSR of Malappuram to ILDM as per reference 4th cited and the same is forwarded herewith for further necessary action. It is requested to publish the same on the Website of the Land Revenue Commissioner and Malappuram

518256/2024/Tapal CLR

I/171896/2024

District's Websites at the earliest.

Signed by A Geetha Ias
Date: 03-02-2024 14:46:12

A GEETHA IAS
EXECUTIVE DIRECTOR ILDM

Copy to:1 Director (Administration) - (For publishing in ILDM Website)
2. RDO/Sub-Collector, Perinthalmanna -For information.

LR/11909/2023-LR(K1)

Govt. of Kerala

District Survey Report

For

Sand Mining or River-bed Mining

Malappuram District

(Prepared as per the Gazette Notification S.O. 3611(E) dated 25-07-2018 of MoEF&CC)

Approved by the State Environment Impact Assessment Authority (SEIAA), Kerala vide Lr. No. 3162/A/2021/SEIAA dated 10.01.2024

Submitted to

Revenue Department

Govt. of Kerala

Prepared by

CSIR-National Institute for Interdisciplinary Science and Technology (NIIST)
Thiruvananthapuram, Kerala

January 2024

ACKNOWLEDGEMENT

CSIR – National Institute for Interdisciplinary Science and Technology (NIIST) would like to thank and show its sincere appreciation to the Commissioner, Land Revenue Department and Director, Institute of Land and Disaster Management (ILDM), Government of Kerala for entrusting the work for preparation of District Survey Reports for Riverbed or sand mining in Kerala. The team gratefully acknowledge the help of ILDM in providing the pre-monsoon data of sand audit reports and other associated files.

We would like to express our deepest gratitude to the District Magistrate, Additional District Magistrate, Revenue Inspector's, Revenue Officer's and other respected officers of the Malappuram district. The project team is also thankful to Tropical Institute of Ecological Sciences, Kottayam (TIES) for carrying out the sand audit survey in all the identified rivers. We are very much thankful to the India Meteorological Department (IMD) for providing the rainfall historical data to determine the replenishment rate. We are also thankful to the Department of Mining and Geology, Government of Kerala for their support in providing information.

CSIR-NIIST is extremely grateful to the villagers in and around the Malappuram district who have offered their full and unwavering cooperation, without which the work would not have gone as smoothly as it has. Our sincere thanks are due to the Director, scientific and administrative staff of CSIR-NIIST in constantly supporting the project since inception.

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

राष्ट्रीय अंतर्विषयी विज्ञान तथा प्रौद्योगिकी संस्थान
NATIONAL INSTITUTE FOR INTERDISCIPLINARY SCIENCE AND TECHNOLOGY
वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद | Council of Scientific & Industrial Research
इंडस्ट्रियल एस्टेट पी.ओ., पप्पनमकोड, तिरुवनंतपुरम, भारत - 695019 | Industrial Estate P.O., Pappanamcode, Thiruvananthapuram, India - 695019

CERTIFICATE

The District Survey Report (DSR) content and information on river sand resources are factually correct and have been prepared in compliance with the Sustainable Sand Mining Management Guidelines (SSMMG-2016) along with the Enforcement and Monitoring Guidelines for Sand Mining (EMGSM-2020). The latest report is based on a scientific study of the erstwhile and future potential sand mining sites, which are conclusive in nature. There are no other potential sand mining sites other than those mentioned in the report, which was prepared after a detailed scientific investigation.

27/01/2024

Saurabh Sakhre
Scientist & project coordinator

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Executive Summary

The District Survey Report (DSR) is prepared to compile data about the district's mining activities, mineral resources, and other relevant factors. The method used to prepare the DSR complies with the notification guidelines provided by the MoEF&CC in S.O. 3611(E) dated July 25, 2018. The Honourable National Green Tribunal (NGT) ordered all states and union territories to strictly adhere to the Sustainable Sand Mining Management Guidelines (SSMMG-2016) and the Enforcement and Monitoring Guidelines for Sand Mining (EMGSM-2020). These directives were further strengthened by mechanisms for the preparation of the DSR, Environmental Management Plan, replenishment studies, the assessment and recovery of compensation, the seizure and release of vehicles involved in illegal mining, and other safeguards against violations.

The rivers draining the district include Chaliyar, Kadalundi, Bharathapuzha and Tirur. The Tirur River is located along the coastal stretch of the district, with tidal influence and no sand mining prospects based on the high-resolution earth viewing tools. Based on the sand audit survey conducted as per Section (29) of the Kerala Protection of River Banks and Regulations on Removal of Sand Act, 2001 by the Institute of Land and Disaster Management (ILDM), and the latest studies carried out by CSIR-NIIST considering the data generated by the Tropical Institute of Ecological Sciences (TIES), it was observed that sand suitable for sustainable mining was available in the Chaliyar, Kadalundi and Bharathapuzha rivers, which have been considered in this report. The ILDM provided the sand audit survey reports for the rivers Chaliyar, Kadalundi and Bharathapuzha in the Malappuram district to carry out the work. The prime objective of the report is to identify the areas of aggradation and erosion of sand-bearing stretches that pass through the district and determine the rate of replenishment of sand at various sites using empirical models. Needless to say, the already identified potential sand mining sites as per the previous sand audit report are considered, and any changes in volume and location are reported.

As the replenishment studies require a two-season field survey, CSIR-NIIST has hired the TIES, Kottayam to carry out the post-monsoon field survey. Accordingly, two-season volumetric data on sand volume were obtained, and analysis was carried out to determine the rate of replenishment. The pre-monsoon and post-monsoon sand audit reports are submitted to ILDM, and the post-monsoon survey with cross-sections of identified sand mining sites is provided as a separate annexure.

The area of Malappuram district is about 3554 km^2 and the land use land cover classes of the district are classified as: inland water bodies, mixed vegetation, vegetation (flooded), agricultural fields/crops, built-up areas, barren land, unclassified or cloud cover, and range land/open.

The technical comments from the expert committee constituted by ILDM were also addressed in the report. Two Sub-Divisional Committees (SDC) were formulated by the district collector of Malappuram, i.e., Tirur and Perinthalmanna revenue divisions, with the objective of assessing the viability of potential sand mining sites identified in the District

Survey Report based on the SSMMG-2016 and EMGSM-2020. The observations and findings of the SDC were addressed, and the inspection report is enclosed as a separate annexure. The final list of potential sand mining sites, along with other details is provided as a separate annexure.

The present report has been evaluated by the State Expert Appraisal Committee (SEAC), Kerala in its 153rd meeting on November 14, 2023 and the State Environment Impact Assessment Authority (SEIAA), Kerala in its 135th meeting approved the DSR with the observation of SEAC. A copy of the minutes is enclosed as a separate annexure.

The number of sand mining sites observed in the Bharathapuzha stretch of Malappuram district is 11, Chaliyar is 19 and Kadalundi is 6 with a total of 36 sand mining sites in Malappuram district. The total area of all the sand-bearing sites combined is 405.75 ha. The total sand availability across all sites is 99,07,484 m^3, with 38,35,954 m^3 (57,53,931 tonnes) of mineable sand above the summer water level. The average bulk density is worked out as 1.5 g/cc and the analysis was carried out as per IS 2386 Part-3 & Kim H. Tan, 2nd Edition.

As far as the number of sand mining sites from an area perspective is concerned, there are 26 sand mining sites that are less than 5 ha, 6 sand mining sites between 5 and 25 ha and 3 sand mining sites between 25 and 100 ha. 1 sand mining site >100 ha. The potential sand mining sites are identified on both halves of the river, and considering the environmental angle to reduce the cumulative impact of mining, it is recommended that the adjacent mines be operated phase-wise based on area and location concerning other mine sites.

The replenishment studies are carried out using an empirical model and by measuring the difference between previous and present sand volumes from the audit reports. The replenishment study was carried out for the entire Bharathapuzha, Chaliyar and Kadalundi watersheds. Bharathapuzha watershed only shares 9% of its area in Malappuram district.

The rate of replenishment for the Bharathapuzha stretch is 13% each year, considering the total sand volume in February 2020 as the base value. The rate of replenishment for the Chaliyar River is 2% each year, considering the total volume of sand in February 2020.

A separate chapter on environmental safeguards is also provided for sand mining sites. Boundary coordinates, along with individual details of total sand and mineable sand, are also provided. An environmental management plan is outlined to minimise adverse impacts on the environment.

Compliance table

As per the Sustainable Sand Mining Management Guidelines (SSMMG, 2016), the district is the unit of administration that is most suitable for the mapping of sand and gravel resources in a particular river. The idea of DSR lies in the fact that all the rivers flowing or existing through a district and associated aspects related to river sand mining can be monitored by the district magistrate. That is why the mapping of sand and gravel resources is proposed at the district level. The other guidelines that are relevant for the preparation of DSR are Enforcement and Monitoring Guidelines for Sand Mining (EMGSM, 2020) issued by MoEF&CC. The aim of the compliance table is to chalk out all the relevant points to be included from (SSMMG, 2016) and (EMGSM, 2020) for the preparation of the DSR. Needless to say, the report structure given in SSMMG, 2016 for the preparation of the DSR shall be strictly followed. The following points are included in the report, and their relevant sections are given.

Sr.no	Structure of the report	Compliance
1	Introduction of the project	Background to the project and objectives are given in **Chapter-1**. A brief scope of the study is also provided and complied. The details are given in **Chapter-1.**
2	Overview of mining activity in the district	A general note on the mining activity in the Malappuram district is given in **Chapter-3.** Mineral resources in the Malappuram district with available sand resources is also addressed in **Chapter 3 (Section 3.1 and 3.2) .**
3	The list of mining leases in the district with location, area, and period of validity;	The present DSR aims to identify the sand mining sites based on an already existing list of potential sand mining stretches as provided by ILDM.
4	Details of royalty or revenue received in last three years	**Complied** Since there are no operating sand mining leases, the revenue is NIL. The same has been communicated by ILDM vide letter no: ILDM/3009/2022-E1 (Part-1).
5	Details of production of sand in last three years	**Complied** Details of production of sand in last three years is provided in **Chapter-3 (Section 3.5).**
6	Process of deposition of sediments in the rivers of the district	**Complied** The process of deposition of sediments is discussed in **Chapter-5.**
7	General profile of the district	**Complied** General profile of the district on various aspects like administrative setup, historical background etc. is discussed in **Chapter-2.**
8	Land utilization pattern in the district: forest,	**Complied** The Land use Land cover map of the Malappuram district is provided in **Chapter-4 (Section 4.0).**

	agriculture, horticulture, mining, etc.;	
9	Physiography of the district	**Complied** The physiography of the district is provided in **Chapter-4 (Section 4.1).**
10	Rainfall: month-wise	**Complied** Month wise rainfall data was procured from IMD and the same has been presented and interpreted in **Chapter-5 (Section 5.3).**
11	Geology and Mineral wealth	**Complied** The geology and the mineral wealth are provided in **Chapter-4 (Section 4.2).**
12	District wise details of **i.** River or stream and other sand sources; **ii.** Availability of sand; **iii.** Existing mining leases of sand	**Complied** The details of rivers flowing through the Malappuram district is given in **Chapter-2.** Sand availability is given in **Chapter-5** as **Table 5.3** There are no existing operating sand mining leases in Malappuram district.
13	List of the individual, cluster, and contiguous cluster situation of sand mining potential sites/Kadavu with their location, area, mineable sand volume.	**Complied** The list is provided in **Chapter-5 Table 5.3.**
14	Calculation of annual rate of replenishment and allowing time for replenishment after mining in the area.	**Complied** The rate of replenishment is determined on the basis of a two-season cross-section study. The first sand auditing study was conducted by ILDM in 2020 for the Chaliyar, Kadalundi, and Bharathapuzha stretches. The other cross-section studies are conducted by the Tropical Institute of Ecological Sciences (TIES), Kottayam hired by NIIST in January, 2023. The difference in accumulation over the years is taken as the base, and the Dendy-Bolton equation is used to calculate the sediment yield. The details of replenishment studies are given in **Chapter 5 (Section 5.6).**
15	Current sand resources and M-Sand Production in the district	**Complied** The current sand resources estimated are provided in **Chapter-5 Table 5.3.**
16	Demand-supply details of river sand	**Complied**

		General statistics of the sand requirement and available resources is provided in **Chapter-3 section 3.2.**
17	Transportation routes for individual sites/kadavus and sites/kadavus in clusters	**Complied** Nearby places with accessibility are given for each sand mining site. Same has been listed in **Chapter 5 Table 5.3.**
18	Remedial measures to mitigate the impact of sand mining	**Complied** Remedial measures for safeguarding the environment are given in **Chapter-6.**
19	Reclamation plan for already mined out areas	**Complied** There are no operating mine leases in the district. However, same has to be followed as per SSMMG, 2016 and Enforcement and Monitoring Guidelines for Sand Mining (EMGSM, 2020).
20	Infrastructure facilities along the stretches to avoid mining	**Complied** List of infrastructure is addressed in the present sand audit report prepared in January 2023 and is provided in **Chapter-6.**
21	Environmental protection measures to be followed during mining and post-mining along the river stretches	**Complied** Environmental protection measures to be followed is provided in **Chapter-6**.

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ABBREVIATIONS

AMSL	Above Mean Sea Level
BM	Benchmark
CAGR	Compound Annual Growth Rate
CGWB	Central Ground Water Board
CSIR-NIIST	Council of Scientific & Industrial Research - National Institute for Interdisciplinary Science and Technology
DGPS	Differential Global Positioning System
DSR	District Survey Report
DTW	Depth to Water
EMGSM	Enforcement and Monitoring Guidelines for Sand Mining
ESRI	Environmental Systems Research Institute
ILDM	Institute of Land and Disaster Management
IMD	India Meteorological Department
IT	Information Technology
KINFRA	Kerala Industrial Infrastructure Development Corporation
LULC	Land Use Land Cover
MMDR	Mines and Minerals (Development and Regulation)
MoEF&CC	Ministry of Environment, Forest and Climate Change
NGT	National Green Tribunal
NH	National Highway
SIDCO	Small Industries Development Corporation
SSMMG	Sustainable Sand Mining Management Guidelines
SVO	Special Village Officer
TIES	Tropical Institute of Ecological Sciences
VA	Village Assistant
VFA	Village Field Assistant
NCERT	National Council of Educational Research and Training
USGS	United States Geological Survey
GIS	Geographic Information System
NRSC	National Remote Sensing Center
ISRO	Indian Space Research Organization
AEZ	Agro-Ecological Zone
LPM	Liters per minute
DEM	Digital Elevation Model
HFL	Highest Flood Level
SDC	Sub-divisional Committee
DMG	Directorate of Mining and Geology
SWL	Summer Water Level
EMP	Environmental Management Plan
PPE	Personal Protective Equipment
PUC	Pollution Under Control

List of Annexures

No	Description
I	Estimation of bulk density and grain size distribution analysis
II	Cross-sections of sand mining sites
III	Sub-divisional committee (SDC) inspection report
IV	Final list of potential mining sites
V	Final list of cluster and contiguous cluster
VI	State Environment Impact Assessment Authority (SEIAA), Kerala approval

CHAPTER – 1

INTRODUCTION

1.0 General

The Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India specifies the intent and format of the District Survey Report (DSR) for sand mining or riverbed mining and mining of other minor minerals under paragraph 7(iii) (a) and Appendix-X of the notification S.O. 141(E) dated January 15, 2016. The DSR is prepared to catalogue the district's mineral resources, mining operations, and pertinent information. Additionally, the procedure for preparing the DSR is in accordance with the notification guidelines published by the MoEF&CC, S.O. 3611(E), dated July 25, 2018, regarding sand mining or riverbed mining. The Hon'ble National Green Tribunal (NGT) directed all the States/UTs to strictly follow the Sustainable Sand Mining Management Guidelines (SSMMG-2016) along with the Enforcement and Monitoring Guidelines for Sand Mining (EMGSM-2020) reinforced by mechanisms for the preparation of DSRs; Environment Management plans, replenishment studies, assessment and recovery of compensation, seizure and release of vehicles involved in illegal mining, other safeguards against violations, grievance redressal and periodic review at higher levels.

Nowadays, illegal sand mining is a highly widespread practice as settlements move closer to the river and sites like to be close to markets or along traffic routes to cut down on transportation costs. Extensive sand extraction damages the land's natural features and upsets aquatic life and the stream channel's balance. The DSR provides accurate field data and pertinent information about the presence of riverbed sand, gravel, boulder, and bajari deposits to ensure systematic and scientific utilization of mineral resources and sustainable sand mining practices to restore and maintain the ecosystem of river and sand sources. Along with the primary data collected from field studies, this DSR includes data published and approved by various departments and websites about the geology of the area, information on mineral wealth, mining activities in the district, revenue from minerals, meteorology, physiography, hydrogeology, etc. Scientific analysis and calculation of the sediment yield/load using the Dendy-Bolton equation are also discussed to estimate the annual replenishment of sand in the river. Further, the impact on the environment due to river sand mining activity, identifying measures for the protection of the environment and ecology, and determining measures for the protection of bank erosion are also described in this report.

1.1 Objectives

The initial task of DSR is to create an inventory of the riverbed material and other sand sources in the district. For this, a thorough audit of the rivers is necessary, as well as creating benchmarks at prominent locations regularly for future surveys. The revenue department of Kerala has already conducted river bank mapping and sand auditing of around 20 rivers in Kerala, wherein the profiles of rivers were created at regular intervals and deposition was identified along with water level. As the replenishment studies require a two-season cross-

section survey in the field, CSIR-NIIST has hired the Tropical Institute of Ecological Sciences, Kottayam, to carry out the sand audit at pre-identified potential sand mining sites. With the above background, the objectives of the study are mentioned below.

a) Identification of areas of aggradation/deposition where mining can be allowed; and identification of areas of erosion and proximity to infrastructural structures and installations where mining should be prohibited.
b) Calculation of yearly replenishment rate and allowance for replenishment time after mining in the region.
c) Identifying scientific and sustainable mining methods.
d) To improve the effectiveness of monitoring mining and transportation of mined-out material.
e) Recommending safeguards for checking illegal and indiscrete sand mining.

1.2 Scope of the study

The preparation of the present DSR strictly adheres to the guidelines given in "Sustainable Sand Mining Management Guidelines 2016" and "Enforcement and Monitoring Guidelines for Sand Mining, 2020". The following points are covered in subsequent chapters of the report.

1. Introduction to the project
2. Overview of mining activity in the district.
3. The list of mining leases in the district with location, area, and period of validity.
4. Details of royalty or revenue received in last three years.
5. Details of production of sand in last three years.
6. Process of deposition of sediments in the rivers of the district.
7. General profile of the district.
8. Land utilization pattern in the district: forest, agriculture, horticulture, mining, etc.
9. Physiography of the district.
10. Rainfall: month-wise.
11. Geology and Mineral wealth.
12. District-wise details of
    i. River or stream and other sand sources;
    ii. Availability of sand;
    iii. Existing mining leases of sand
13. List of the individual, cluster, and contiguous cluster situation of sand mining potential sites/Kadavu with their location, area, and mineable sand volume.
14. Calculation of annual rate of replenishment and allowing time for replenishment after mining in the area.
15. Current sand resources and M-Sand production in the district.
16. Demand-supply details of river sand.
17. Transportation routes for individual sites/kadavus and sites/kadavus in clusters.
18. Remedial measures to mitigate the impact of sand mining.

19. Risk Assessment and Disaster Management Plan.
20. Existing infrastructure along the stretches to avoid mining.
21. Environmental protection measures are to be followed during mining and post-mining along the river stretches.
22. Post-mining monitoring mechanism.

1.3 Methodology

The methodology adopted in preparing the DSR and the assumptions made is as follows.

- A field survey was carried out during the month of January 2023.
- The cross-sections were taken across the rivers at an interval of two times the width of the river or 100 m, whichever is less, using levelling equipment (DGPS) from a permanent benchmark (BM).
- Every cross-section was surveyed between two documented endpoints and tied up to a permanent benchmark (BM). A GPS reading of both end points was recorded.
- The calculation of sand volumes is done by leaving a setback distance of 15 m from the riverbank.
- The summer water level in the river for each cross-section was ascertained along with the groundwater level in the nearby or surrounding well(s) with respect to the BM. The depth/redline of sand extraction was fixed as follows: (a) If the lean summer water table in the nearby wells is at par with or below the lean season water level in the river channel, then the water level in the river is deemed as the redline (b) If the lean summer water table in the nearby wells is above the lean season water level in the river channel, the water level in the wells is deemed as the redline.
- However, in the present case, the water levels in the nearby wells were very high, and if it were considered, the mineable sand would theoretically be nil. So, the calculation of mineable sand is estimated using the water level (summer) in the river.
- The length of the zone of influence of each cross-section is the sum of half the distance between the previous cross-section and the subsequent cross-section.
- If the variation in the volume of sand between adjacent cross-sections is more than 50%, in such cases, the cross-sections were taken in between, and the sand was estimated.
- The mineable quantity of sand in the river channel was estimated. A mineable quantity of sand means the resource up to the depth indicated by the redline.
- The riverbank was digitized using high-resolution earth viewer tools like Google Earth Pro, and the center line of the Bharathapuzha river (administrative boundary of Malappuram) is taken from the shape files provided by ILDM from previous sand audit reports. The boundary coordinates given based on the field survey and riverbank are approximately and logically digitized using visual interpretation and preliminary site visits.
- The surveyed data was transferred to ArcGIS, and a buffering operation (setback distance of 15 m from the riverbank) was carried out for the same.

- The transportation route is worked out based on the nearest accessible landmark and proximity to the proposed sand mining sites.
- The replenishment study of the sand is carried out using empirical modelling and is substantiated by the change in the volume of sand at the site.

CHAPTER – 2

GENERAL PROFILE OF THE DISTRICT

2.0 General

Malappuram district is located in the northern part of Kerala and is composed of a portion of the erstwhile Palakkad and Kozhikode districts. It was carved out of Ernad taluk, portions of Tirur taluk in Kozhikode district, and portions of Perinthalmannna and Ponnani taluks in Palakkad district. The district has several small hills, woods, backwaters, minor rivers, and streams flowing to the west, as well as plantations for rice, arecanut, cashew nut, pepper, ginger, pulses, coconut, bananas, tapioca, and rubber. Numerous streams that wind through these hills eventually reach the lovely sea beachfront, which is bordered by coconut trees. The district, with a coastline of 70 km, is the most populous district in Kerala, with 13% of the total population of the state. The overview of the district is given in **Table 2.1.**

Table 2.1: District at a glance

S.No.	Particular	Details
A	**Geographical data**	
	Latitude	10°40'N to 11°32'N
	Longitude	75°50'E to 76°32'E
	Geographical area	3554 km^2
B	**Administrative setup**	
	Revenue Divisional Offices	2
	Taluk	7
	Villages	138
	Block	15
	Panchayats	100
	Municipalities	7
	Assembly Constituencies	16
C	**Demography**	
	Total Population i. Male ii. Female	5,716,959* 1,960,328 2,152,592
	Density	1157 per km^2
	Sex ratio	1098 Female/1000 Male
	Average literacy	93.57%

*Source: 2011 provisional statistics, * Estimated as per Aadhar uidai.gov.in Dec 2023 data*

2.1 Location and geographical area

Malappuram district has a geographic area of 3554 km^2 and is located between latitudes 10°40'N and 11°32'N and longitudes 75°50'E and 76°32'E. Malappuram is a hilly terraced tract, and the numerous streams that meander through these hills eventually reach the coconut-fringed and scenic seashore. In many areas, these streams are connected by backwaters, allowing for a network of inland waterways. The midland portion is rich, with dense coconut groves, while the mountainous section contains dense woods and huge teak plantations, as well

as being the source of several streams and rivers. The location map of the Malappuram district is shown in **Figure 2.1.**

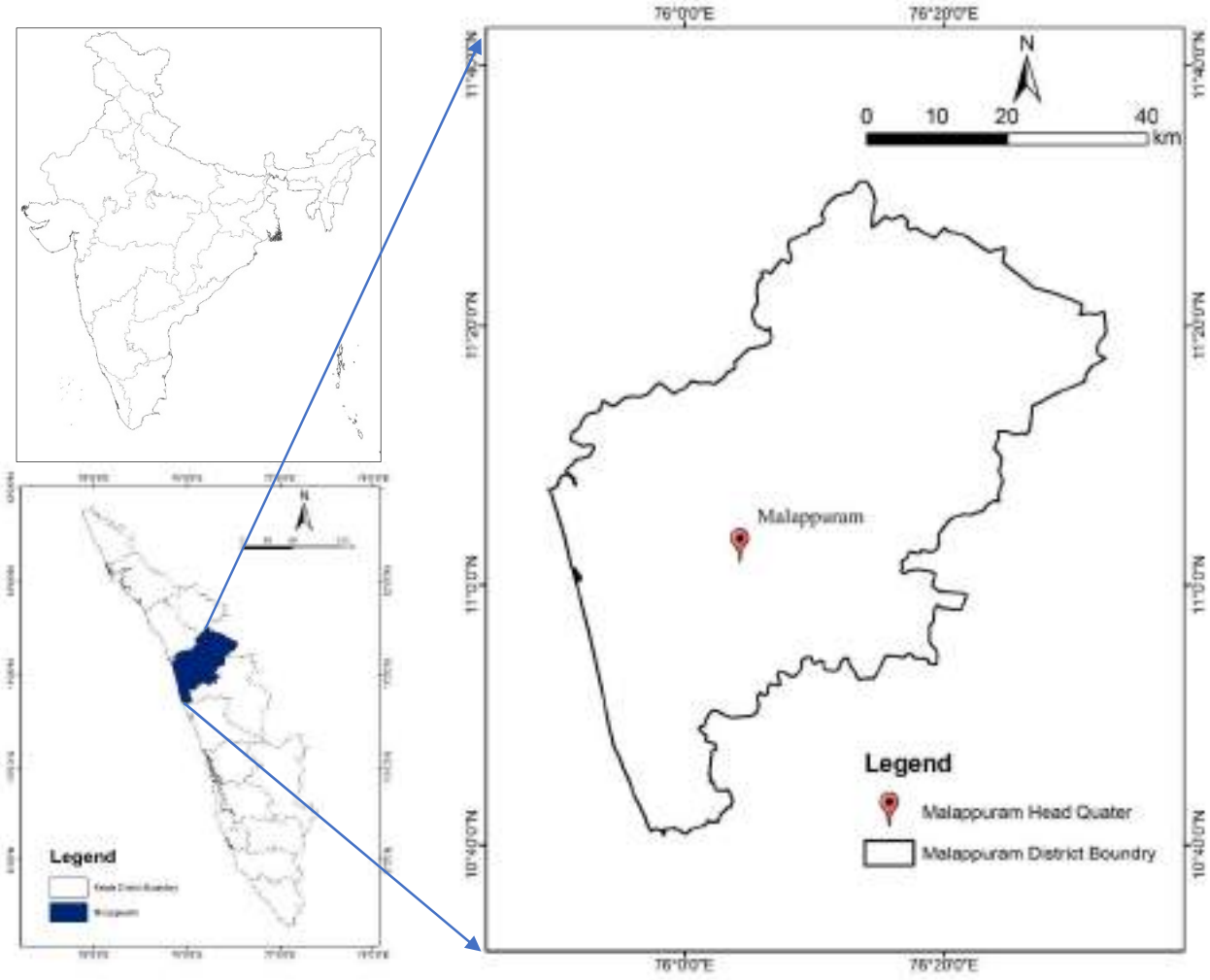


Figure 2.1: Location map of Malappuram district

2.2 Historical background

Malappuram was a part of the Malabar district in the Madras Presidency of British India before India gained its independence in 1947. The early monarchs were the Kings of Valluvanad, the Zamorins, the Kings of Perumpadappu Swarupam, and the Kings of Vettathunadu. The Portuguese, Mysore sultans, and Britishers all had some control over this region. The district has a rich cultural and political heritage. The port of Ponnai was a centre of trade with Ancient Rome. In the early years of the British Colonial administration in Malabar, this port served as a centre for trade between Arabs and Europeans. The Zamorin of Calicut had several residences, including Trikkavu in Ponnani, from which he oversaw trade and commerce. Malappuram was a military headquarters in ancient times.

Following independence, Malabar district remained a part of Madras state for a while, but on November 1st, 1956, it united with Travancore-Cochin to establish the state of Kerala. The current district's territory was governed as a portion of the taluks of Kozhikode, Ernad,

Valluvanad, and Ponnani. Four taluks were combined to form the new district of Malappuram: Ernad, Perinthalmanna, Tirur, and Ponnani. Later, three further taluks were combined: Tirurangadi, Nilambur, and Kondotty.

2.3 Administrative setup

The district's organisational structure is made up of revenue divisions, taluks and villages. A Revenue Divisional Officer or a Sub-Collector leads each Revenue Division and is backed by a Senior Superintendent and other employees. Tahsildar heads each taluk, who is aided by Deputy Tahsildars. The Revenue Department's basic unit is a village office, which is led by a village officer and aided by SVOs, VAs, and VFAs. The district has two revenue divisions: Perintalmanna and Tirur. The seven taluks of the district are Ernad, Perintalmanna, Tirur, Ponnani, Nilambur, Tirurangadi, and Kondotty, and their respective taluk headquarters are Manjeri, Perintalmanna, Tirur, Ponnani, Nilambur, Tirurangadi and Kondotty. The taluk map of the Malappuram district is shown in **Figure 2.2** below. The district comprises 138 villages, 15 development blocks and 100 Grama Panchayats. The seven municipalities in the district are Malappuram, Perinthalmanna, Manjeri, Ponnani, Tirur, Kottakkal and Nilambur. There are 16 Assembly constituencies, viz. Malappuram, Manjeri, Kondotty, Ernad, Mankada, Perinthalmanna, Thirurangadi, Vengara, Vallikunnu, Tirur, Tanur, Kottakkal, Nilambur, Wandoor, Ponnani, and Thavanur.

Figure 2.2: Taluk map of Malappuram district

2.4 Connectivity

Through three modes of transportation—road, train, and air, the area is well connected to other regions of the state and the nation. The district's major regional linkages of national importance are the Kochi - Mangalore National Highway (NH-17) and Palakkad - Kozhikode National Highway (NH-213).

Air transport: An international airport at Karipur (Calicut Airport), 26 km away from Malappuram, links to the other major Indian cities and to several cities in the Gulf, a traditional trading partner of the region.

Rail transport: The 'Shoranur – Mangalore' and 'Shoranur Nilambur road' are the two rail links in the district. Tirur is the most important station in the district; services are available from this station to most of the towns within the state and the country.

Road transport: NH 66 and 966 are the major national highways in the district. It has a total length of 221.35 km, passing through the district. The major state highways in the district are Perumbilavu - Nilambur, Tirur - Manjeri, Parappanangadi - Malappuram, and Kozhikode – Nilambur – Gudallur roads.

Figure 2.3: Malappuram district road map *(source: Maps of India)*

Water transport: Only the Ponnani area has access to water transportation. The relatively shallow port of Ponnani is located in the estuary of the river Bharathapuzha. Waterways connect key locations, including Ponnani, Tirur, and Tirurangadi. The north-south Tirur River is a component of the West Coast water transportation network.

2.5 Population and literacy

According to Census data for the year 2011, the district had a total population of 4,112,920 people, 1,960,328 of whom were men and 2,152,592 of whom were women. Malappuram has a sex ratio of 1098 females for every 1000 males and a 93.57% literacy rate. In Kerala, Malappuram has the highest fertility rate. Most of the population is Muslim (68.53%), followed by Hindus (29.17%) and Christians (2.22%). However, the estimated population of the district in 2023 is 5,716,959.

Table 2.2: District demography

Total population	5,716,959*		
Male	1,960,328		
Female	2,152,592		
Sex ratio	1098 Female/1000 Male		
Age group population (0-6 years)	288366		
Population density	1157/km^2		
Rural population	**Total**	**Male**	**Female**
	2295709	1095308	1200401
Urban population	**Total**	**Male**	**Female**
	1817211	865020	952191
Birth rate	22.28		
Mortality rate	4.68		
Infant mortality rate	4.6		
Decadal growth rate	13.39		
Literacy rate	**Total**	**Male**	**Female**
	93.57	95.76	91.62

***Source**: District Census, 2011, * Estimated as per Aadhar uidai.gov.in Dec 2023 data*

2.6 Education and healthcare

Thenjipalam is where the University of Calicut is situated. The Malappuram centre of Aligarh Muslim University is located in the Elamkulam grama panchayat near Chelamala. Another prominent institution is Thunchaththu Ezhuthachan Malayalam University, located at Thunchan. The Central Government operates one Kendriya Vidyalaya, the NCERT operates one Navodaya in Oorakam, and the Special School for the Blind is located at Mankada, Pallippuram. Additionally, there are four technical high schools operating in Tirurangadi, Manjeri, Kuttippuram, and Nannamukku. MES Medical College and Hospital, MIMS College of allied Health Sciences, Vazhayoor, EMS College of Paramedical Sciences, Government Medical College, and Manjeri are the prominent medical institutes in the district.

Table 2.3: Education profile in the district

Institution	Total nos.
Lower Primary	872
Upper Primary	363
High Schools	323
Higher Secondary	248
Vocational H. S	27
Technical High Schools	3
University	2
Arts & Science College	21
Poly Technics	5
Engineering College	12
Medical College	3
Nursing College	4
Dental College	3

Source: Economic review, 2017

2.7 Agriculture and irrigation

Agriculture is the major occupation of the rural population of the district. There is intense competition for land for agricultural purposes because of the astonishingly high population density. The typical farming pattern includes intercropping with crops including pepper, arecanut, nutmeg, tapioca, cocoa, banana, legumes, and oil seeds, along with coconut production in the coastal and midlands. In lowlands and valleys, two or three crops are grown using a rice-based agricultural method, depending on the water supply. Vegetables, legumes, and oil seeds are annual crops that are produced as intercrops or as summer crops. The area under principal crops in Malappuram district is shown in Table 2.4.

Table 2.4: Area cultivated for different crops in the district

S.No.	Name of Crop	Area (in Ha) (2020-21)
1	Rice	9540
2	Cardamom	65
3	Arecanut	19064
4	Cashew	1589
5	Pepper	2527
6	Pulses	36
7	Tapioca	4183
8	Tubers	1137
9	Vegetables	3991
10	Coconut	104276
11	Rubber	42750
12	Banana & Plantain	6502.58
13	Other plantain	3857.75
14	Mango	7552.8
15	Tea & Cocoa	225

Source: *A compendium of Agricultural Statistics; Kerala 2023*

The Malappuram coast is where you can mostly find coconuts, palms, and paddy. Coconut cultivation in the district ranks second in the state and plays a significant role in the agricultural economy. The largest areas cultivated for coconuts are in Kuttippuram, Kondotty, and Perinthalmanna. In addition to the agricultural practices in the lowland and midland sections of the district, intercrops like bananas, cocca, tapioca, legumes, vegetables, etc. are cultivated. Plantation crops like rubber, pepper, cashew nuts, tea, etc. are planted in the elevated portions of the district. The cultivation of arecanuts is mostly focused on the blocks of Kalikavu, Areekod, and Perinthalmanna.

Minor irrigation projects, such as government canals and tanks, help with irrigation on a smaller scale. The state agency built and maintained small storage tanks, diversion weirs, wells, irrigation canals, and salinity control, among other things. The area covered by different types of irrigation practices in the Malappuram district is given in **Table 2.5** below.

Table 2.5: Details of the area under rainfed and irrigation in the district

Irrigated (Area in Ha)		Rainfed (Area in Ha)	
Gross irrigated area	**Net irrigated area**	**Partially irrigated / protective vegetation**	**Unirrigated or totally rainfed**
41221	32757	-	199509

***Source**: Agricultural Statistics, Department of Economics and Statistics*

2.8 Industries

There are no significant industrial facilities in the Malappuram district; instead, small businesses predominate in this industry. Agro-based businesses dominate the numerous developed small-scale industries, followed by soda water, wooden furniture, paper goods, rubber, etc. Information on numerous industrial facilities, including their number, is provided in **Table 2.6**.

Table 2.6: Details of industrial units in Malappuram district

S.No.	Industrial Units	Numbers
1	Number of Factories	233
2	Number of SSI units registered	10629
3	Number of Industrial cooperative societies	152
4	Number of Women SSI units	1769
5	Number of SC/ST SSI units	479
6	Others	4475

***Source**: Aquifer Mapping and Management Plan of Malappuram District, Kerala, (AAP:2020-21)*

At Kakkancherry, there is a KINFRA Food Park and an IT Park. At Payyanad, there is also an industrial park and a common facilities centre for the rubber industry. The Malappuram district is home to several businesses that deal with wood. Some of the large-scale units in the district are given in **Table 2.7.**

Table 2.7: Large-scale industries in the district

S.No.	Name of the unit	Sector
1.	Keltron-Kuttippuram	Public
2.	Keltron-Edarikkode	Public
3.	Edarikkode Textiles	Public
4.	Malappuram Spinning Mill	Co-operative
5.	Malco Tex	Co-operative
6.	Keltex	Co-operative

2.9 Flora and fauna

The district's lowland areas are home to significant biotope formations, including marshes, ponds, streams, and backwaters. The formation is characterised by species of *Nymphaea, Nymphoides, Limnophylla, Hydrolea,* etc. (Biodiversity of Malappuram district, Kerala state, by the Kerala Forest Research Institute, March 2010). In the district, there are also several disturbed mangrove patches with typical *Avicennia, Excoecaria, Kandelia, and Carallia* species. With the exception of a few components of the wild flora and fauna that can be found in arid regions and gaps between cultivated fields, terrestrial formations in the midlands are more indicative of agrobiodiversity. There are very few sacred groves in the area, and those that do exist often contain species of *Hopea, Vateria, Vatica, Diospyros, Terminalia,* etc.

A total of 758.86 km^2 of forestland makes up the district, of which 325.32 km^2 are reserve forests and 433.54 km^2 are vested forests. In the Western Ghats, the largest forest area is centred in the Nilambur and Wandoor blocks, as well as Melattur. The woodlands are mostly deciduous, with the remainder being evergreen. Moist deciduous, semievergreen, evergreen, savannahs, and southern wet temperate forests are the natural forests found in the district. Characteristic species like *Xylia, Terminalia, Albizia, Dellenia,* and others predominate in wet deciduous woods. The major species in semi-evergreens are *Diospyros buxifolia, Hopea parviflora, Vateria indica, Toona ciliate,* etc. In the evergreens, species of *Cullenia, Palaquium, Persea, Dysoxylum, Toona, Vateria,* etc., are more prevalent, while the sholas have a greater representation of Lauraceae genera. The forests are home to a wide variety of birds and reptiles, as well as elephants, deer, tigers, blue monkeys, bears, boars, and rabbits, among other animals. Mangroves cover about 50 acres of the Kadalundi Estuary in Vallikkunnu Grama Panchayath.

Table 2.8: List of species

S.No.	Items	Nos
1.	Flowering plants	4000
2.	Grass species	350
3.	Bamboo species	15
4.	Reeds species	9
5.	Orchid species	214
6.	Gymnosperms	4
7.	Ferns and fern allies	200

8.	Liverworts	200
9.	Algae	231
10.	Fungi	1044
11.	Lichens	800
12.	Large and medium-sized mammals	48
13.	Bird species	475
14.	Water birds	101
15.	Reptiles genera	60
16.	Lizard (endemic) species	30
17.	Snake (endemic) species	57
18.	Amphibian (endemic) species	87
19.	Freshwater fish (endemic) species	84
20.	Butterflies	313

***Source**: Kerala State Land Use Board report*

2.10 Tourism

The Malappuram district, literally the area atop the hills, is notable for its exceptional natural beauty. It is bordered by the Nilgiris hills on the east and the Arabian Sea on the west. The area conceals a unique and exciting past, perched among the undulating hills and the meandering rivers that flow to the coconut-fringed seacoast. The state's cultural and artistic traditions owe a lot to the hill country as well. The land's mosques and temples are renowned for their grand festivities. The district has carved out a special place for itself in Kerala's history as the homeland of renowned poets, writers, political figures, and religious leaders.

Table 2.9: Major tourist spots

S.No.	Tourist center	Focus
1	Kadalundi	Bird sanctuary
2	Padinjarekara	Beach
3	Kodikuthimala	Hilltop
4	Valamthode	
5	Adyanpara	Waterfall
6	Nilambur	Teak Museum
7	Kottakunnu	Old Fort
8	Biyyam Kayal	Water sport
9	Manjeri	Legendary place
10	Tirur	
11	Tanur	
12	Tirurangadi	

***Source**: Kerala State Land Use Board report*

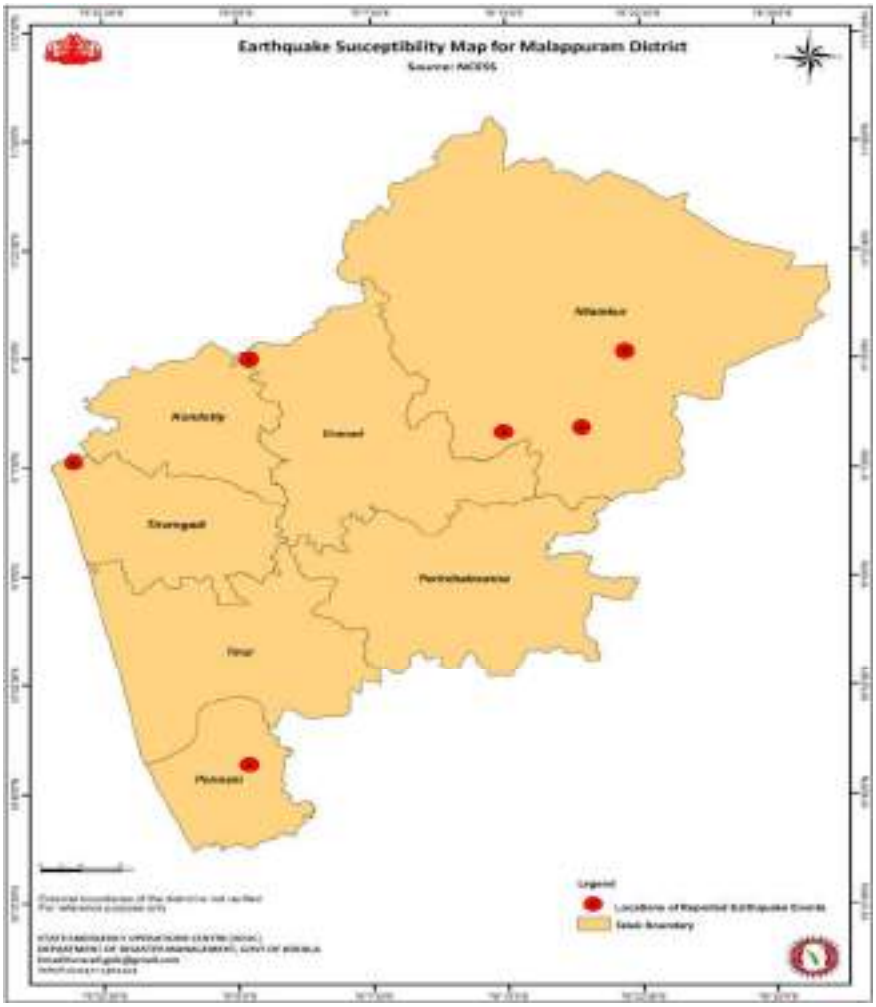
2.11 Art and culture

The Malappuram district has a strong history of artistic and cultural expression. This region of the country has produced several well-known authors and poets. Nearly 400 years ago, Thunchath Ezhuthachan, regarded as the founder of contemporary Malayalam literature, was born at Trikkandiyur, a village close to Tirur. Mampuram was historically a key location in Malabar's anti-British uprisings, particularly the Moplah Rebellion of 1921. This is where Mampuram Thangal's burial is. Omar Qazi, a Muslim scholar and pioneer of anti-British

organisations, was also born there. The Kathakali musician Kalamandalam Tirur Nambissan was born in Ezhoor. Malappuram is the birthplace of poets like Mahakavi Vallathol, Narayana Menon, V.C. Balakrishna Paniker, and Moyinkutty Vaidyar. Poonthanam was born in Malappuram and is well known for his masterpiece, Jnanappana.

2.12 Seismicity

Since ancient times, there have been little tremors occasionally felt in Kerala. There are numerous major deep-seated faults in Kerala, but the Periyar, Idamalayar, Muvattupuzha, Bhavali, and Kuthuparamba faults stand out. In addition, there are a lot of tinier faults and fractures that might cause tremors of a smaller magnitude due to crustal readjustment. In the regional seismic zonation map of India, Kerala has been placed in Zone III, where the maximum expected intensity is VIII on the MM scale or 5.6 M on the Richter scale. Districts like Kottayam-Idukki and Thrissur-Palakkad have more earthquake activity. Other areas, including Thiruvananthapuram, Kannur, and Kozhikode, also exhibit mild earthquake activity. The earthquake susceptibility map of the Malappuram district is shown in **Figure 2.4.**



Source: NCESS

Figure 2.4: Earthquake susceptibility map of Malappuram district

CHAPTER – 3

OVERVIEW OF MINING ACTIVITY IN THE DISTRICT

3.0 General

The Mines and Minerals (Development and Regulation) Act 1957 regulates the mining sector in India and mandates the requirement of granting leases for mining operations. Minerals include all minerals except mineral oils, natural gas and petroleum. "Minor minerals" means building stones, gravel, ordinary clay, ordinary sand other than sand used for prescribed purposes, and any other mineral that the central government may, by notification in the official gazette, declare to be a minor mineral. The state government may create regulations for controlling the issuance of quarry leases, mining leases, or other mineral concessions in respect of minor minerals and for related reasons by notifying them in the official gazette.

The MMDR Act contains no legal definition of "major minerals." As a result, anything that is not designated as a "minor mineral" may be considered a major mineral. Major minerals are those specified in the first schedule appended to the MMDR Act 1957, and the common major minerals are lignite, coal, uranium, iron ore, gold, etc. The Ministry of Mines, under the central government, is in charge of drafting laws pertaining to major minerals.

3.1 Mineral resources in Malappuram district

The major economic minerals reported in the district are iron ore, gold, clay, lime shell, etc. Minor minerals include ordinary earth, ordinary clay (tile/brick clay), ordinary sand, laterite and granite dimension stone, and granite (building stone). The midland regions are abundant in laterite stone. It is commercially exploited for building work, and thousands of people are employed by the hundreds of quarries that are in operation and cut the laterite stone known as Vettukallu. Lime shell deposits may be found along the shore, mostly in the Ponnani and Kadalundi nagarams. Heavy minerals, including ilmenite and monazite, may be found in the Ponnani and Veliyancode coastal sands. The primary raw material for the porcelain industry, china clay, is widely distributed across the area. Nilambur, Vaniyambalam, Kalikavu, and Chembrassery are the locations where iron ore, also known as magnetite-quartzite, is discovered.

3.2 Sand resources in Malappuram district

One of the most abundant resources in the world is river sand, which can replenish itself and may make up as much as 20% of the Earth's crust. It is critical for human health and the survival of rivers. It may be used to make concrete, fill roads, create sites, make bricks, make glass, sandpaper, reclamation, and so on. Sand is a naturally occurring granular substance made up of minutely split rock and mineral particles that range in size from 150 microns to 4.75 mm (IS 383-1970). Sand is formed when mechanical forces cause rocks to weather. Weathered rocks first turn into gravel and then sand during the process. To meet the constantly growing needs of the construction sector, the demand for sand and gravel has increased quickly over time. In Kerala, due to a shortage of river sand and ordinary sand occurring in paleochannels, the construction industry is seeking possibilities for using M-sand obtained by crushing crystalline rocks. Additionally, it is believed that increased use of alternative materials (such

as manufactured sand, artificial sand, etc.) and building technologies, as well as sustainable resource usage, might significantly lessen the damaging effects of mining on the environment.

The sources of sand in the district include the river floodplain and paleochannels of the Bharathapuzha stretch, Chaliyar and Kadalundi rivers in the district. There are no major dams in the district for desilting; however, there are a few check dams present to lower the velocity of flow. The manufacture of cement for concrete is one indirect technique to estimate aggregate consumption (concrete is made with cement, water, sand, and gravel). The consumption volume of cement in India for the year 2022 is estimated at around 379 million metric tonnes **(statista.com 2022)**. The consumption of cement in India is expected to grow at a CAGR of 5.68% from FY16 to FY22 (Cement Industry Report, June 2022). Cement production in India increased by 19.4% in June 2022, compared to June 2021. At present, six lakh metric tonnes of cement are being produced in Kerala every month, and two more production units will be started in another two years to double the cement production to twelve lakh metric tonnes monthly (TOI, December 21, 2021). The construction industry requires around six to seven times the amount of sand and gravel for each tonne of cement **(USGS, 2013b)**. However, it depends on the type of concrete mix recommended for construction. Thus, the utilization of aggregates in Kerala for concrete in 2021 was estimated to be 50.4 million metric tonnes against 7.2 million metric tonnes of cement production. It is anticipated to reach 100.8 million metric tonnes against 14.4 million metric tonnes of cement production by the year 2025.

As per the Aadhar statistics, the population of Kerala in 2022/2023 is estimated to be 35,330,888 as compared to the last 2011 Census data of 33,406,061. The Malappuram district population as estimated by Aadhar uidai.gov.in Dec 2023 data, is 5,716,959 which is around 16.18% of the state's total population. Assuming the demand for construction sand to be directly proportional to population, it is estimated that 8.15 million metric tonnes of sand are required, and the mentioned figure is based on total state requirements of 50.4 million metric tonnes.

The Kadalundi River flows through the Malappuram district and rises in the western ghats near the western edge of the silent valley and passes through 17 panchayats and two municipalities in which the sand deposit is available. It has the Olipuzha and Veliyar as its two principal tributaries. Kadalundi River has a total length of 130 km, and the approximate volume of sand available is 65976 m^3. The western ghats range in Kerala's Wayanad plateau is where the Chaliyar River originates. For the majority of its length, the river travels through the Malappuram district, which is around 43 km long and traverses 12 panchayats and one municipality. The approximate volume of sand available in the Chaliyar River is around 882180 m^3 in total. Bharathapuzha, also referred to as the Nila is a 209 km long river. This originates in Tamil Nadu and continues along the Palakkad, Thrissur and Malappuram districts of Kerala. The Bharathapuzha River stretch is approximately 22.7 kilometres in the district of Malappuram. The river flows through Irimbiliyam, Thirunavaya, Triprangode, Kuttipuram and Tavanur Panchayats of Malappuram district. The approximate sand volume available in the Bharathapuzha stretch in the Malappuram district is about 10611950 m^3. The total volume of sand available in the above-mentioned river stretches of the Malappuram district is around 11560106 m^3.

3.3 List of mining leases in the district with location, area and period of validity

In the Malappuram district, no river sand mining leases are sanctioned by the Department of Mines & Geology, Government of Kerala. Potential sand mining areas will be identified in the District Survey Report, based on which river sand mining leases shall be sanctioned. The revenue department of Kerala has already conducted river bank mapping and sand auditing of around 20 rivers in Kerala, wherein the profile of rivers was created at regular intervals, and deposition was identified along with water level.

3.4 Details of royalty or revenue received in the last three years

The details of royalty or revenue received in the last three years from mining if river sand in the district is given in Table 3.1

Table 3.1: Details of royalty received in the last three years

S.No.	Year	Revenue received
1.	2020-21	Nil
2.	2021-22	Nil
3.	2022-23	Nil

3.5 Quantity of Silt (m^3) removed from rivers in Malappuram

The details of quantity of silt removed from the rivers in the district in the last three years is given in Table 3.2

Table 3.2: Quantity of silt (m^3) removed from rivers in Malappuram

Sl.No	Name of the River	Quantity of silt (m^3) removed		
		2019-20	2020-21	2021-22
1.	Olippuzha	12184.47	Nil	Nil
2.	Chaliyar	Nil	Nil	306456
3.	Kadalundi Puzha	Nil	Nil	601643
4.	Tirur Puzha	Nil	Nil	4055
5.	Bharathapuzha	Nil	Nil	3480
6.	Pookkottumanna Regulator cum Bridge	Nil	3215	9710

Source: ILDM Letter No. ILDM/3009/2022-E1-Part(1) dated 07-12-2022

CHAPTER – 4
EARTH SURFACE FEATURES

4.0 Land utilization pattern in the district

The pattern and distribution of land use and land cover (LULC) may be mapped using satellite remote sensing technology, which also makes it possible to track changes and trends in LULC over time. The term "land use" describes all human activities and other uses that take place on land. The terms "land usage" and "land cover" are closely linked and can be used interchangeably. Land cover refers to "natural flora, water bodies, rock/soil, artificial cover, and other results due to transformation."

As the approximate coverage area of Malappuram District is 3554 km^2, land use land cover through a medium-resolution approach will be apt for understanding the land cover of the district. The Environmental Systems Research Institute (ESRI, Inc.), in collaboration with Impact Observatory, Microsoft provides global land cover derived using sentinel-2 satellite imageries with a cell size resolution of 10 m x 10 m.

Image analysis

The vector files were classified under the LULC classes of inland water bodies, mixed vegetation, vegetation (flooded), agriculture fields/crops, built-up, barren land, unclassified and range land/open land. The classified LULC of the Malappuram district is shown in **Figure 4.1**.

In our LULC analysis of Malappuram district in Kerala, we observed a slight variation in the reported district area (3554 km^2 on government websites) compared to the calculated area using shapefiles (3498.52 km^2). It's worth noting that for our specific project, which does not require precise land use estimation at the district level, this difference in land area is of limited significance. Such minor variations can arise due to disparities in data sources, cartographic projection methods, and GIS software algorithms. In our context, where the focus lies on broader regional trends, these discrepancies in district-level land area estimation do not substantially impact the overall findings of our study.

DSR Malappuram

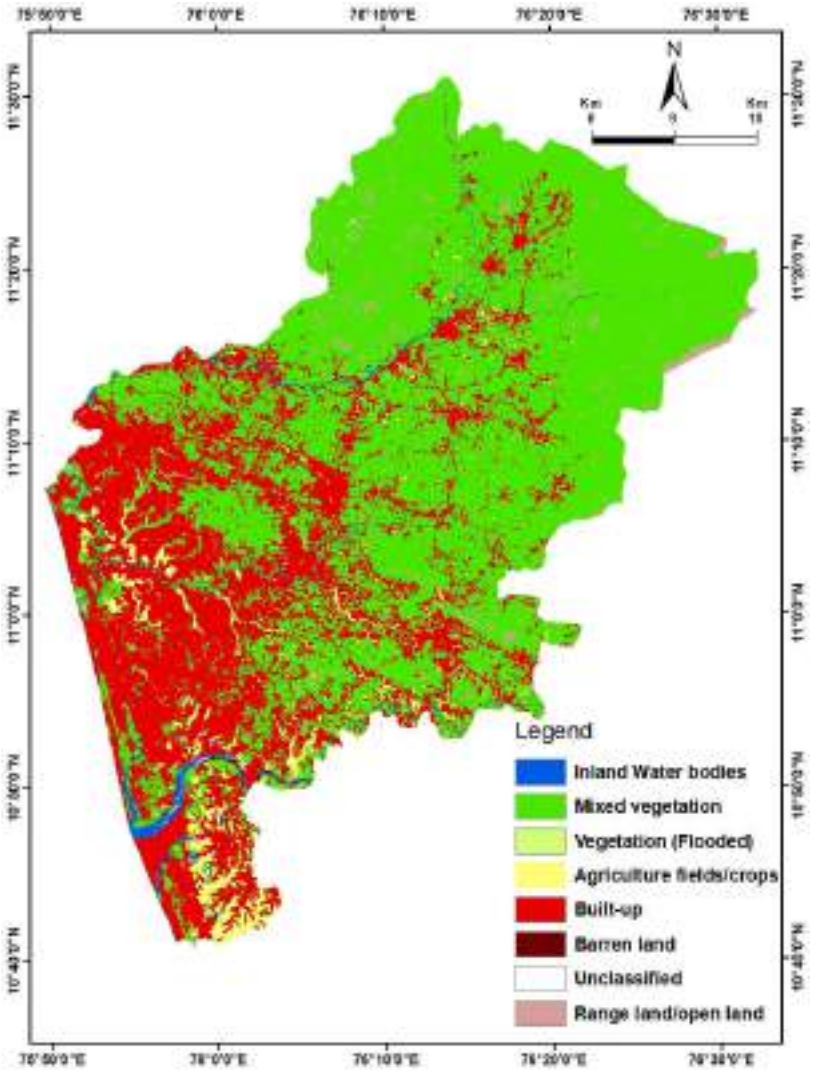


Figure 4.1 LULC classification of Malappuram district

The overall inventory in terms of the percentage share of LULC classes in the district is presented in **Table 4.1** and graphically represented in **Figure 4.2**.

Table 4.1 Inventory of Land use Land cover classes in the district

S.No.	LULC class	Area (km^2)	% of area
1.	Inland water bodies	45.19	1.29
2.	Mixed vegetation	2166.23	61.92
3.	Vegetation (Flooded)	1.66	0.05
4.	Agriculture fields/crops	117.40	3.36
5.	Built-up	1096.20	31.33
6.	Barren land	3.54	0.10
7.	Unclassified/cloud cover	0.58	0.02
8.	Rangeland/open land	67.72	1.94
Total		**3498.52**	**100.00**

DSR Malappuram

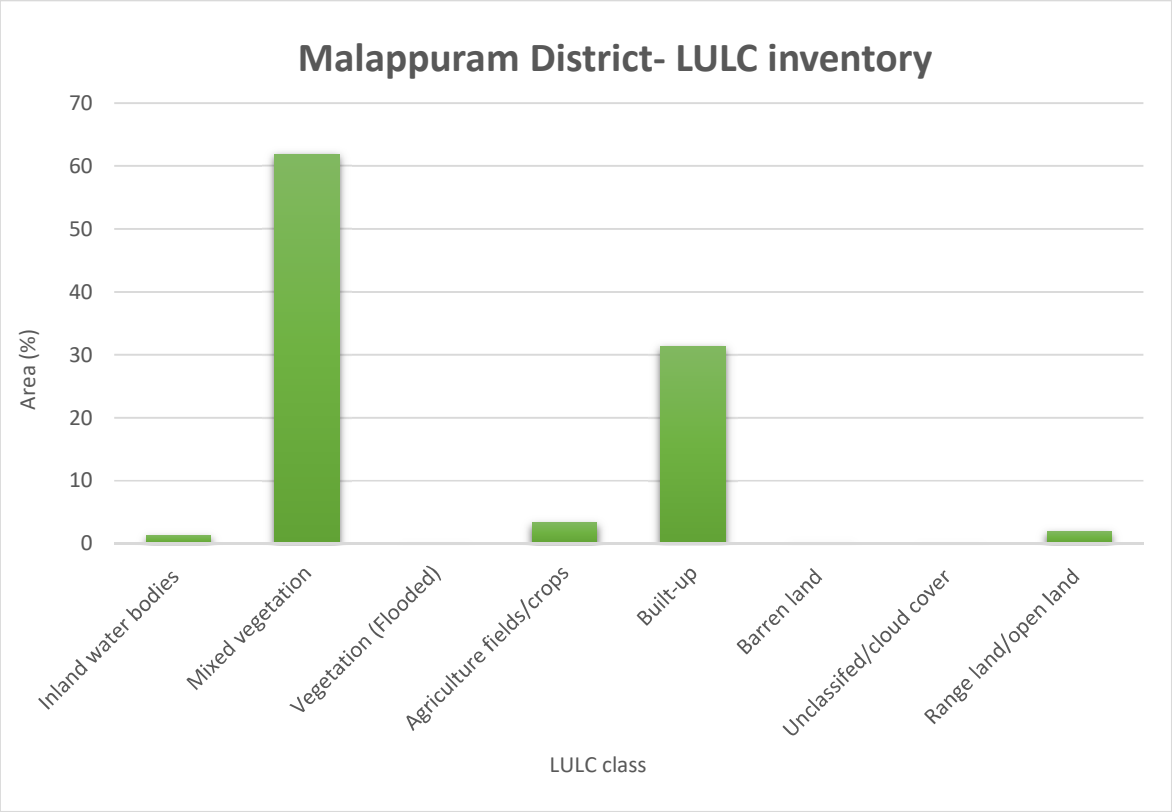


Figure 4.2 Graphical representation of LULC classes

The major classes, which cover almost 90% of the total area are mixed vegetation, built-up and agriculture. LULC analysis shows that there is abundant mixed vegetation in the study area; it covers 61.92% of the total area. 31.33% of the area is covered by built-up, and 3.36% of the area is covered by agricultural fields/crops. Rangeland/open land covers 1.94%, inland water bodies cover 1.29%, barren land covers 0.10%, vegetation (flooded) covers 0.05%, and unclassified/cloud cover is 0.02% of the total area. The various class definitions, as per ESRI, are shown in **Table 4.2**.

Table 4.2 LULC class definitions (ESRI)

Class	Definition
Water	Areas where water was predominantly present throughout the year; may not cover areas with sporadic or ephemeral water; contains little to no sparse vegetation, no rock outcrop nor built-up features like docks; examples: rivers, ponds, lakes, oceans, flooded salt plains.
Trees	Any significant clustering of tall (~15 feet or higher) dense vegetation, typically with a closed or dense canopy; examples: wooded vegetation, clusters of dense, tall vegetation within savannas, plantations, swamp or mangroves (dense/tall vegetation

	with ephemeral water or canopy too thick to detect water underneath).
Flooded vegetation	Areas of any type of vegetation with obvious intermixing of water throughout a majority of the year; seasonally flooded area that is a mix of grass/shrub/trees/bare ground; examples: flooded mangroves, emergent vegetation, rice paddies and other heavily irrigated and inundated agriculture.
Crops	Humans planted/plotted cereals, grasses, and crops not at tree height; examples: corn, wheat, soy, and fallow plots of structured land.
Built-up	Human-made structures; major road and rail networks; large homogenous impervious surfaces including parking structures, office buildings and residential housing; examples: houses, dense villages/towns/cities, paved roads, asphalt.
Bare ground	Areas of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation; examples: exposed rock or soil, desert and sand dunes, dry salt flats/pans, dried lake beds, mines.
Snow/Ice	Large homogenous areas of permanent snow or ice, typically only in mountain areas or the highest latitudes; examples: glaciers, permanent snowpack, and snow fields.
Clouds	No land cover information due to persistent cloud cover.
Rangeland	Open areas covered in homogenous grasses with little to no taller vegetation; wild cereals and grasses with no obvious human plotting (i.e., not a plotted field); examples: natural meadows and fields with sparse to no tree cover, open savanna with few to no trees, parks/golf courses/lawns, pastures. A mix of small clusters of plants or single plants dispersed on a landscape that shows exposed soil or rock; scrub-filled clearings within dense forests that are clearly not taller than trees; examples: moderate to a sparse cover of bushes, shrubs and tufts of grass, savannas with very sparse grasses, trees or other plants.

Source: Credits (Attribution) – Impact Observatory, Microsoft, and ESRI

The national LULC classification system was designed as a reconnaissance scheme applicable in the Indian environment with varying needs and perspectives, which is shown in **Table 4.3** below.

Table 4.3: Land use, land cover (LU/LC) classification scheme (NRSC/ISRO)

Sr. no	Description-1	Description-2	Classes from NRC LULC5OK Mapping Project
1	Built-up	Urban	Residential, Mixed built-up, Public / Semi-Public, Communication, Public utilities/facility, Commercial,

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			Transportation, Reclaimed land, Vegetated Area, Recreational, Industrial, Industrial / Mine dump, Ash / Cooling Pond
		Rural	Rural
		Mining	Mine / Quarry, Abandoned Mine Pit, Landfill area
2	Agriculture	Cropland	Kharif, Rabi, Zaid, Two cropped, more than two cropped
		Plantation	Plantation - Agricultural Horticultural, Agro Horticultural
		Fallow	Current and Long Fallow
		Current Shifting cultivation	Current Shifting cultivation
3	Forest	Evergreen / Semi-evergreen	Dense / Closed and Open categories of Evergreen / Semi-evergreen
		Deciduous	Dense / Closed and Open categories of Deciduous and Tree Clad Area
		Forest Plantation	Forest Plantation
		Scrub Forest	Scrub Forest, Forest Blank, Current & Abandoned Shifting Cultivation
		Swamp / Mangroves	Dense / Closed & Open Mangrove
4	Grass/ Grazing	Grass/ Grazing	Grassland: Alpine / Sub-Alpine, Temperate / Sub Tropical, Tropical / Desertic
5	Barren/ unculturable / Wastelands	Salt Affected Land	Slight, Moderate & Strong Salt Affected Land
		Gullied / Ravinous Land	Gullied, Shallow ravine & Deep ravine area
		Scrub land	Dense / Closed and Open categories of scrubland
		Sandy area	Desertic, Coastal, Riverine sandy area
		Barren rocky	Barren rocky
		Rann	Rann
6	Wetlands /Water Bodies	Inland Wetland	Inland Natural and Inland Manmade wetland
		Coastal Wetland	Coastal Natural and Coastal Manmade wetland
		River / Stream/canals	Perennial & Dry River/stream and line & unlined canal drain
		Water bodies	Perennial, Dry, Kharif, Rabi & Zaid extent of lake/pond and reservoir and tanks
7	Snow and Glacier	-	Seasonal and Permanent snow

***Source**: NRSC/ISRO - 2006*

4.1 Physiography of the district

Based on its physiographic nature, Malappuram district is divided into three regions, namely highland, midland, and lowland. Along the seashore, the lowland region extends, followed by the midland in the centre and the highland zone in the eastern and northeastern regions. Malappuram district falls under five sub-micro regions viz.

a) Malappuram coast

The Malappuram coast region falls all along the coastal tract of the Malappuram district. This region is drained by major rivers like Chaliyar, Kadalundi, Ponnani, etc., canals and backwaters. This coastal plain slopes towards the west very gently. The maximum height (104 m) is located at Kalpakancherry village in Tirur taluk.

b) Malappuram undulating plain

Malappuram undulating plain shares boundaries with Nadapuram-Mavoor undulating plains in the north, the Chaliyar river basin and the Perinthalmanna undulating upland in the east, Pattambi undulating plain in the south and the Malappuram coast in the west. The Nenmini hill (478 m) in the central part of the region located at Kannamangalam village in Tirurangadi taluk is the highest spot in the region.

c) Chaliyar river basin

The Chaliyar river basin falls entirely into Ernad taluk. Its boundaries are defined by the Nilambur forested hills in the north and east, the Perinthalmanna undulating upland in the south, and the Malappuram undulating plains in the east. This region falls under the middle course of the Chaliyar River. The highest point (343m) is in Kalikavu village (31 m) in Nilambur taluk, and the lowest point (50m) is in Porur village (29 m) in Nilambur taluk.

d) Nilambur forested hills

The Nilambur forested hills region is bounded to the north by Kozhikkode forested hills and Wayanad forested hills; to the east by Tamilnadu; to the south by Mannarkkad and Palakkad forested hills; and to the west by the Chaliyar river basin. This region is a part of the Western Ghats. There are many peaks over 1000 m in height in this region. The minimum height (115 m) is located in Mambad village.

e) Perinthalmanna undulating upland

The Perinthalmanna undulating upland region is bounded in the north by the Chaliyar river basin, in the east by the Mannarkkad-Palakkad forested hills, in the south by the Palakkad gap, and in the west by the Malappuram undulating plain. The Kadalundi River drains through this region. The maximum height of the region is 610 m at the Vadakkankara village of Perinthalmanna taluk. The 100 m contour, which shows the minimum height, runs throughout this region.

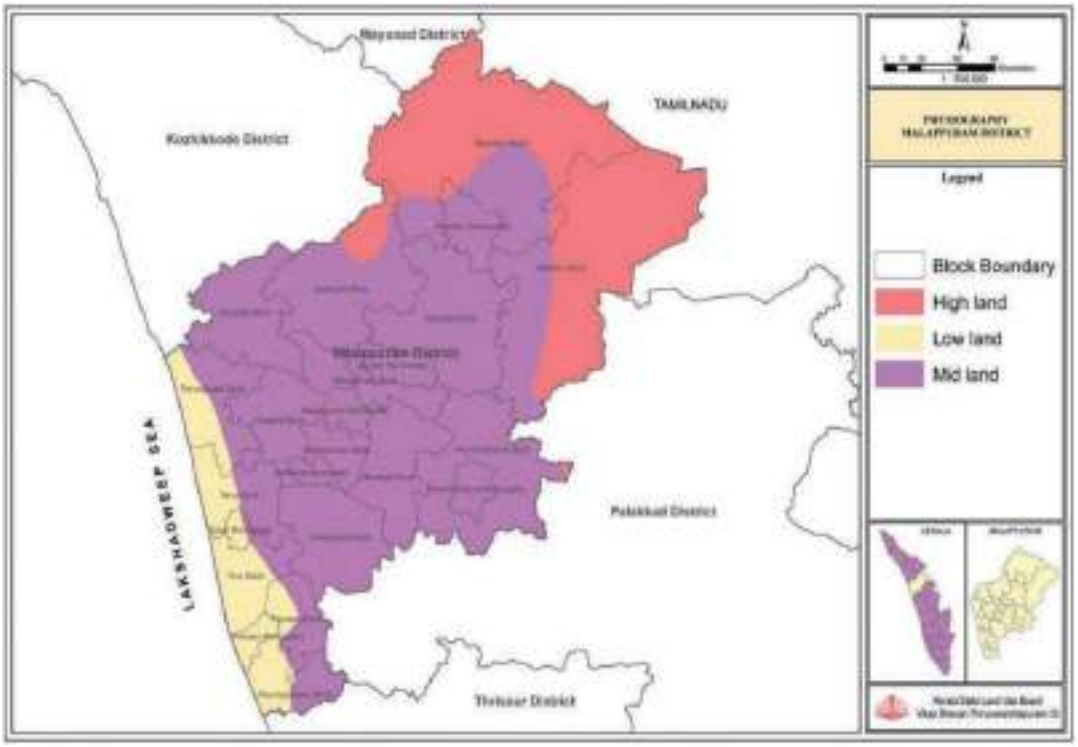

Figure 4.3: Physiography map of Malappuram district *(Source: KLUB,2013)*

4.2 Geology & mineral wealth

The Malappuram District has a distinctive geological setting; Francis Buchanan first noticed it in the Angadipuram railway station, and it has since attained geological prominence as the type locality of laterite. The majority of the area is covered with laterites and crystalline rocks that date back to the Archaean period. However, a small section of tertiary formations that are covered in more recent alluvial deposits is exposed in the western half of the area. The district can be separated into two geological belts based on how the various rock types are exposed:

i. The Charnockite group of rocks covers the majority of the area.
ii. The Migmatite Complex is located to the east.

The geological succession noticed in the district is shown in **Table 4.4** below.

Table 4.4 Stratigraphic succession of Malappuram district

Era	Age	Formation	Lithology
Quarternary	Recent	Alluvium	Sand and clay are seen along the coast, river alluvium, and valley fills
	Sub Recent	Laterite	Laterite derived from crystalline rocks and Tertiary Sediments
Tertiary	Oligocene To Eocene	Vaikom beds	Sand, pebble and gravel bed clays and lignite are seen.

	Undated	Intrusion	The intrusion of gabbro, dolerite, quartz veins, granites etc
Pre Cambrian	Archaean	-	Charnockite, Charnockite gneiss, Granulites, Hornblende biotite Gneiss, Schists.

*(**Source**: Aquifer Mapping and Management Plan of Malappuram District, Kerala, CGWB (AAP:2020-21))*

The Charnockite, Charnockite gneiss, Biotite, Biotite hornblende, and Migmatite rocks make up the district's crystalline group of rocks. Charnockite occupied the majority of the district's land area and was exposed across the hills around Edavanna, Palpatta, Pandikkad, Manjeri, and Nilambur. Around Mambad, Wandur, and Nilambur, migmatites are found with biotite gneiss and biotite hornblende gneiss. Along the Pandalur hills, one may see low-grade banded magnetite quartzite rocks. The geological map of Malappuram district is shown in **Figure 4.4.**

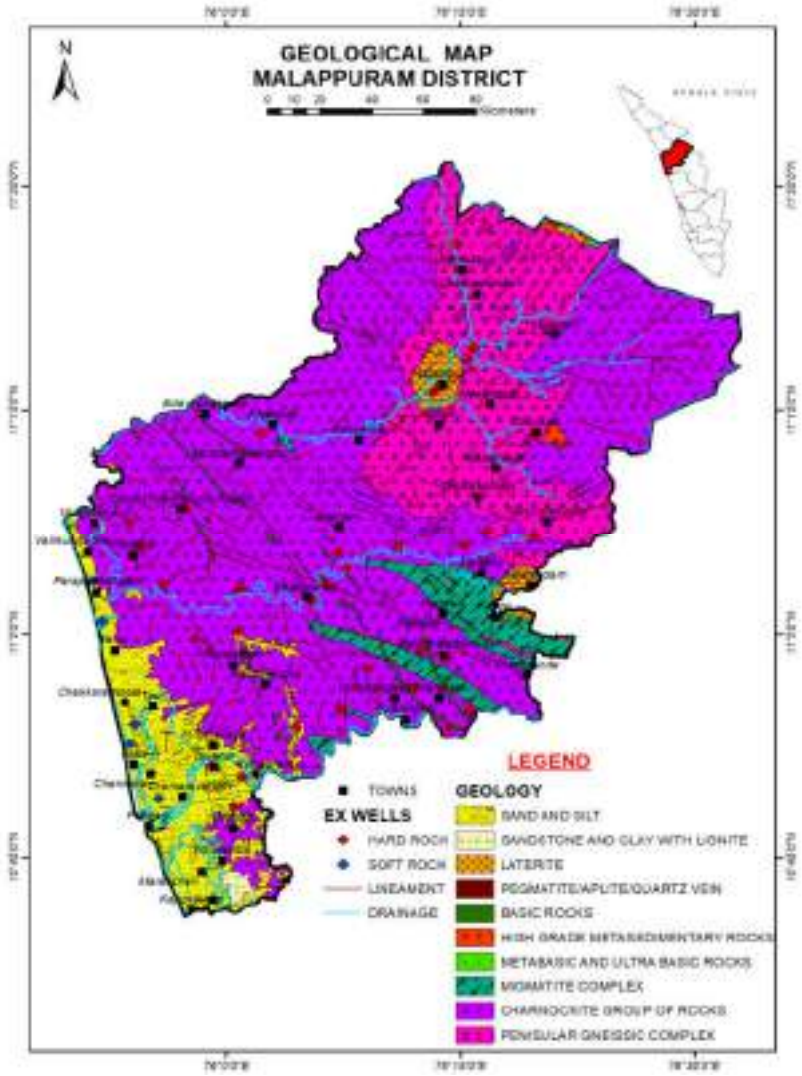

Figure 4.4: Geological map of Malappuram district (**Source**: *Aquifer mapping and management of groundwater resources, CGWB*)

The area is home to one of the largest gabbro dykes in Kerala, which spans tens of kilometres. From Cherukkara, southwest of Perinthalmanna, to Manjeri, northwest, the dike may be observed. The dyke's width ranges from 30 to 50 metres, and it is heading northwest. The breadth reaches 100 metres in certain spots. There aren't many dolerite dykes that are sympathetic. A few more dolerite dykes may be found snaking through the basement rocks. The majority of the dykes go from northwest to southeast.

Along the western edge of the district, abutting the Lakshadweep Sea, tertiary structures may be found. The Tertiary Formation of Kerala is made up of the vaikom beds, which are composed of sandstone, clay, and lignite seams. Wherever the tertiary sediments are exposed, only laterites are visible because they are lateritized at the top. Tertiary rocks are exposed between Thiurnavaya and Kuttipuram, as well as in the Tirur region. These are covered by the recent alluvial deposit, which is typically less than 75 metres thick. Five boreholes that were bored in the area provide the lithological sequence, which is typically thickest along the shore and thinnest in the east.

This is the district's most significant lithographical unit, and it can be found practically everywhere in the district's midland. In certain spots, the laterite can be up to 25 metres thick. The tertiary formation and the crystalline are both the sources of the laterites. The laterites are very compact and exceedingly permeable. They make excellent construction stones and are carved into bricks. Thick lithomargic clay may be visible underneath the laterite, and in certain areas, the clays have grown into sizable caverns. These caverns may be found in the district's Chappanangadi and Kuttipuram areas.

The district's exposed alluvial deposit may be roughly split into three units: river alluvium, which is seen by the sides/banks of major rivers; coastline alluvium; and valley fills, which are visible throughout the midland region of the valley. Red Teri sands are visible as a thin strip along the coast between Pallikara and Pariyapuram, where the coastal alluvium reaches a thickness of up to 15 m. These sands have an iron layer and are linked to heavy minerals. The drill holes at Pariyapurm show that the Teri Sands range in thickness from less than a metre to 9.0 m. Along the major rivers, one may see the river alluvium. Valley fill deposits are visible all over the major valleys in the district, particularly in the Charamavattom, Thiruvengapa, and Kuttipuram regions by the Bharathapuzha River (Ponnani River). They often consist of minerals eroded from nearby hills and slopes as well as deposits from flood plains.

4.3 Geomorphology

The landforms in the study area are carved out by a combination of fluvial and denudational activities, which can be grouped into erosional and depositional landforms. The various geomorphic units that are visible in the district are plateaus, denudational hills, piedmont zone, pediplains, flood plains, coastal plains, etc. (*Aquifer Mapping and Management Plan of Malappuram District, Kerala, CGWB (AAP:2020-21)*). The details of the geomorphological features in the district are given in **Table 4.5** below.

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Table 4.5: Details of the geomorphological features in the Malappuram district

S.No.	Features	Area (km^2)	% of area
1	Coastal Plain	290.92	8.2
2	Denudational Hills	1.88	0.1
3	Denudational Structural Hills	749.86	21.1
4	Flood Plain	18.92	0.5
5	Marshy	0.39	0.0
6	Pediplain	383.31	10.8
7	Piedmont Zone	513.40	14.5
8	Plateau	1458.40	41.1
9	Residual Hill	7.51	0.2
10	Rock Exposure	11.22	0.3
11	Structural Hills	60.91	1.7
12	Water Body	54.90	1.5

***Source**: Aquifer Mapping and Management Plan of Malappuram District, Kerala, CGWB (AAP:2020-21)*

The narrow coastal plain that persists on the western edge and the equivalent heavily dissected pediplain to the east reflect classic erosional landforms formed by fluvial and denudational activity. These undulating pediplains are commonly dissected into U-shaped troughs in the midland area, giving rise to the appearance of solitary low mounds. The district is characterised by plateaus with pediplains in general. The undulating to rolling terrain of the lower dissected piedmont plains is characterised by low hills and narrow valleys. The topography in the east is harsh, with sharply inclined slopes and tiny tops. It forms the Western Ghats' foothills. This terrain is often more than 80 metres above mean sea level, and it is covered with densely protected forest. The following are some of the district's most notable morphometric characteristics:

Denudational structural hills:

There are hills that are subject to external weathering, erosion, and mass wasting processes. They are found in Agro-Ecological Zone (AEZ)-I, which includes the Western Ghats and its spur hills. This geomorphological unit is centered in the eastern half of Nilambur, Kalikavu, and near the northern boundary of the Areekode block, aside from the deconstructed aspects of the Perinthalmanna and Malappuram blocks. In general, the height is higher than 100 metres above sea level, with complicated slopes, scarps, and solitary elongated hills within it. Their average slope is roughly 30%; however, in certain places, it is much higher.

Piedmont zone:

A piedmont is a gently sloping transportation and/or erosion slope that connects eroding slopes or scarps to lower-level sediment deposition regions. This zone is mostly situated within AEZ-I, with a limited distribution in AEZ-II, the Central Midlands. This zone is located in the midst of the Nilambur, Kalikavu, Vengara, and Perinthalmanna blocks. This zone's elevation ranges from 20 to 100 metres. The topography is generally undulating, with tiny winding valleys between low hills with complicated slopes. The average slope is between 15% and 25%.

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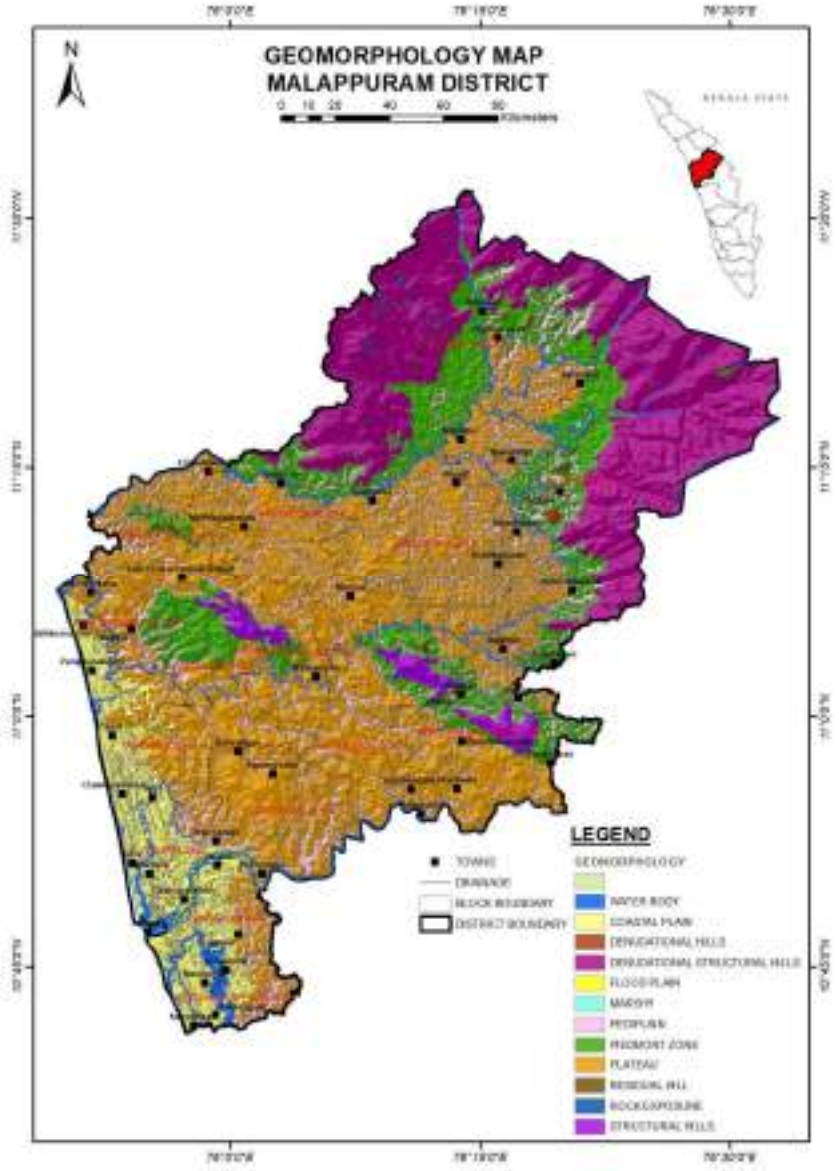

Figure 4.5: Geomorphological features in Malappuram district (***Source***: *Aquifer mapping and management of groundwater resources, CGWB, 2022*)

Lower dissected plateau:

A plateau is a flat, raised landform that rises tabularly above the surrounding region. The term "dissected plateau" refers to plateaus that have been badly degraded by streams or rivers. Lower dissected plateaus occur when such plateaus appear at a lower height. This geomorphic unit is found in the district's AEZ II Central Midland Zone. This geomorphic unit is distributed throughout the majority of the blocks, accounting for 41% of the total geographical distribution. This zone has an elevation of up to 20 metres. This region is characterised by moderately undulating to low-rolling topography that is widely crisscrossed by narrow to vast valleys. The average slope is 5-15%, with some sections reaching up to 25%.

Coastal plains:

A coastal plain refers to a limited tract of flat, low-lying land near the seashore. Beaches, coastal alluvial plains and other notable features can be found in coastal planning. These characteristics were formed by the deposition of suspended and rolling debris brought by west-flowing rivers along the shore. The district's coastal plains are dispersed in the western sections of the Tirurangadi, Tanur, Tirur, Ponnai, and Perumpadappa blocks. This zone's elevation ranges from 0 to 20 metres. The coastal plains provide 8% of the district's land.

4.4 Soil

Soil is an essential component of the natural environment that forms as a result of natural rock disintegration. Soil is composed of four components: mineral material, organic material, air, and water. Soils were categorised into distinct categories based on the quantity of sand, silt, and clay. The district has been categorised as lateritic, brown hydromorphic, hydromorphic saline, coastal alluvium, riverine alluvium, and forest loam soil. Lateritic soil is the most common type of soil in the midland area. These soils are well-drained, with minimal levels of organic matter and plant nutrients. Coconut, tapioca, rubber, arecanut, pepper, cashew, and spices are the most important crops farmed. These soils have a deep to extremely deep character.

Brown hydromorphic soil is the second most common soil type in the study region, and it forms in valley bottoms or undulating topography in the district's midlands and the low-lying coastal strip. They originated as a result of the transfer and sedimentation of material from adjacent hills and slopes, as well as river deposits. Clay and plant nutrients are abundant in the soil. The soil is ideal for rice farming. In coastal areas, hydromorphic saline soils can be found in patches. They are dark, deep, and inadequately drained, with a broad range of textures. Coastal alluvium may be found along the shore from Kondungalloor to Chettuvai. These have formed from recent marine deposits with a sand-dominated texture and are excessively drained with very quick permeability. Riverine alluvium is found only on river banks and tributaries. They are rich in plant nutrients and made up of sandy to clayey loam. It is suitable for a wide range of crops such as coconut, rice, arecanut, pepper, vegetables, and so on. Coconut is the most important crop in these soils. Forest loamy soil is found in the district's steep southern hills. These are distinguished by their high organic matter content.

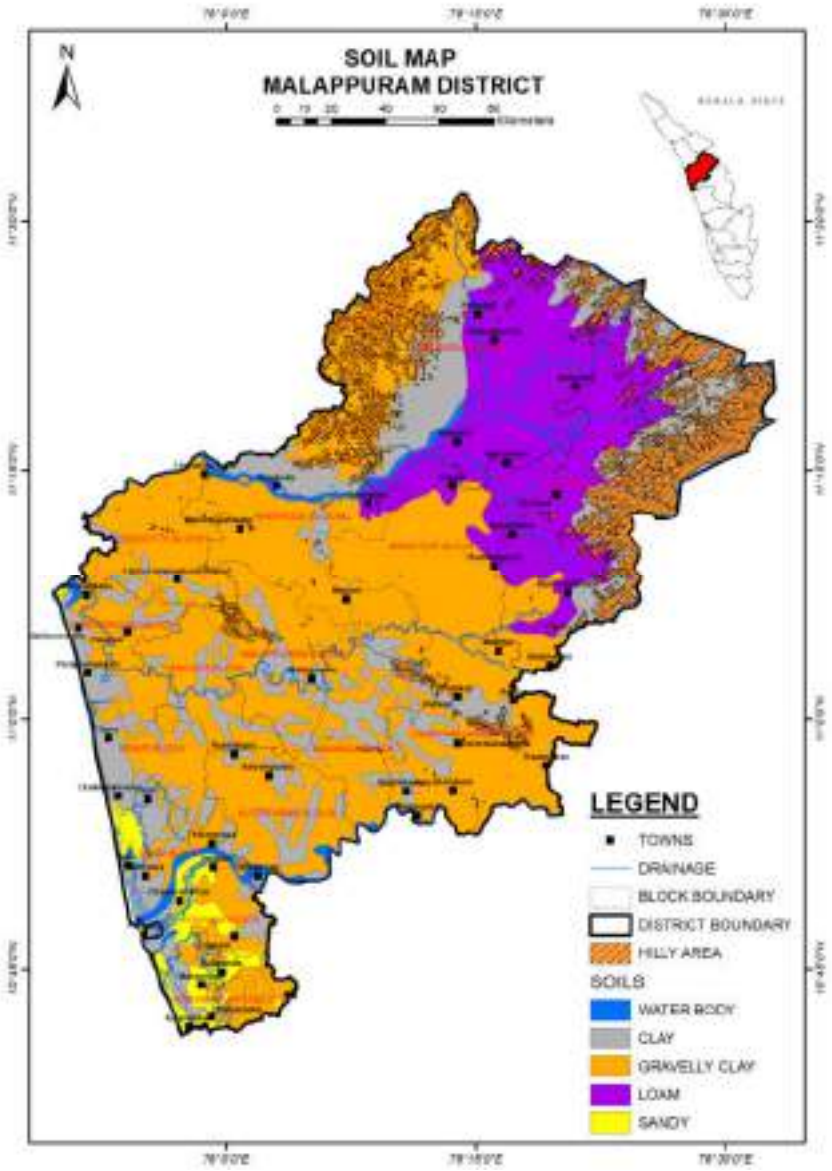

Figure 4.6 Soil map of Malappuram district ***(Source****: Aquifer mapping and management of groundwater resources, CGWB, 2022)*

4.5 Hydrogeology

The three main types of aquifers found in the Malappuram district are laterite, tertiary sedimentary, and hard rock aquifers. The sedimentary aquifers are exposed along the district's river and coastal tracts, while the hard rock and laterite aquifers make up the district's primary aquifers. The features of the aquifer and its behaviour throughout the year were depicted using the hydrological data collected during the aquifer mapping research conducted by CGWB during 2020-21. According to the results of the aquifer mapping research, there are two separate aquifer systems: the phreatic aquifer-I (Shallow Aquifer) and the hard rock aquifer-II (fracture aquifer system). The depth of the phreatic aquifer in the Malappuram district is shown in **Figure 4.7**

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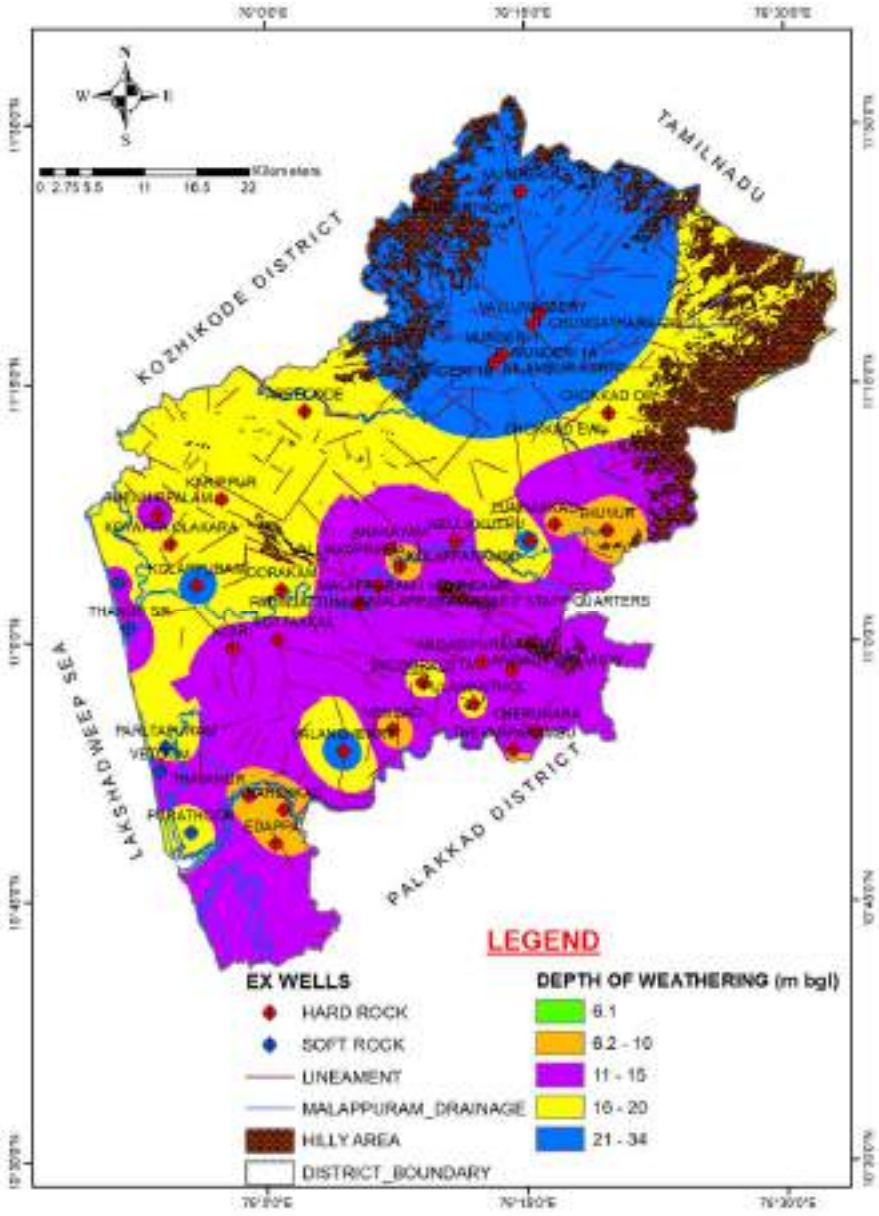

Figure 4.7 Depth of Phreatic Aquifer in Malappuram District *(**Source**: Aquifer mapping and management of groundwater resources, CGWB, 2022)*

4.5.1 Phreatic aquifer – I (Shallow Aquifer System)

It is made up of laterite/coastal alluvium, weathered and partially weathered crystalline rocks, and sandstone. The depth of weathering in Charnockite and Gneiss varies greatly due to mineralogical composition. The gneissic rock exposed in the district's eastern section has deeply weathered zones down to a depth of 33 m. Charnockite exposed in the central and western parts contains a shallow weathered zone down to a depth of 24 m. Laterite, in conjunction with alluvium, forms the phreatic aquifer, with thicknesses ranging from 12 to 33 m. Laterite thickness naturally increases towards the north, reaching a maximum at the Nilambur-Munderi section.

The depth of dug wells generally ranges from 7 to 22 m bgl, and the depth to water level generally ranges from 1.96 to 18.54 m bgl during the pre-monsoon and 0.88 to 16.52 m bgl during the post-monsoon period. The wells located in this zone yield groundwater in the order of 30 to 300 LPM in laterite and 50 to 400 LPM in alluvium for one to five hours of pumping.

4.5.2 Aquifer parameters – Phreatic aquifer

The Central Ground Water Board (CGWB) calculated the aquifer characteristics of alluvial and lateritic aquifers by pumping tests at a few places, which are mentioned again in this report. The coastal alluvium is the most promising aquifer, and it is being exploited using dug and filter point wells. This aquifer's yield potential ranges from 50 to 400 LPM for a maximum of five hours of pumping. A limited pumping test was carried out in an alluvial region. It demonstrates that with a pumping discharge of 60 to 360 LPM with a duration of 30 m, the measured drawdown ranged from 0.54 to 3.32 m.

4.5.3 Groundwater level

Pre-monsoon depth to water level

The pre-monsoon depth to water level ranges from 1.84 to 19.54 m bgl at the Ponnani, Purathur, Chemaravattom, and Anjuvadi wells in the coastal area of Ponnani, Tannur, and Tirur blocks. Deeper depths to sea level in excess of 10 m bgl were measured at many localities, including Akkaparambu (10.17 m bgl), Karipol (10.72 m bgl), Edappal (13.63 m bgl), and Karunechi (19.54 m bgl). Water levels vary from 0 to 2 m bgl in around 1% of the research area, 2 to 5 m bgl in 22%, 5 to 10 m bgl in 53%, 10 to 20 m bgl in 23% and >20 m bgl in 1%. The majority of the district has water levels in the 5 to 10 m bgl range, which is observed in the northern, central, and northwestern parts, followed by water levels in the 10 to 20 m bgl range, which covers approximately 76% of the region.

Post-monsoon depth to water level

The range of the post-monsoon water's depth at this time is 0.88 m bgl to 16.52 m bgl. Thiruvali (0.88 m bgl), Chamravattom (1.00 m bgl), and Vettom (1.69 m bgl) are only a few of the wells in the Ponnani, Tannur, and Tirur blocks that have shallow water levels. More than 10 m bgl of deeper water were seen in Kadambuzha (10.34 m bgl), Karumbil (12.03 m bgl), Edappal (13.05 m bgl), and Karunechi (16.52 m bgl). A little over 12% of the region has water levels between 0 and 2 m bgl, whereas just above 2 and 5 m bgl make up roughly 27%. 14% of the area has water levels more than or equal to 20 m bgl. The majority of the study area's water levels are between 2 and 5 m bgl in the northeastern and eastern parts and from 5 to 10 m bgl in the south, central, north, and northwestern parts.

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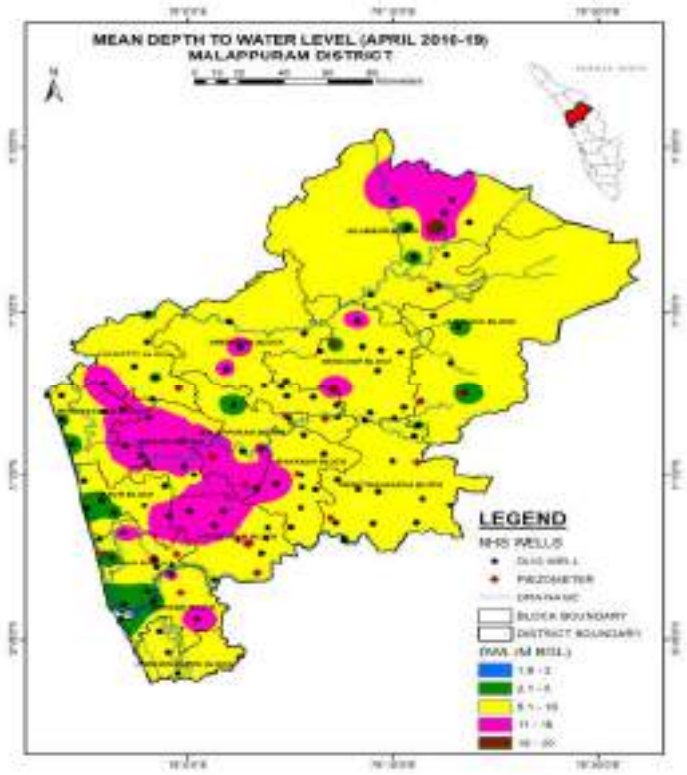

Figure 4.8: Mean pre-monsoon depth to water level map ***(Source****: Aquifer mapping and management of groundwater resources, CGWB, 2022)*

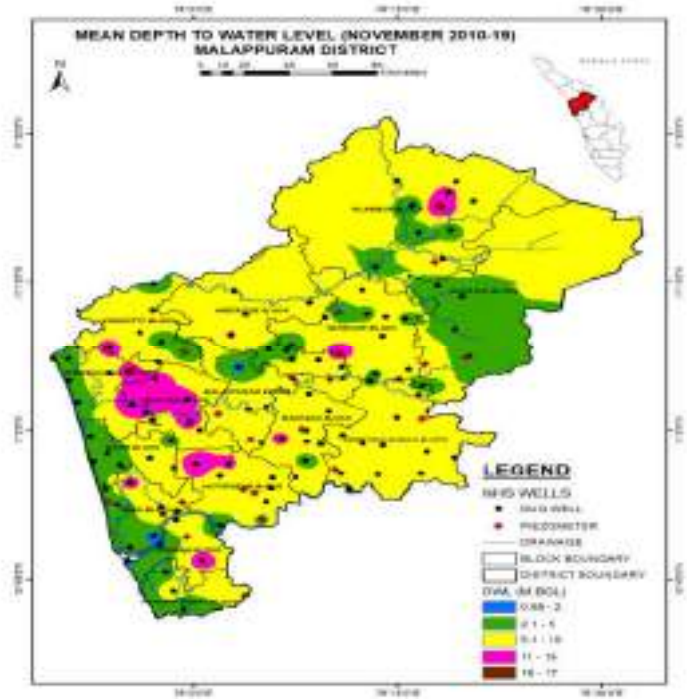

Figure 4.9: Mean post-monsoon depth to water level map ***(Source****: Aquifer mapping and management of groundwater resources, CGWB, 2022)*

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4.5.4 Water level fluctuation

The overall volumetric change in the storage of an aquifer may be determined by the variation in water level between the pre and post-monsoon periods. Planning for sustainable groundwater development must consider the net change in groundwater storage throughout the period as a result of recharge and discharge components. **Figure 4.10** shows the water level fluctuation map (Apr vs. Nov) in the Malappuram district.

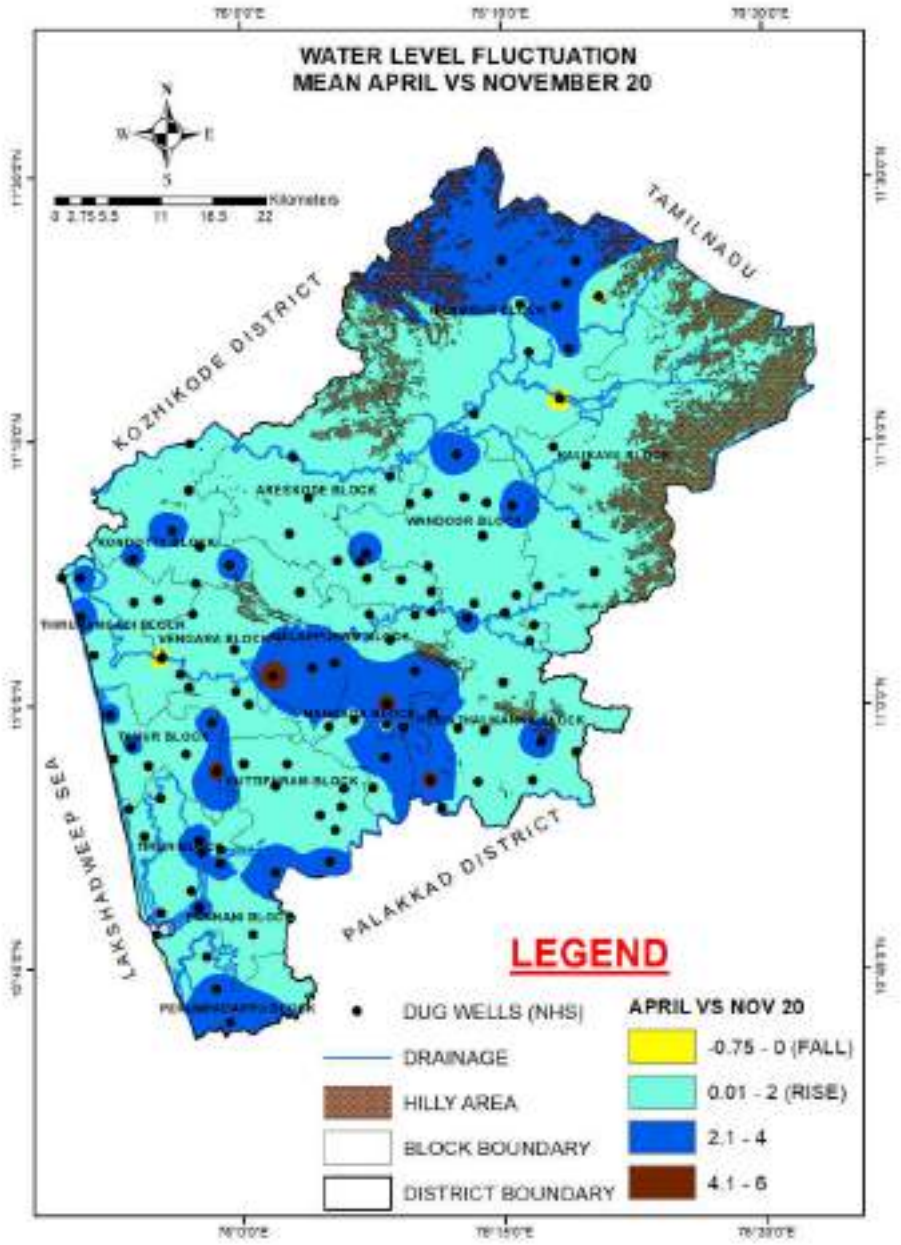

Figure 4.10: Water level fluctuation map (Apr vs Nov) Malappuram district ***(Source****: Aquifer mapping and management of groundwater resources, CGWB, 2022)*

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4.5.5 Water table elevation

The water table contour for the phreatic aquifer has been constructed by CGWB in order to determine the groundwater flow behaviour in both the high and midland zones. The water table contour map for the Malappuram district was created using pre-monsoon water level data to indicate flow direction. It reveals that the water table contour follows the terrain in mid and low-land areas. The groundwater table map of the Malappuram district is shown in **Figure 4.11**

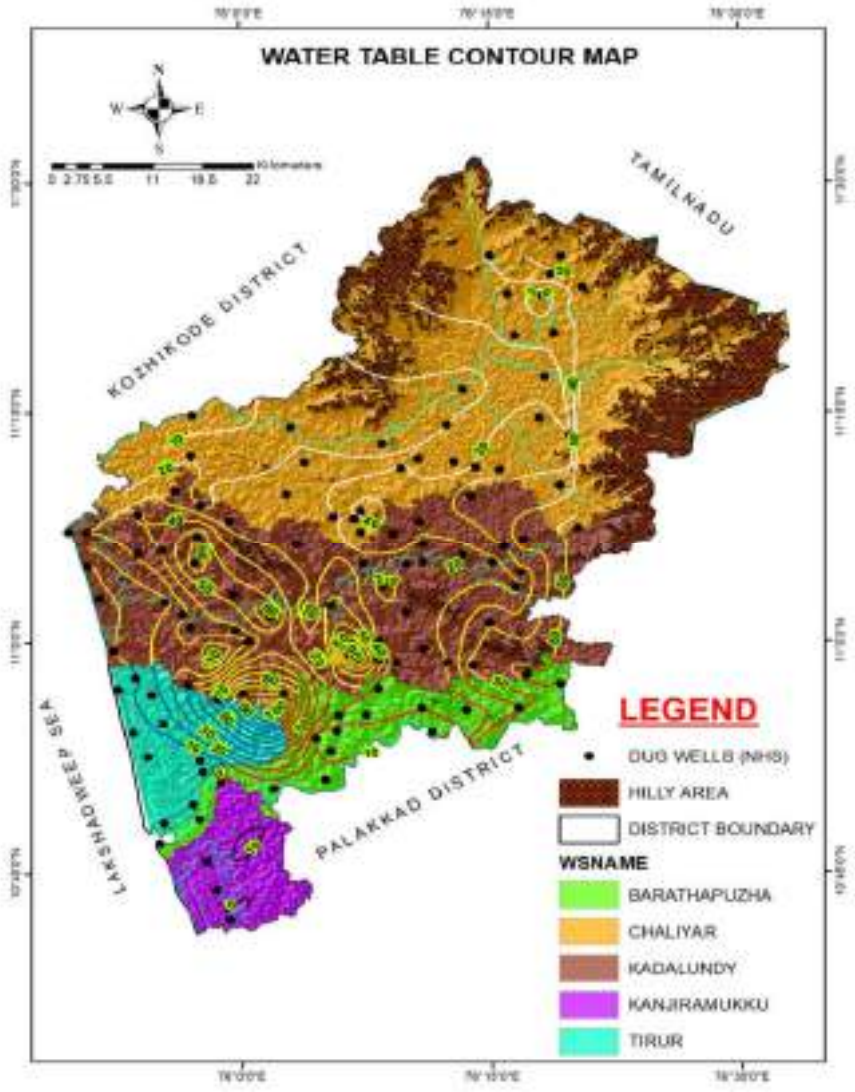


Figure 4.11 Groundwater table map of Malappuram district *(**Source**: Aquifer mapping and management of groundwater resources, CGWB, 2022)*

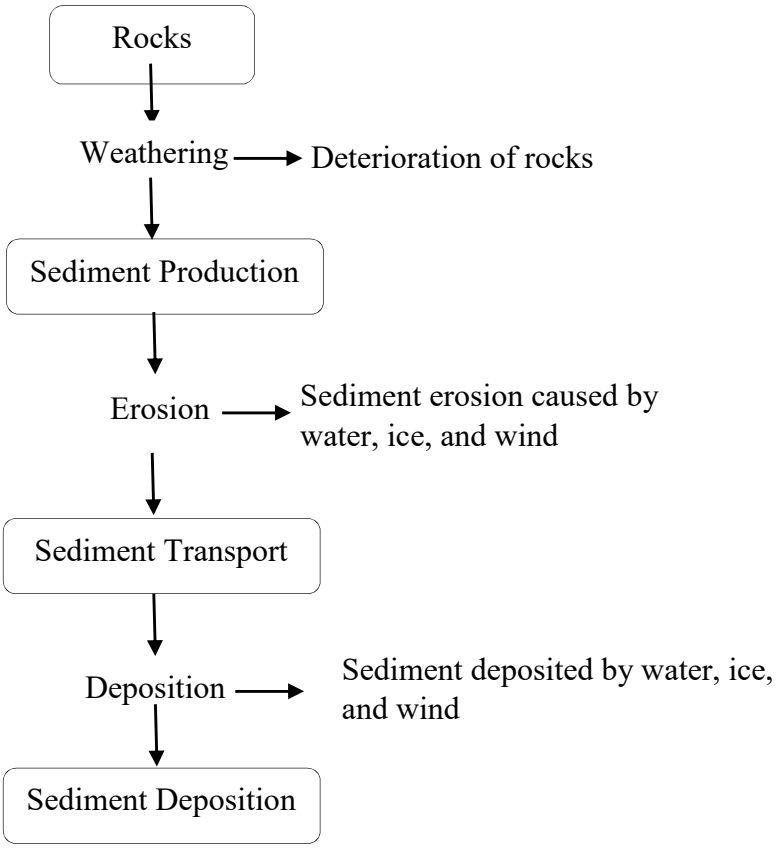
The water table contour agrees with the hydrological border with a gradual slope across the Chaliyar water shed/sub-basin. In contrast, the water table contour established across the middle and southern sections of the region reveals a tiny peak with steep slopes, and it shows that groundwater drains more easily towards the valley in the centre and southern parts of the valley than in the northern section.

CHAPTER – 5

WATERSHED ANALYSIS AND REPLENISHMENT STUDIES

5.0 Process of deposition of sediments in the rivers of the district

Sediment is a naturally occurring substance that is broken down by weathering action and is eroded by the action of wind, water, or both or moved by the force of gravity. Sediment in an aquatic environment could be bedded or float. The transport of sediment is based on its own size, volume, density, and shape, as well as the power of the flow that propels it. Larger or denser particles will have a higher likelihood of falling through the flow, while stronger flows will increase the lift and drag on the particle, forcing it to ascend. Previously eroded silt is carried by wind, ice, and water as well as it flows due to gravity. Among them, water is the most common mode of movement for sediments. Sediment transport describes the movement of organic and inorganic particles through the water. A higher flow will often deliver more sediment. Particles can be suspended in the water column as they move downstream or pushed down the bottom of a river by sufficiently strong water flow. Transported sediment contains a variety of elements, including minerals, pollutants, and organic materials.



Material that is being transported by a river is deposited during the deposition process. The geological process of deposition involves the addition of sediments, soil, and rocks to a landform or land mass. Sediment deposition is the process through which floating particles

settle to the bottom of a body of water. Heavy particles that were previously supported by the bed turbulence begin to settle when water flow is reduced or halted. Sediment deposition can be observed anywhere in a water system, including high mountain streams, rivers, lakes, deltas, and floodplains. Excessive or insufficient sediment deposition can have negative effects on the environment. Layers of sediment accumulate along the floodplain following a succession of floods. This could happen when a river floods and enters the flood plain, or it could happen near the river's mouth as it empties into another body of water. When enough kinetic energy in the fluid is lost, the sediment is deposited, and layers of sediment are created. The term "floodplain" refers to the territory over which they flood, and it frequently corresponds with areas where meanders develop. Meanders aid in the lateral erosion that creates floodplains. The flow of water slows down as rivers flood. As a result, the river's ability to move materials is diminished, and deposition takes place. The entire floodplain is covered in a layer of sediment as a result of this deposition.

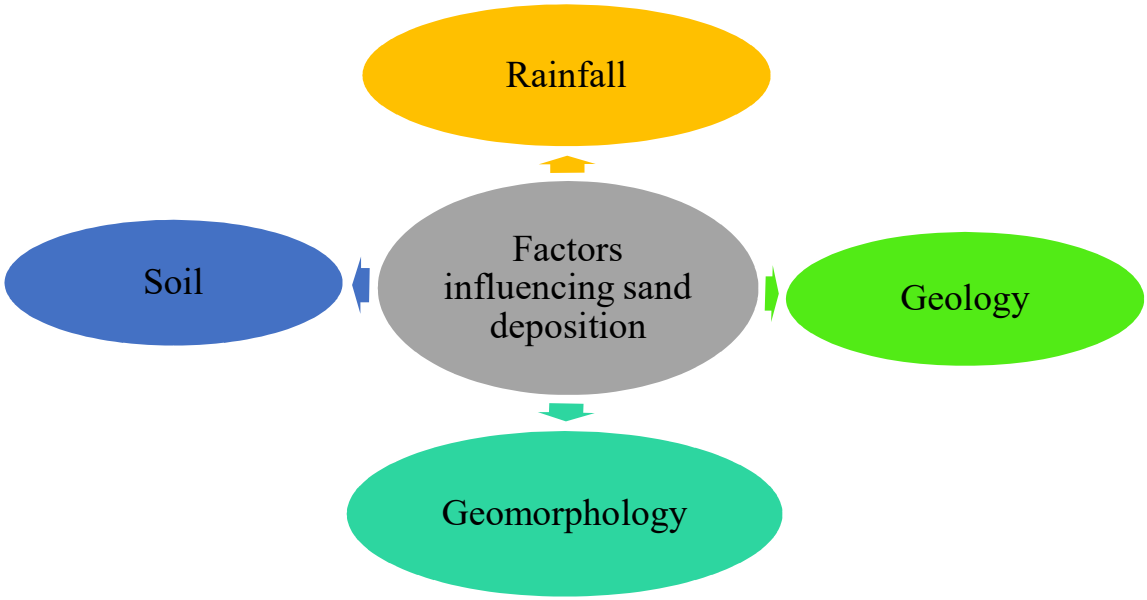


Figure 5.1 Factors influencing sand deposition

The supply, transport, and deposition of sediments are significantly influenced by the geomorphic characteristics of the landscape. The geography of the area has an impact on sediment movement in addition to wind and rain. The topography that a canal passes through determines how much silt enters the stream and how far it goes. Streams that flow through bedrock are less likely to add to the sediment load since the channel will not quickly erode. The majority of variations in water level are caused by meteorological events such as rainfall. Precipitation causes water levels to increase initially, then fall (base flow) over a period of hours or days. Rainfall, whether light or severe, has the potential to disrupt water flow and sediment transfer. The amount of silt accessible determines how much a meteorological event may affect sediment movement. Heavy rainfall will cause runoff in a region with loose soil and little vegetation, transporting loose particles into the stream. Similarly, floods will pick up silt from the surrounding environment. In Kerala, the average net precipitation and run-off

have an impact on sediment discharge. The amount of sediment produced by rivers varies on the climate, land usage, and underlying bedrock geology. Any region's climate, degree of weathering, soil formation, denudation, and aggradations are all influenced by physiography.

Variations in rainfall are expected to have an impact on the processes of erosion and sediment transport because they are directly related to rainfall. Physiography has a considerable influence on how rainfall is distributed spatially. Runoff and sediment discharge have a positive correlation with rainfall variability. The common form of soil in the district is brown hydromorphic soil, which is found in valley bottoms with undulating terrain and in low-lying areas along the coastal strip. This was created by the movement and sedimentation of debris from nearby hills and slopes, as well as by river deposition. The sedimentary aquifers are exposed along the district's river and coastal tracts, while the hard rock and laterite aquifers make up the district's primary aquifers. The dynamics of sediment transport make it difficult to assess the effect of transport mode and intensity on channel shape as well as the overall denudational output of sediments from the watershed.

Particles that are monitored when they are both floating and settled are known as suspended and bedded sediments. Bed load is the portion of sediment transport that rolls, slides, or bounces down the bottom of a river and occurs when the force of the water flow is powerful enough to overcome the weight and cohesion of the sediment. Transport of beds is possible both at low and high flows, and it accounts for roughly 5-20% of all sediment transfer.

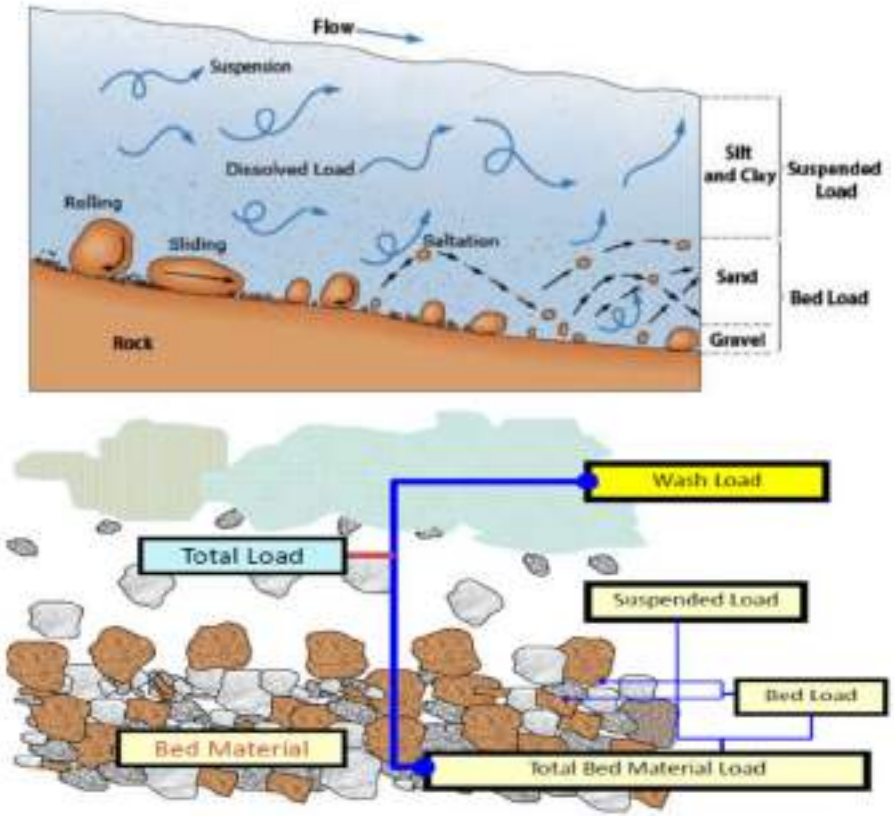


Figure 5.2: Wash load, Suspended load and Bed load

The suspended load is the quantity of sediment that the water flow carries downstream within the water column. Particles that can be transported as suspended load depends on the flow rate. In contrast to the suspended load, which sinks to the bottom of a river when there is little or no flow, the wash load is a subtype of the suspended load. As they are small enough to bounce off water molecules and remain floating, these particles remain suspended permanently. But when there is a water flow, the wash load and suspended load are indistinguishable.

5.1 Salient features of the major rivers

In the context of the comprehensive district survey conducted for sand mining activities in the Malappuram district of Kerala, it becomes imperative to provide an inclusive overview of the aquatic resources within the region. The district encompasses a network of four rivers, namely Bharathapuzha, Chaliyar, Kadalundi and Tirur river each contributing to the hydrological intricacies of the area. However, as per the findings of the meticulous sand auditing executed by the Institute of Land and Disaster Management (ILDM), the presence of sand deposits has been ascertained exclusively in three of these rivers - Bharathapuzha, Chaliyar, Kadalundi. Visual interpretation carried out on high resolution earth viewer software's like google earth pro also confirms to the findings of ILDM. To substantiate and as add-on, a visual survey was also carried out to see any visible signs of sand availability on river stretches. Figure 5.3 shows snap shots of river Tirur. The snaps reveal that spatial extents of rivers are mostly covered with water and mixed vegetation with no signs of mineable sand.

Figure 5.3 Snap of Tirur-Ponani River flowing through Malappuram district

In view of the above, it is pertinent to acknowledge that this report is thereby focused solely on the aforementioned rivers, where viable sand resources have been identified, and intends to offer a comprehensive analysis of their current state, potential impacts of sand mining, and sustainable management strategies. By constraining the study to these specific rivers, the report endeavours to furnish a detailed, scientifically grounded assessment and replenishment studies that will pave the way for sustainable mining in the river stretches under consideration.

5.1.1 Chaliyar River

Chaliyar is one of the major rivers in Kerala, with a length of 169 km, and it is ranked as the fourth longest river in Kerala. The drainage area of the Chaliyar River is 2,923 km^2, of which 2,535 km^2 are in Kerala and the remaining in Tamil Nadu. The catchment area for the Chaliyar River is situated in Kozhikode, Malappuram, and Wayanad Districts and lies between latitudes 11° 05' to 11° 40' North and longitudes 75° 35' to 76° 45' East. In the north, it is bordered by the taluks of Kozhikode and Koyilandi in the Kozhikode district, in the south by the taluks of Perithalmanna and Tirur in the Malappuram district, in the east by Tamil Nadu, and in the west by the Arabian Sea. The river empties into the Lakshadweep Sea at an "azhi" (estuary), of which the southern portion is called Chaliyam and the northern portion is called Beypore. Some of the towns/villages located along the banks of Chaliyar include Nilambur, Edavanna, Areacode, Keezhuparamba, Cheruvadi, Mavoor, Peruvayal, Feroke, and Beypore.

The Chaliyar River rises at Elambalari hills in Kerala's Wayanad plateau's western ghats range, flows through Malappuram district for the majority of its length, then forms the border between Malappuram district and Kozhikode district for about 17 km before entering the city of Kozhikode for its final 10 km before emptying into the Lakshadweep Sea. The drainage system for the Chaliyar River is comprised of five principal streams: Punnapuzha, Kanjirapuzha, Karimpuzha, Iruvahnipuzha, and Cherupuzha. In addition, Kurumanpuzha, Pandipuzha, Maradipuzha, Kuthirapuzha, and Karakkodupuzha are significant tributaries. Some of these tributaries come from Wayanad and join Chaliyar in Malappuram. The majority of these rivers originate in the Wayanad and Nilgiri highlands in the north and east, respectively, where they create numerous waterfalls and rapids.

Geology

Geologically the Chaliyar river basin is characterized by charnockite and Hornblendes genesis. The main source of gold and a major contributor to the alluvial placer gold deposit in the Nilambur valley are quartz veins in the Chaliyar river basin. The Chaliyar river basin is defined geologically by pre-Cambrian charnockites, metapelites, schists, gneisses, quartz reefs, Pleistocene laterites, and recent to sub-recent alluvial deposits. Laterites emerge as a residual deposit as a result of the tropical weathering of crystalline rocks, capping over earlier strata. Laterites can be found as primary (in situ) or secondary (transported) material. They are seen as uneven patches ranging in thickness from one geomorphic unit to the next.

Coastal sand, river alluvium, and valley fill are examples of recent alluvial formations. These are made up of fine to medium-grained sand.

Geomorphology

The Chaliyar drainage basin geomorphologically contains parts of diverse provinces such as the Wayanad plateau and the Nilgiri hills at higher altitudes, the Nilambur valley forming the slopes of the foothills and lowlands surrounding the Chaliyar River's main stem. Beyond 110 km from the source, the geomorphology of the Chaliyar main channel changes abruptly in the downstream direction. The channel makes a severe turn around 110 km, after which the river meanders at regular intervals. The geography of the Chaliyar basin is undulating with a sharp slope. The basin has been divided into lowland (sections of the lower plateau), floodplain, intermediate upland, and residual highland regions. The coastal region and its surroundings are represented by the floodplain areas. The two main types of soil in this area are flood alluvium and coastal alluvium, both of which are fertile. These types of soils contain the majority of the monsoon trees. The region enclosing the Chaliyar riverbanks or revering areas makes up the lower plateau regions. These areas were created by the flooding action of the Chaliyar River and its tributaries. Hard rock fills the upland part of the midland, which mainly consists of laterite. However, the midland region does have sporadic tiny hillocks that are 100 to 500 m above MSL. Hard laterite covers these little hillocks, which have sparse flora. The residual hills and highlands are located at an elevation of 500 metres or above mean sea level. It is determined that around 65% of the region is within the 100-meter MSL ground elevation range.

Socio-economic characteristics of the basin

The upper section of the river is inhabited by a variety of tiny hills, woodlands, rivers and streams flowing to the west and backwaters. It also has a lot of animals. Paddy, arecanut, cashew, pepper, ginger, pulses, coconut, banana, tapioca, and rubber plantations, among other crops, are grown along the riverbank. Because of this, the majority of people who live close to the river depend on agriculture for their living. In the deep trenches of the river upstream, numerous native fish species can be found. With up to 66 species, the Chaliyar River system was found to have the largest fish diversity, accounting for 92% of the primary freshwater fish diversity of the world.

5.1.2 Kadalundi River

The Kadalundi River is a rain-fed river that runs for 130 kilometres (81 miles) and is one of the most important rivers that flow through the Malappuram district. The river rises in the Western Ghats at the western end of Silent Valley in the Palakkad district and flows primarily east to west across virtually the whole Malappuram district. But when the river gets close to Palathingal (11°02'16.90"N, 75°52'38.50"E), the trend in that direction shifts. The river then resumed flowing north before diverting to the west, and a significant river distributary began to flow southward at that time. The distributary is called "Poora Puzha" and is around 8 kilometres long. It merges with the Lakshadweep Sea near Ottumpuram, 12 kilometres south of the mother river's mouth. It has the Olipuzha and Veliyar as its two

principal tributaries. The 120 km long Kadalundi River drains a region with a surface area of 1274 km^2.

The Kadalundi River rises in the river basin's eastern region, runs westward toward the Chaliyar and then merges with the Arabian Sea about 5 kilometres south of the Chaliyar's river mouth. The districts of Malappuram, Palakkad, and Kozhikode in Kerala state make up the watershed for the Kadalundi River, which is located between 10° 55' and 11° 15' North Latitudes and 75°45' to 76° 30' East Longitudes. It is bordered by the Malappuram district's Ernad taluk in the north, the Malappuram district's Tirur and Perinthalmanna taluk in the south, the Malappuram district's Mannarkad taluk in the east, and the Arabian Sea in the west.

Geology

Achaean formation is the primary geological formation in the river basin. The main types of rock in the upper part of the river basin include hornblende gneiss, hornblende-biotite and quartz mica gneiss of the migmatite complex, hornblende gneiss, hornblende-biotite and quartzite of the charnockite group, and biotite-hornblende gneiss. Pyroxene granulite, charnockite group quartz-feldspar-hyprerathene granulite, laterite, and pink granite gneiss are the main rock types in the middle region. Coastal sand, alluvium, laterite, and quartz-feldspar-hypersthene granulite of the Charnockite group make up the lower section.

Water resources

The Kadalundi River has a perennial nature. The main tributaries of the west flowing Kadalundi river are the Velli and Olipuzha. Other tributaries include the Purapparamba, the Panampuzha, the Arimbra, the Valiya, the Puchham, the Mankada, the Kakka, the Puliyan, the Palakkazhipuzha, the Maleriyam, and the Vachakayan.

5.1.3 Bharathapuzha River

Bharathapuzha often referred to as the Nila, is a river in Kerala, India. After Periyar, it is the second-longest river in Kerala. Even though Bharathapuzha has a total length of 209 km, 41 km of that distance travels along Tamil Nadu, from where it starts. Nila has cultivated Kerala's south Malabar region's culture and way of life. In ancient writings and texts, it is also known as "Peraar." The Anaimalai Hills (10°36′N, 77°07′E) in the Western Ghats are the source of the primary tributary of Bharathapuzha, which runs westward via Palakkad gap, across Palakkad, Thrissur, and Malappuram districts of Kerala, with many tributaries joining it, including the Tirur River. The river's overall basin area is 6186 km^2, with Kerala accounting for little more than two-thirds (4400 km^2) (71%) and Tamil Nadu accounting for the remaining 29% (1786 km^2). The Bharathapuzha River is heavily dammed, with six reservoirs along its course and two more under construction. The Malampuzha Dam is the largest of the dams in the Bharathapuzha basin, which also contains the walayar dam, Mangalam dam, pothundi dam, meenkara dam, chuliyar dam, and kanhirappuzha. The Bharathapuzha is the lifeline of several cities and villages in Kerala's Malappuram district.

5.2 Drainage system with a description of main rivers

According to the Digital Elevation Model (DEM) for the area, as shown in Figure 5.4, the western to the central section of the study area is inhabited by plateaus and flat-topped hills, while the eastern to south-eastern half is characterized by very rocky terrain with multiple peaks. The overall slope is westward. The major rivers and their drainage details within the district are shown in **Table 5.1** and **Table 5.2**, respectively.

Table 5.1 Drainage details of major rivers

Sl No	Name of the River	Area drained (km^2)	% Area drained in the district
1	Chaliyar	2923	Combinedly in Malappuram & Kozhikode
2	Kadalundippuzha	1100	Combinedly in Malappuram & Palakkad
3	Bharathapuzha	6253	9
4	Tirurpuzha	117	100

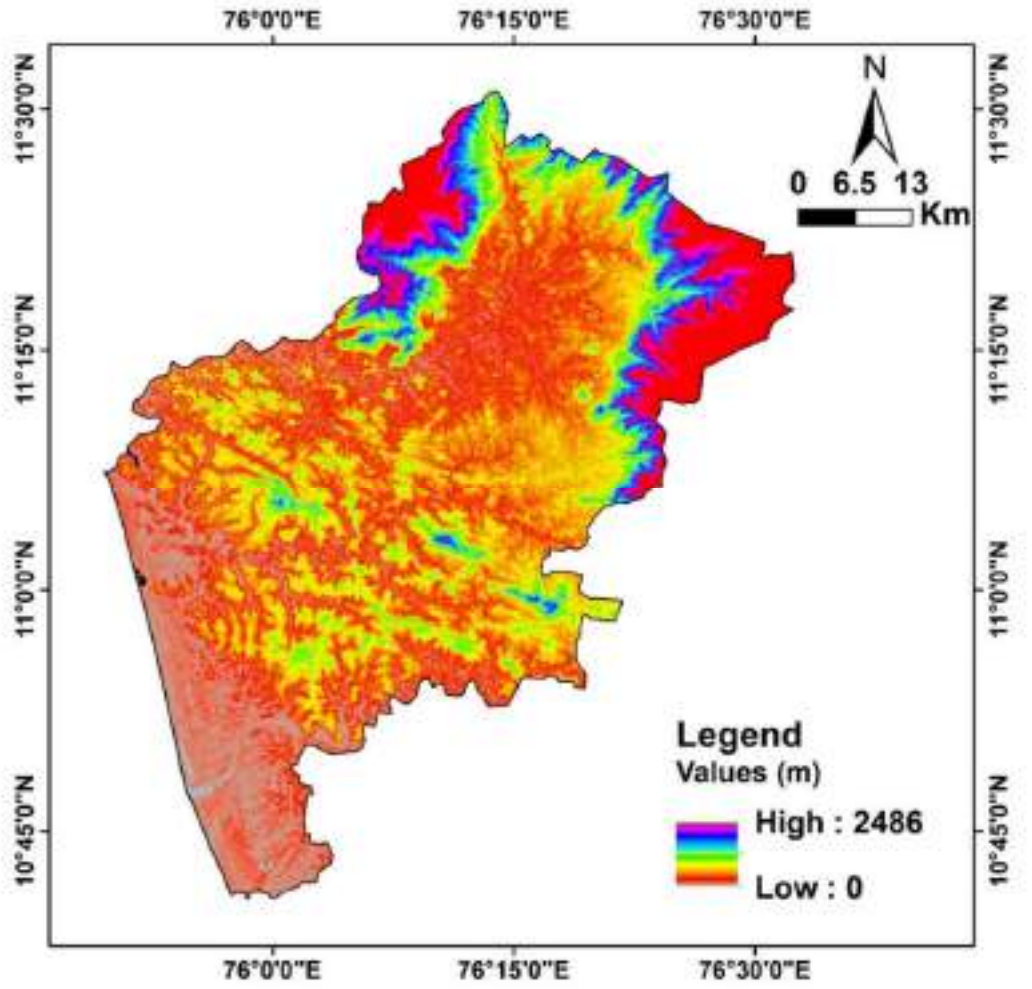


Figure 5.4: Digital Elevation Model of Malappuram district

Table 5.2: Salient features of important rivers and streams

Sl No	Name of the river or stream	Total length in the district (in km)	Place of origin	Altitude at origin
1	Chaliyar	169 (Malappuram and Kozhikode)	Elambalari hills	2067
2	Kadalundippuzha	130 (Palakkad and Malappuram)	Cheerakkombanmala	1160
3	Bharathapuzha	22.7	Anaimalai hills	1964
4	Tirurpuzha	48	Athavanad	86

The watershed areas delineating the major rivers, basins and streams in the district are prepared and provided in **Figure 5.5**, **Figure 5.6** and **Figure 5.7**, which have prominent significance to the ecosystem while preserving a catchment's soil, plant, and water resources. A watershed's surface water features and stormwater runoff eventually flow to other bodies of water. When creating and executing water quality protection and restoration initiatives, it is critical to consider these downstream consequences.

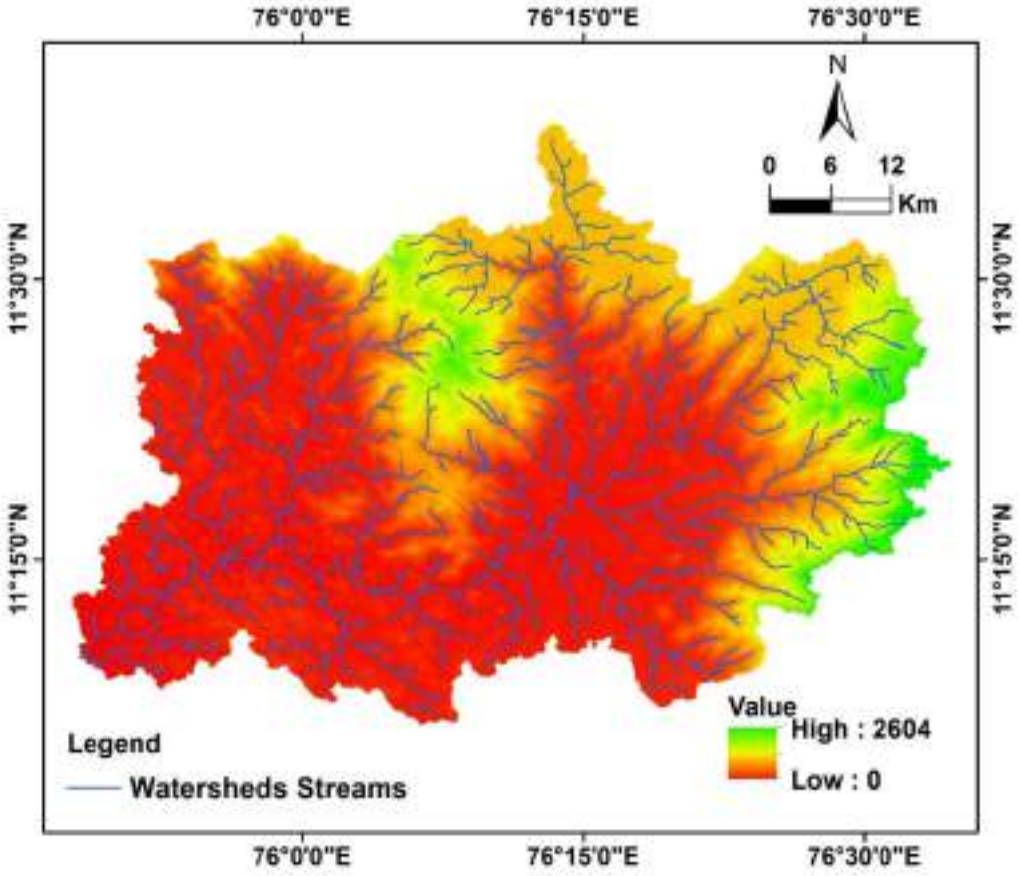


Figure 5.5: Drainage map of Chaliyar basin

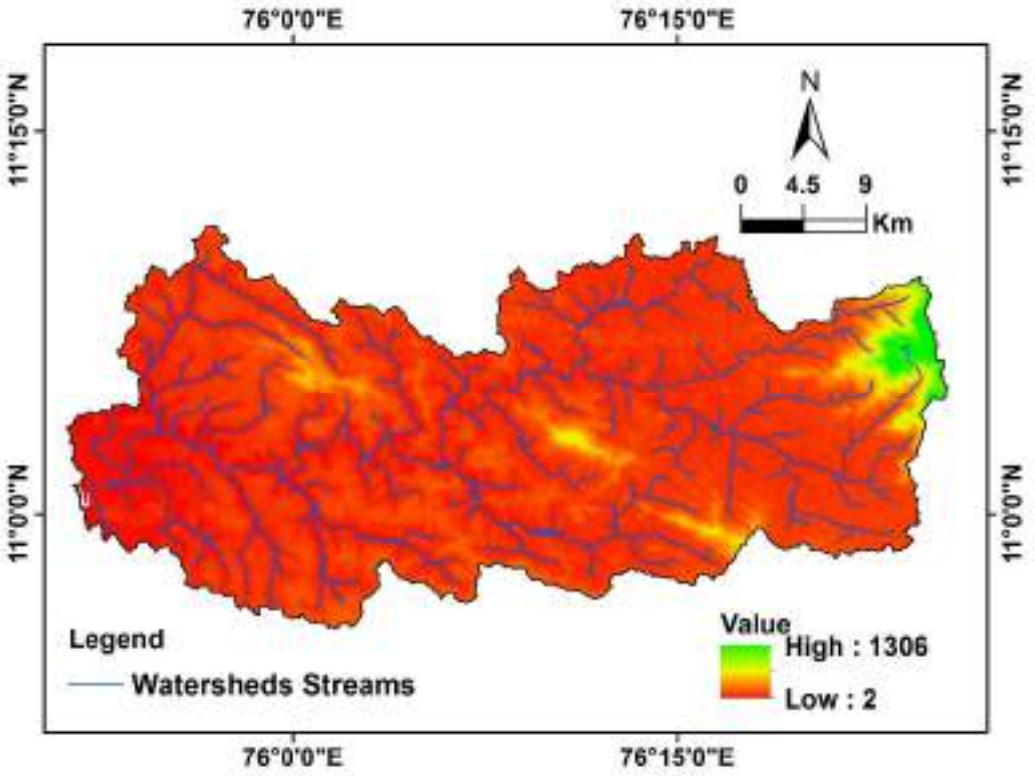


Figure 5.6: Drainage map of Kadalundi basin

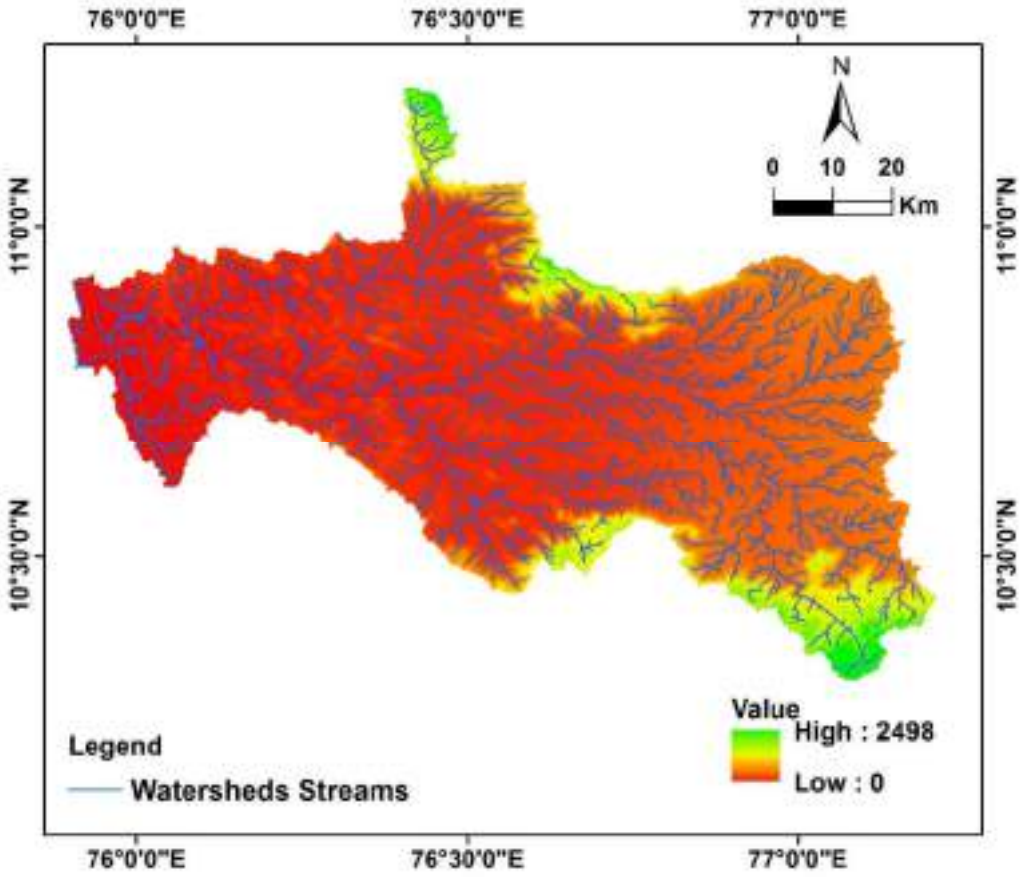
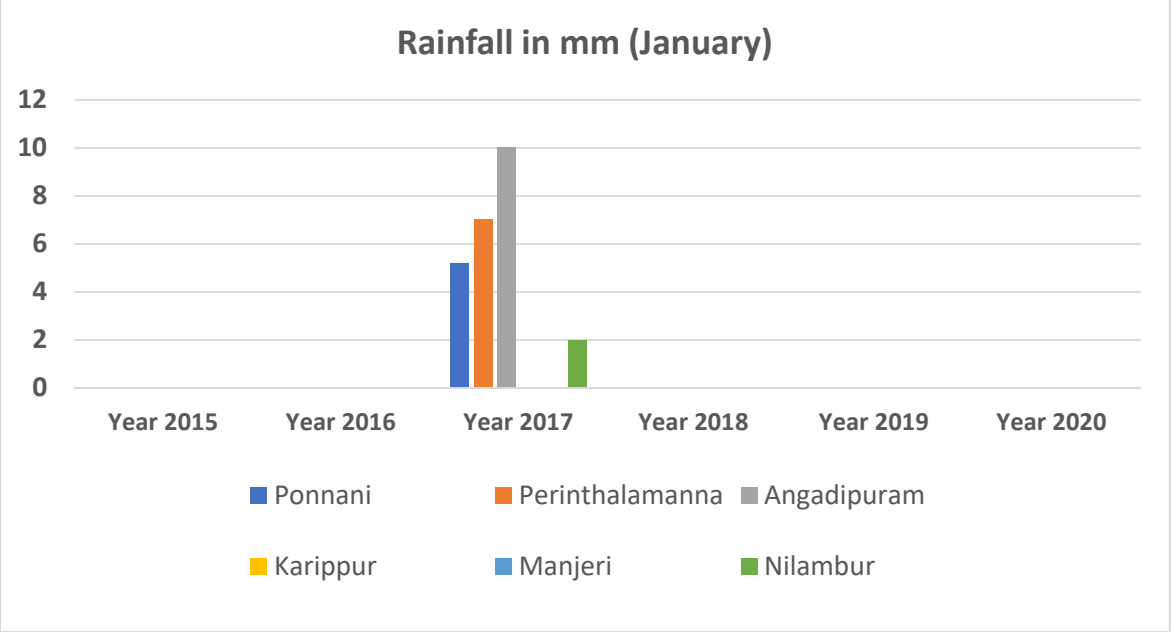


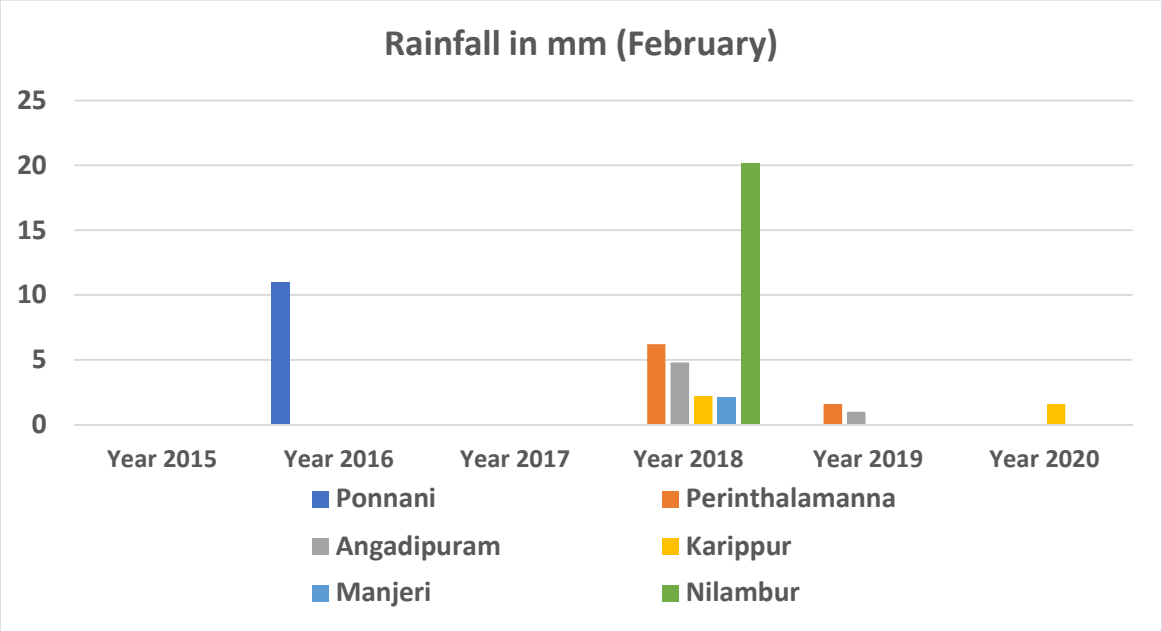
Figure 5.7: Drainage map of Bharathapuzha basin

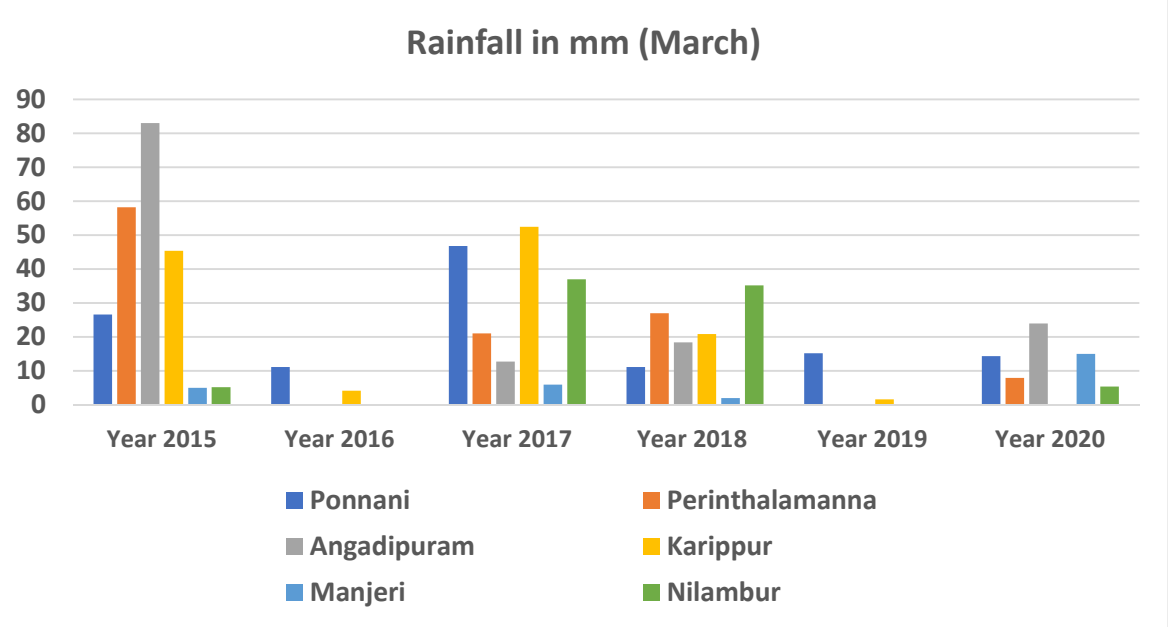
5.3 Climate & Rainfall

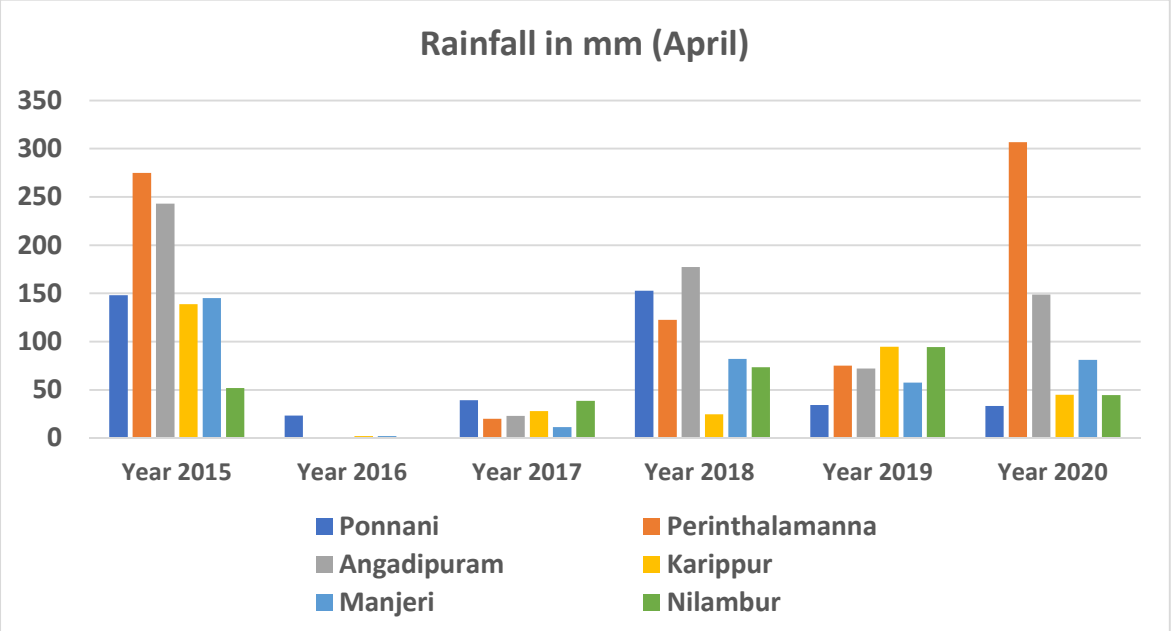
The district experiences roughly the same climatic conditions as the rest of the state, including the south-west monsoon from June to September, the north-east monsoon from October to November, the dry season from December to February and the hot season from March to May. The district has a hot and humid climate, with maximum temperatures ranging from 28.9ºC to 36.20ºC and lowest temperatures ranging from 17.40ºC to 23.40ºC. The warmest months are March and April, while the coldest months are January and February. Temperatures begin to rise in January, peak in March and April, and then fall during the monsoon season. During the early hours, the relative humidity ranges from 84% to 94%. The humidity is higher during the monsoon season, which lasts from June to September. The wind blows primarily from the east in the morning and from the west in the evening.

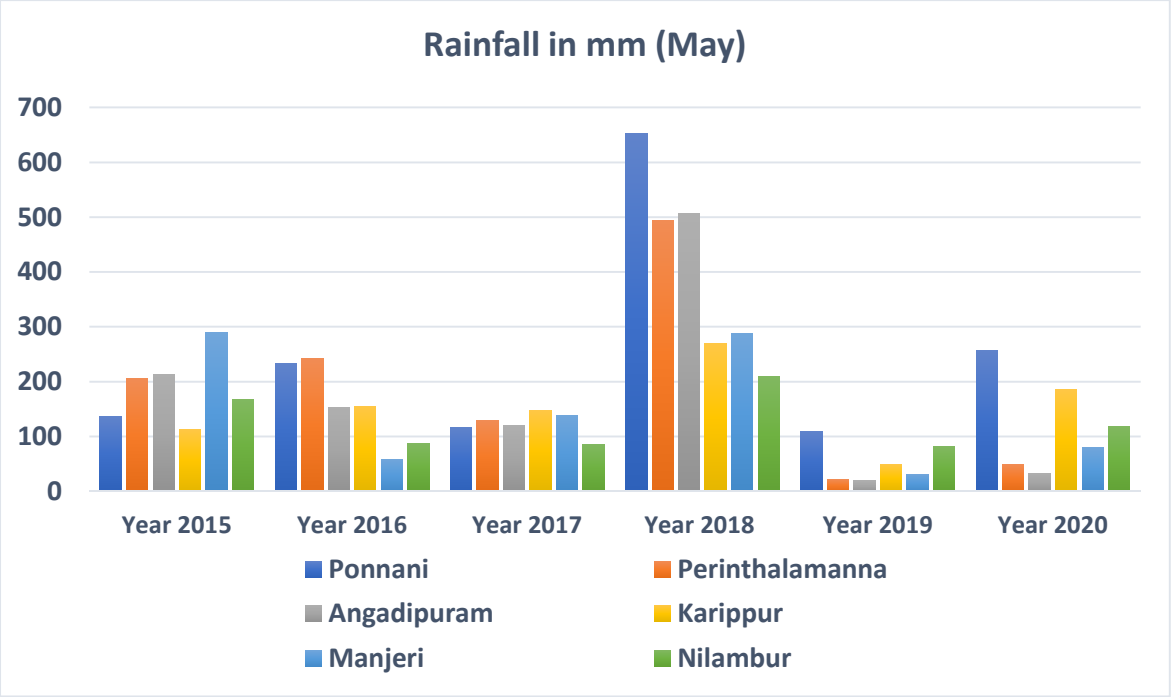
The average annual rainfall in the district is around 2793.3 mm. Out of these, the SW monsoon contributes the most rainfall, followed by the NE monsoon. Southwest monsoon receives more than 68.5% of annual rainfall. The contributions from the NE monsoon and the summer rains from March to May are almost 16.4% and nearly 9.9%, respectively. The remaining 0.2% is accounted for in the months of January and February. *(Source: IMD data supply portal).* The monthly variation of rainfall in mm for six stations in the district from the year 2015-2020 is represented in **Figure 5.8.**

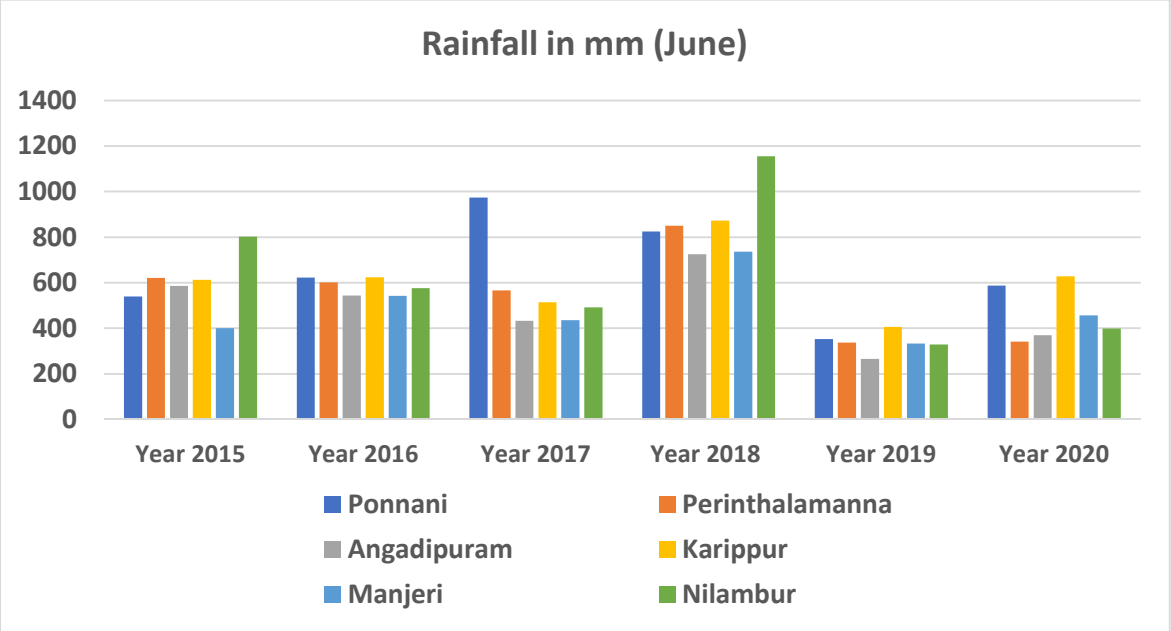


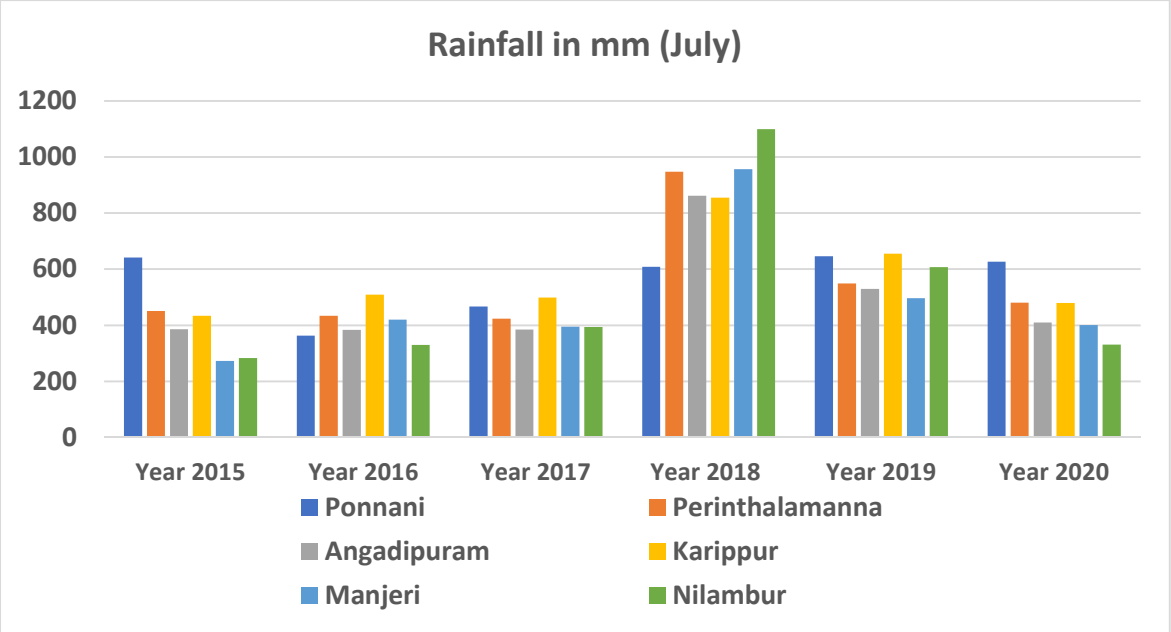

Rainfall in mm (February)
25
20
15
10
5
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur

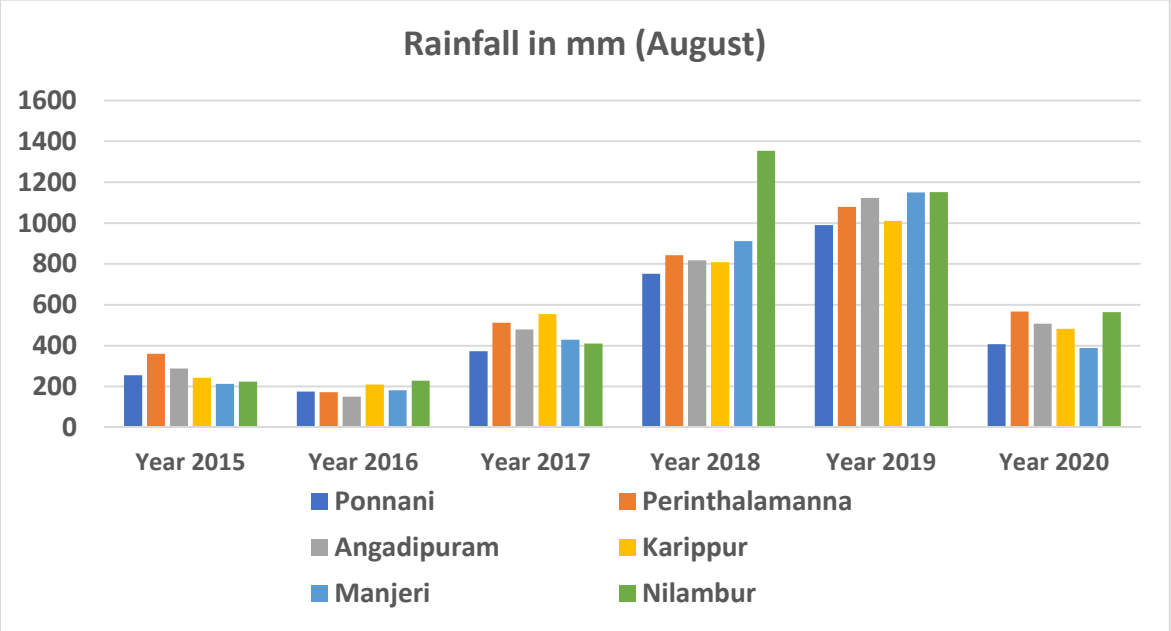

Rainfall in mm (March)
90
80
70
60
50
40
30
20
10
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur

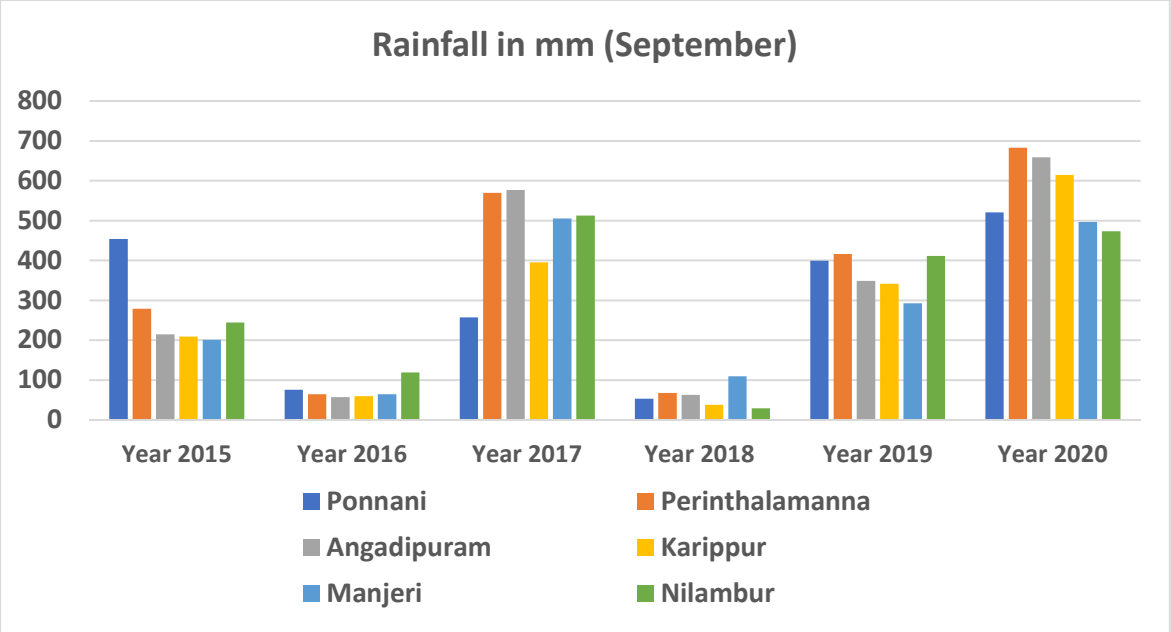

Rainfall in mm (April)
350
300
250
200
150
100
50
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur

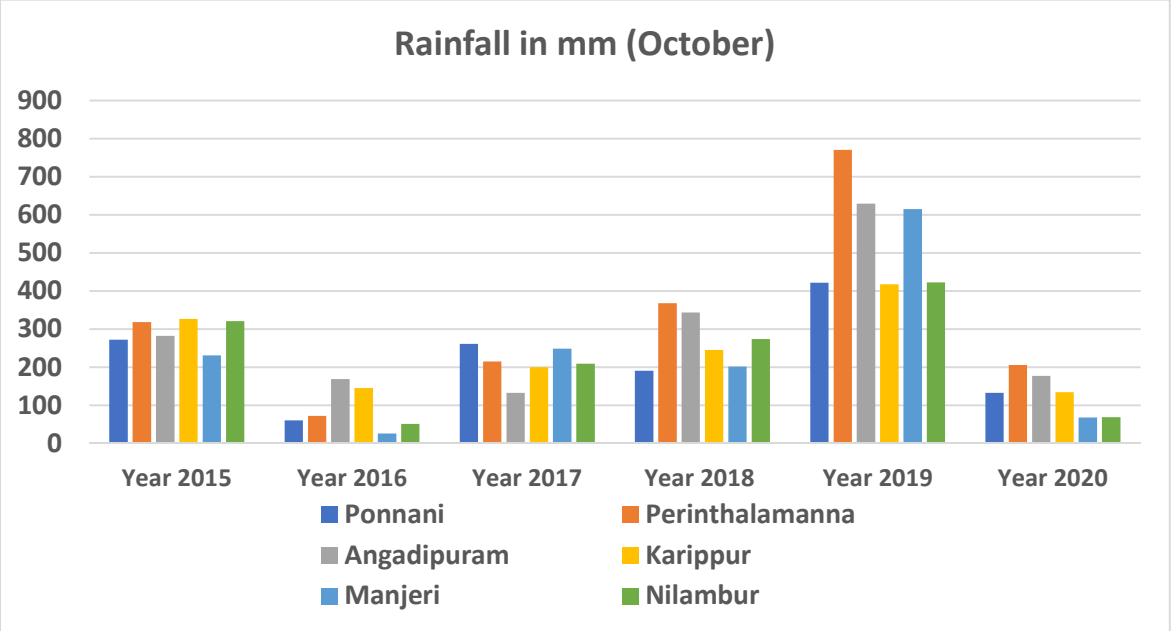

Rainfall in mm (May)
700
600
500
400
300
200
100
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur

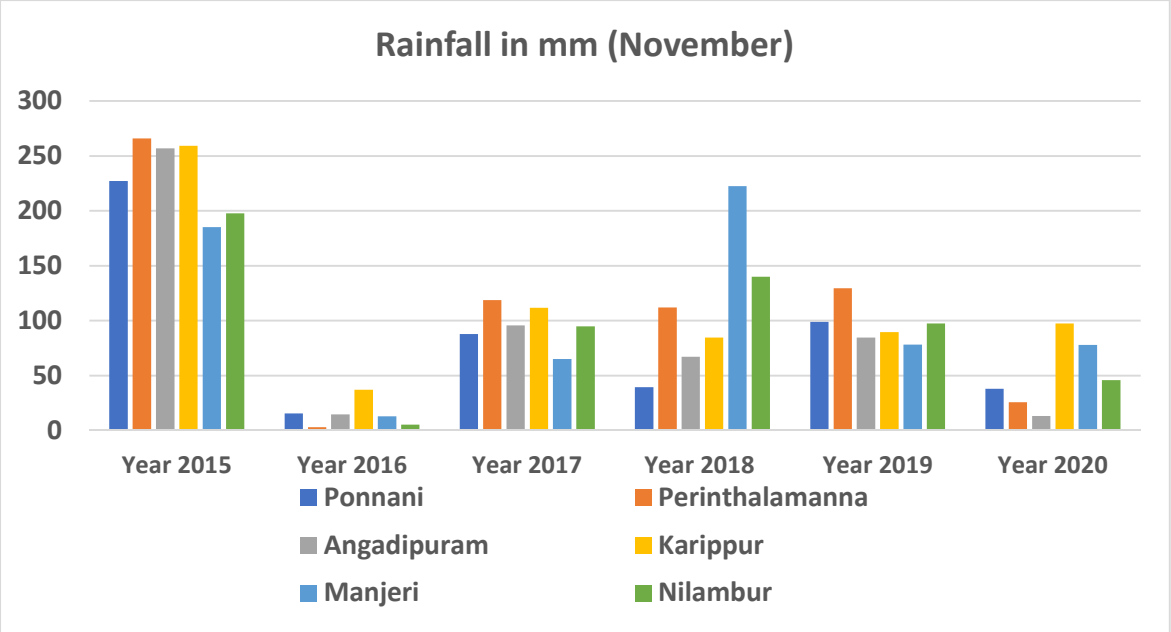

Rainfall in mm (June)
1400
1200
1000
800
600
400
200
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur


Rainfall in mm (July)
1200
1000
800
600
400
200
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur


Rainfall in mm (August)
1600
1400
1200
1000
800
600
400
200
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur


Rainfall in mm (September)
800
700
600
500
400
300
200
100
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur


Rainfall in mm (October)
900
800
700
600
500
400
300
200
100
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur


Rainfall in mm (November)
300
250
200
150
100
50
0
Year 2015
Year 2016
Year 2017
Year 2018
Year 2019
Year 2020
Ponnani
Perinthalamanna
Angadipuram
Karippur
Manjeri
Nilambur

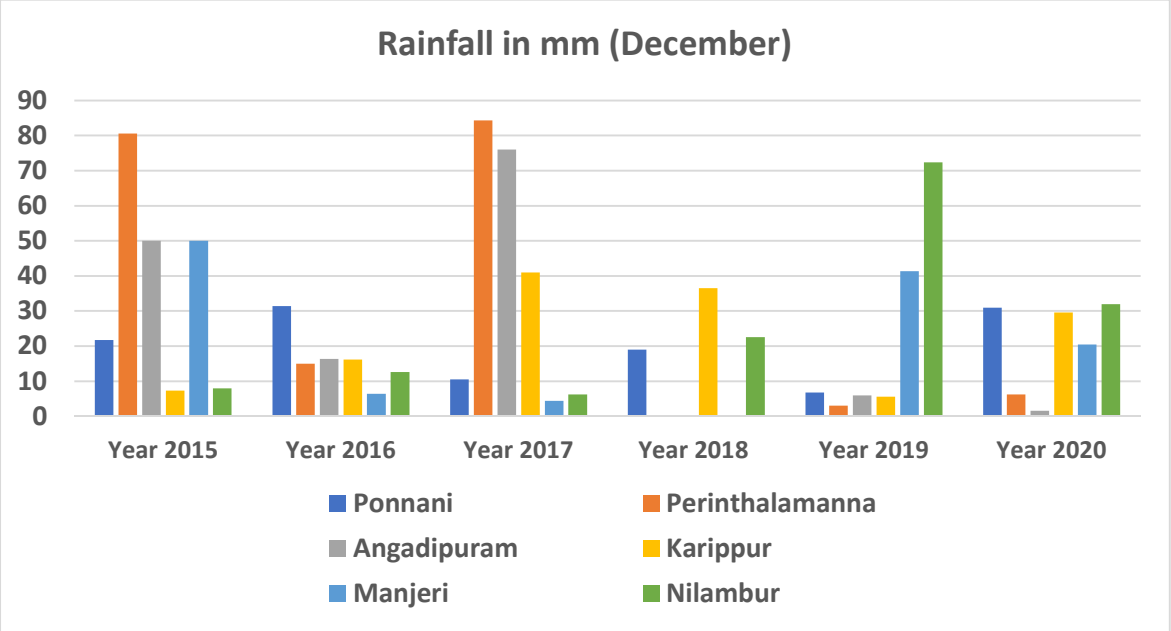


Figure 5.8: Variation of annual rainfall in Malappuram district (2015-2020)

5.4 Riverbank delineation

As per IS: 4410 (Part 3) – 1988, which is the Indian standard code consisting of the glossary of terms relating to river valley projects, the bank of the river is defined as "the elevation of land which confine water of a stream to their natural channel in the normal course of flow; banks are called right and left, as viewed facing downstream".

The handbook for the design of flood protection, anti-erosion measures and river training works prepared by the flood management organization of Central Water Commission, Government of India, shows separate lines representing bank level and Highest Flood Level (HFL) as shown in Figure 5.9 below, the typical cross-section of bank pitching with launching apron (in page number 43 of the handbook).

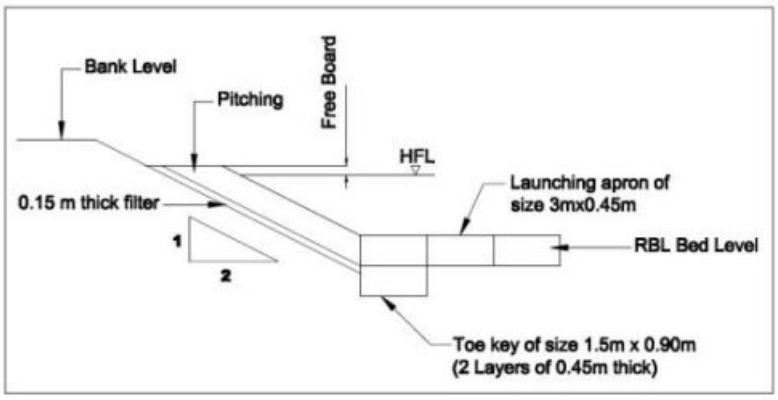


Figure 5.9 Typical cross-section of bank pitching with bank-level and HFL
***Source**: Central water commission, figure 4-10*

As per the references above, we have considered the tip of the riverbank as a point where the ground level changes its topography from horizontal to inclined (starting point of the bank) and the toe of the riverbank as the point representing the end of the bank and starting of the riverbed.

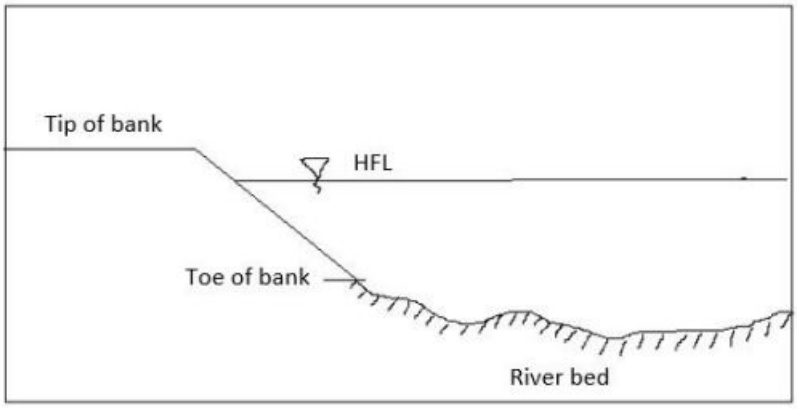


Figure 5.10: Representation of the tip and toe of the bank in a river cross-section

As per our field survey, we have traversed the river and identified the river bank based on changes in the topography. As mentioned above in the figure, a significant change in the topographic levels is considered as the tip of the bank (the highest point at a particular cross-section where topography changes), and the toe is considered a point where the steep slope of the bank started becoming moderate, and this is the area which is typically known as a river bed. Riverbed is an area which typically carries sediments and water in the normal course of time.

5.5 List of potential sand mining sites identified during the field survey

Table 5.3 below shows the list of sand mining sites identified in the Malappuram district based on the field survey conducted. The total Bharathapuzha stretch covered under Malappuram district is 22.7 km. As per the administrative boundary, the width of the river is divided in two parts, left bank (when moving from upstream to downstream) falls under Palakkad district while the right bank falls under Malappuram district).

Table 5.3 Details of sand mining sites with area and sand availability

Site no	CS details	Area in Ha*	Total sediment available** (m^3)	Mineable sand available (m^3)	Mineable sand (Tonnes)	Transportation route/Nearest access road
Bharathapuzha River stretch						
S-1	CS 2- 5 RB	7.0777	163465	43670	65505	Towards Irimbiliyam- Valanchery Road
S-2	CS7RB	3.0855	141660	79910	119865	Towards Irimbiliyam- Valanchery Road
S-3	CS 13- 17 RB	10.0938	274630	49340	74010	Towards Perashannur - Valanchery Road
S-4	CS 23- 41 RB	41.9958	1105720	650450	975675	Perashannur - Kuttipuram Road
S-5	CS 47- 50 RB	7.593	154340	123480	185220	Towards PWD Rest House Road
S-6	CS 52- 57 RB	12.2385	210430	210430	315645	Towards Tirur- Kuttippuram Road
S-7 LB	CS 2- 15 LB	40.2513	1569315	639740	959610	Kumbidi - Thrikkanapuram Road
S-8	CS 65 - 71 RB	34.9262	1214230	629600	944400	Towards Kuttippuram - Malloorkadavu Road
S-9	CS 82- 96 RB	47.9284	1387450	653710	980565	Tirur- Kuttippuram Road
S-10 LB	CS 41- 83 LB	165.4893	3638750	1124410	1686615	Vellanchery- Kanal Road
S-11	CS99RB	2.5607	63580	12720	19080	Tirur- Kuttippuram Road
S-12	CS115RB	2.8786	77110	22390	33585	Tirur- Kuttippuram Road
S-13	CS 117- 125 RB	23.9634	611270	150260	225390	Tirur- Kuttippuram Road
Chaliyar River						
S-14	CS 4 - 7	3.738301	74950	13420	20130	(i)Towards Mannuppadam-Modavanna Road (ii) Kozhikode -Nilambur-Gudalur Road

S-15	CS 13 - 18	6.49309	130330	43420	65130	(i)Towards Mannuppadam-Modavanna Road (ii) High School Road
S-16	CS25	1.495494	21010	21010	31515	(i)Towards Mannuppadam-Modavanna Road (ii) Brick factory road
S-17	CS32	1.005098	8720	3450	5175	Towards Eranjimangad-Modavanna Road
S-18	CS41	0.90564	15650	3700	5550	(i) Odayikkal-Edavanna Road (ii) Mampad-Wandoor Road
S-19	CS43	1.154592	14400	14400	21600	(i) Odayikkal-Edavanna Road (ii) Nilambur-Malappuram Road
S-20	CS 48- 51	4.974194	69230	16370	24555	Nilambur-Malappuram Road
S-21	CS53	0.658703	5380	920	1380	Nilambur-Malappuram Road
S-22	CS 57 - 61	5.523645	89230	44090	66135	(i)Odayikkal-Edavanna Road (ii)Nilambur-Malappuram
S-23	CS 82- 83	1.643374	12090	3130	4695	Odayikkal-Edavanna Road
S-24	CS 66 - 68	2.683266	21100	4810	7215	Odayikkal-Edavanna Road
S-25	CS 73 - 74	1.978395	70410	29360	44040	(i)Odayikkal-Edavanna Road (ii)Gudalur-Nilambur-Kozhikode Rd
S-26	CS 76- 77	1.229615	30380	11260	16890	Gudalur-Nilambur-
S-27	CS 84- 85	2.026941	11820	930	1395	Gudalur-Nilambur-Kozhikode Rd
S-28	CS 88- 90	3.151973	10050	310	465	Areekode-Othayi-Edavanna Rd
S-29	CS92	1.103321	44060	15770	23655	Areekode-Othayi-Edavanna Rd
S-30	CS 102- 103	1.801206	49450	33240	49860	Towards Sea Side Road
S-31	CS106	0.881006	11950	2730	4095	Nearby W end road
S-32	CS 111 - 114	5.70181	15890	450	675	Towards ring road
S-33	CS 117- 118	2.438881	32000	10270	15405	Towards Praiswell Public School Rd
S-34	CS120	1.228133	23400	5500	8250	Areekode-Othayi-Edavanna Rd
S-35	CS127	0.985554	28730	4690	7035	Areekode-Othayi-Edavanna Rd
S-36	CS 128 - 129	3.321486	23520	5110	7665	Thookkupaalam Road and Vadasseri Kadavu Road

S-37	CS 137 - 139	3.711156	68430	7340	11010	(i)Maitra Bridge Road (ii) Koilandy Edavanna Road
Kadalundi River						
S-38	CS 93- 94	0.444095	12000	3096	4644	(i)Towards Pullancheri-Nellikuth-Pandikad Road (ii) Towards Pandallur- Pandikkadu Road
S-39	CS142-143	0.309901	6112	792	1188	(i)Towards Neettuparambu Road (ii)Towards Pottammal Road
S-40	CS149	0.233368	6496	1768	2652	Perimbalam Road
S-41	CS155	0.285779	4704	848	1272	(i)Neettuparambu Road (ii) Perimbalam
S-42	CS168-171	0.786413	15480	2720	4080	(i)Perimbalam Road (ii)Panampattakadavu Road
S-43	CS156	0.26266	4664	744	1116	Malappuram-Manjeri Road,
S-44	CS164-166	0.845509	16520	2528	3792	(i)Towards Malappuram-Manjeri (ii) Towards Panampattakadavu Road
Total		**463.0848**	**11560106**	**4698286**	**7047429**	

** The area of sand mining sites was calculated based on the cross-section field survey, shapefiles created using google earth and GIS in the month of Dec 2022 which gives an estimation of sand bearing sites. However, there may be a slight shift in the sand bearing sites during the preparation of mine plan as change in groundwater level is a dynamic phenomenon which delineates the exact boundary coordinates and change in the area.*

***As per the particle size distribution analysis (Annexure-I), it is found that almost 95-98% of the sediment is consisting of sand and remaining of silt and clay.*

The panchayat wise distribution of sand mining sites is given in **Table 5.4**

Table 5.4 Panchayat wise distribution of sand mining sites

Sl.no	Sand mining sites	Panchayat	Approximate area (Ha)
1.	S1-S2	Irinpiliyam	10.163
2.	S3 - S13	Kuttippuram	389.919
3.	S14 - S17	Nilambur	12.7319
4.	S18- S23	Mambad	14.860
5.	S24 – S35	Edavanna	25.210
6.	S36	Urangathiry	3.321
7.	S37	Kavannur	3.711
8.	S38	Manjeri	0.444
9.	S39-S44	Koottilangadi	2.723

S10[*] includes in both Panchayats of Ottapalam Muncipality and Vaniyamkulam
S21[**] includes in both Panchayats of Shornur Muncipality and Ongallur
S26[***] includes in both panchayats of Ongallur and Pattambi.

The list of potential mining sites with other details as per the format mentioned in EMGSM-2020 is given in **Table 5.5.** The details of cluster and contiguous clusters as per the format mentioned in EMGSM-2020 are given in **Table 5.6.** The map showing all the potential mine sites along with existing structures in Bharathapuzha, Chaliyar and Kadalundi is given in **Figure 5.11, 5.12 & 5.13** respectively.

Table 5.5 List of potential mining sites

River details	Site details	Area (in Ha)	Distance (in km) from PA/BR/WC	Distance from forest area (in km)	Mining leases within 500 meters (if yes cluster area)	Total excavation in Tonnes	Mineral to be mined (Sand/ Bajri/ RBM etc.)	Existing / Proposed
Bharathapuzha	S-1	7.0777	-	-	Yes (10.16 Ha)	65505	Sand	Proposed
Bharathapuzha	S-2	3.0855	-	-	Yes (10.16 Ha)	119865	Sand	Proposed
Bharathapuzha	S-3	10.0938	-	-	-	74010	Sand	Proposed
Bharathapuzha	S-4	41.9958	-	-	Yes (61.83 Ha)	975675	Sand	Proposed
Bharathapuzha	S-5	7.593	-	-	Yes (61.83 Ha)	185220	Sand	Proposed
Bharathapuzha	S-6	12.2385	-	-	Yes (61.83 Ha)	315645	Sand	Proposed
Bharathapuzha	S-7 LB	40.2513	-	-	Yes (75.18 Ha)	959610	Sand	Proposed
Bharathapuzha	S-8	34.9262	-	-	Yes (75.18 Ha)	944400	Sand	Proposed
Bharathapuzha	S-9	47.9284	-	-	Yes (242.82 Ha)	980565	Sand	Proposed
Bharathapuzha	S-10 LB	165.4893	-	-	Yes (242.82 Ha)	1686615	Sand	Proposed
Bharathapuzha	S-11	2.5607	-	-	Yes (242.82 Ha)	19080	Sand	Proposed
Bharathapuzha	S-12	2.8786	-	-	Yes (242.82 Ha)	33585	Sand	Proposed
Bharathapuzha	S-13	23.9634	-	-	Yes (242.82 Ha)	225390	Sand	Proposed
Chaliyar	S-14	3.738301	-	Adjacent to Panangode RF	-	20130	Sand	Proposed
Chaliyar	S-15	6.49309	-	Adjacent to	-	65130	Sand	Proposed

				Nilambur RF				
Chaliyar	S-16*	1.495494	-	Within Nilambur RF	-	31515	Sand	Proposed
Chaliyar	S-17*	1.005098	-	Within Nilambur RF	-	5175	Sand	Proposed
Chaliyar	S-18	0.90564	-	-	Yes (13.22 Ha)	5550	Sand	Proposed
Chaliyar	S-19	1.154592	-	-	Yes (13.22 Ha)	21600	Sand	Proposed
Chaliyar	S-20	4.974194	-	-	Yes (13.22 Ha)	24555	Sand	Proposed
Chaliyar	S-21	0.658703	-	-	Yes (13.22 Ha)	1380	Sand	Proposed
Chaliyar	S-22	5.523645	-	-	Yes (13.22 Ha)	66135	Sand	Proposed
Chaliyar	S-23	1.643374	-	-	Yes (7.53 Ha)	4695	Sand	Proposed
Chaliyar	S-24	2.683266	-	-	Yes (7.53 Ha)	7215	Sand	Proposed
Chaliyar	S-25	1.978395	-	-	Yes (7.53 Ha)	44040	Sand	Proposed
Chaliyar	S-26	1.229615	-	-	Yes (7.53 Ha)	16890	Sand	Proposed
Chaliyar	S-27	2.026941	-	-	Yes (6.28 Ha)	1395	Sand	Proposed
Chaliyar	S-28	3.151973	-	-	Yes (6.28 Ha)	465	Sand	Proposed
Chaliyar	S-29	1.103321	-	-	Yes (6.28 Ha)	23655	Sand	Proposed
Chaliyar	S-30	1.801206	-	-	Yes (12.05 Ha)	49860	Sand	Proposed
Chaliyar	S-31	0.881006	-	-	Yes (12.05 Ha)	4095	Sand	Proposed
Chaliyar	S-32	5.70181	-	-	Yes (12.05 Ha)	675	Sand	Proposed
Chaliyar	S-33	2.438881	-	-	Yes (12.05 Ha)	15405	Sand	Proposed
Chaliyar	S-34	1.228133	-	-	Yes (12.05 Ha)	8250	Sand	Proposed

Chaliyar	S-35	0.985554	-	-	-	7035	Sand	Proposed
Chaliyar	S-36	3.321486	-	-	-	7665	Sand	Proposed
Chaliyar	S-37	3.711156	-	-	-	11010	Sand	Proposed
Kadalundi	S-38	0.444095	-	-	-	4644	Sand	Proposed
Kadalundi	S-39	0.309901	-	-	Yes (0.83 Ha)	1188	Sand	Proposed
Kadalundi	S-40	0.233368	-	-	Yes (0.83 Ha)	2652	Sand	Proposed
Kadalundi	S-41	0.285779	-	-	Yes (0.83 Ha)	1272	Sand	Proposed
Kadalundi	S-42	0.786413	-	-	Yes (1.89 Ha)	4080	Sand	Proposed
Kadalundi	S-43	0.26266	-	-	Yes (1.89 Ha)	1116	Sand	Proposed
Kadalundi	S-44	0.845509	-	-	Yes (1.89 Ha)	3792	Sand	Proposed

** S16 & S17 are falling within the Nilambur Reserve Forest and are not recommended for mining.*

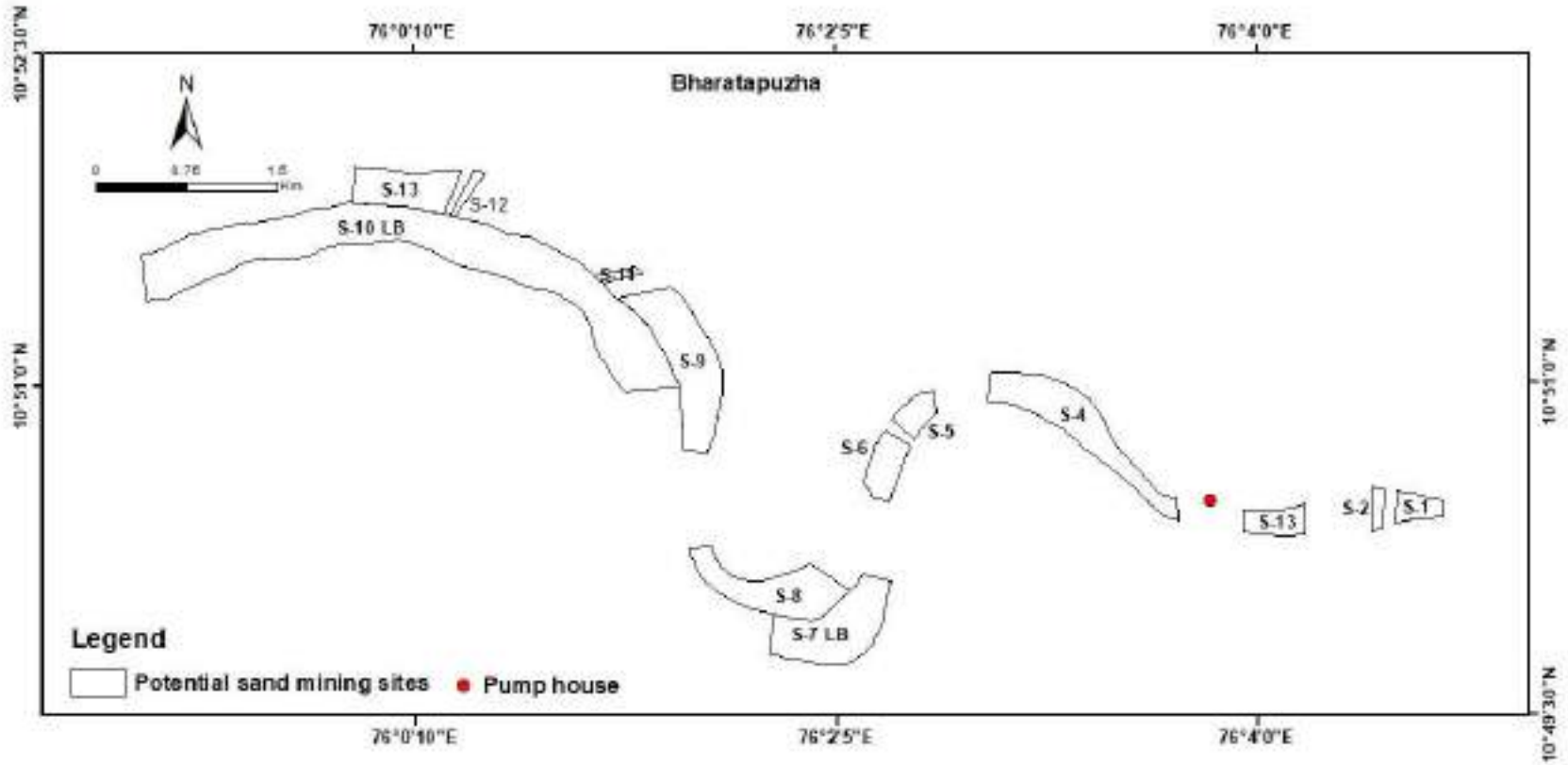


Figure 5.11 Map showing all the potential mine sites along with existing structures in Bharathapuzha stretch of Malappuram

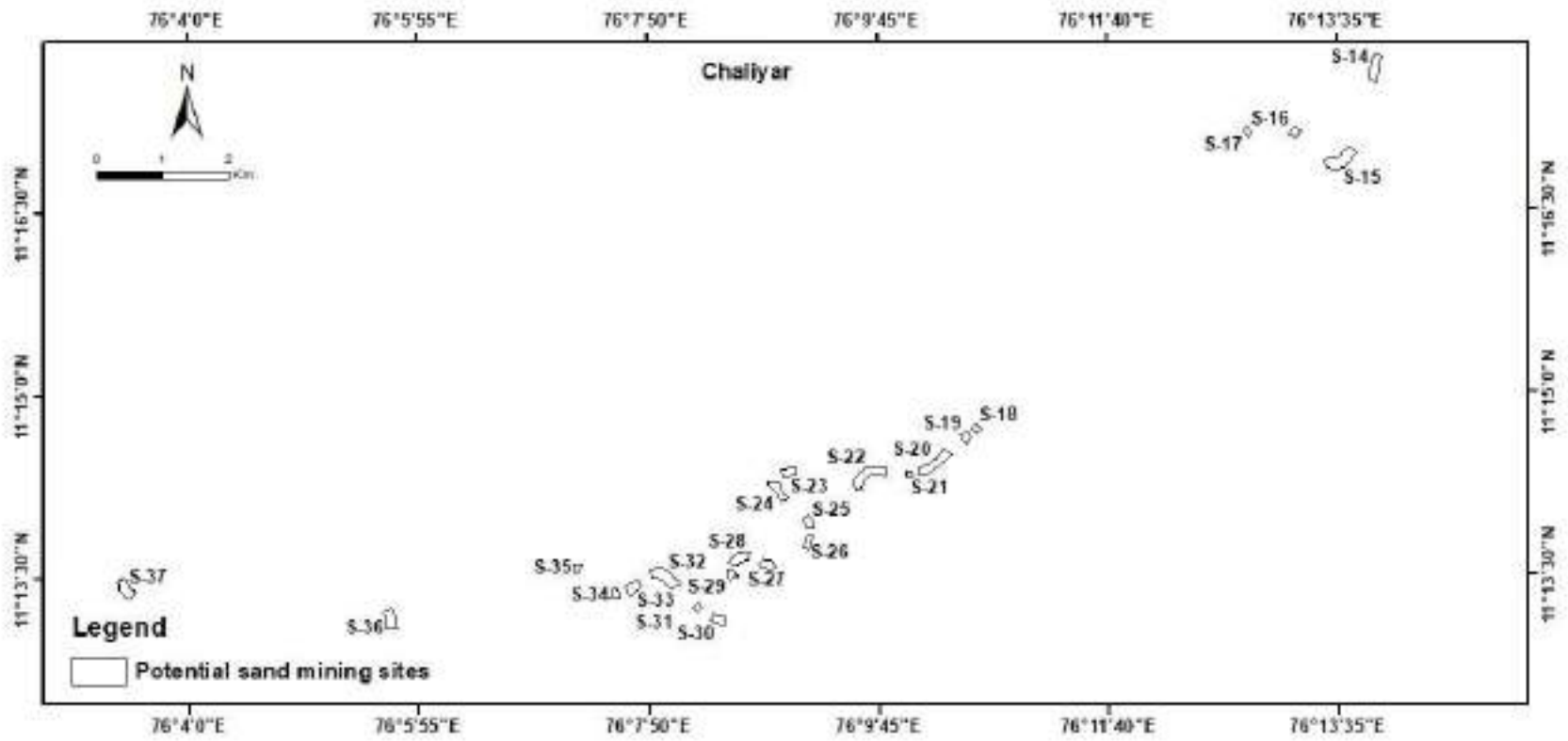


Figure 5.12 Map showing all the potential mine sites along with existing structures in Chaliyar

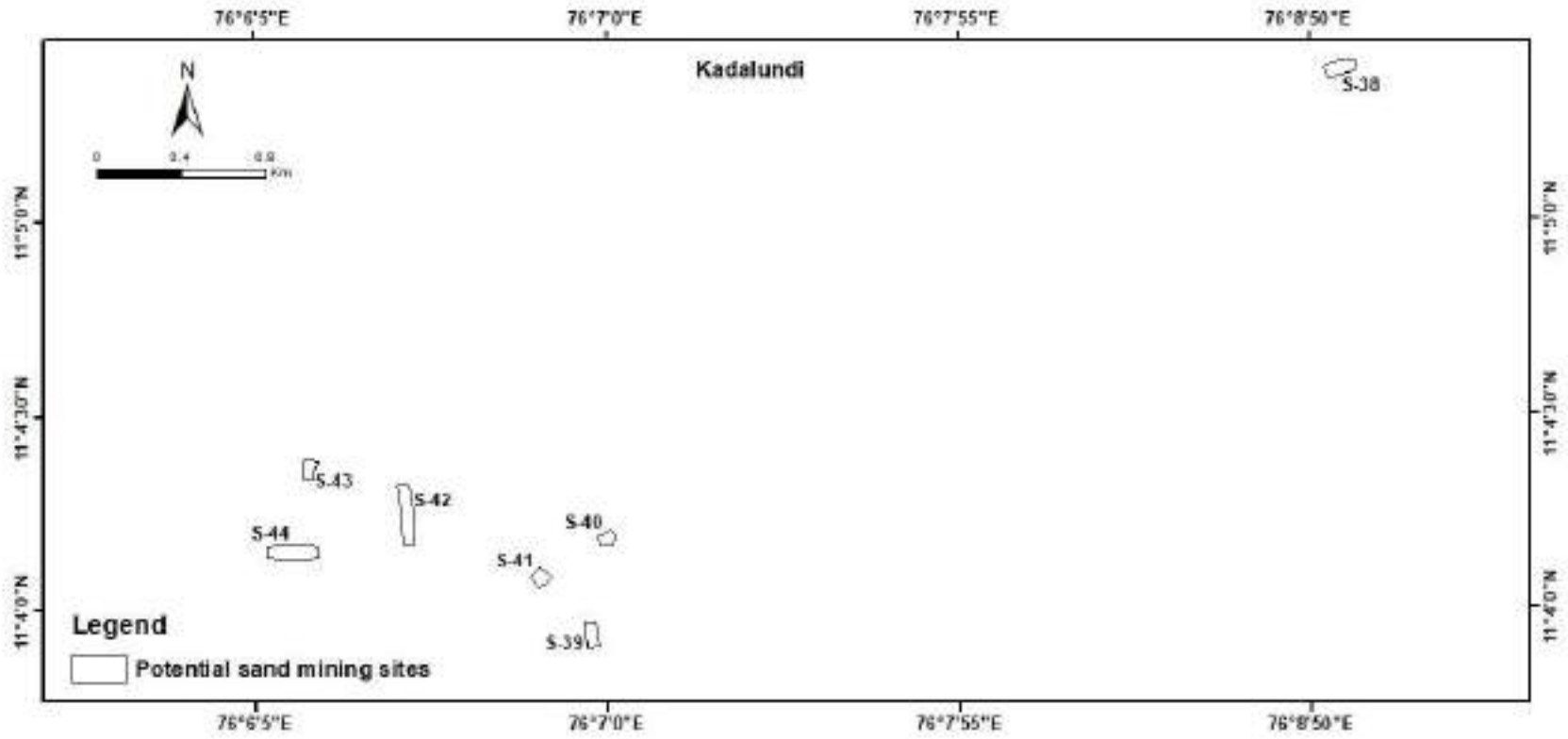


Figure 5.13 Map showing all the potential mine sites along with existing structures in Kadalundi

Table 5.6 Details of cluster and contiguous clusters

River name	Cluster no	Sand mining sites falling under cluster	Panchayath Name	Area (Ha)	Total sand (Tonne)	Mineable sand (Tonne)
Bharathapuzha	C-1	S1, S2	Irinpiliyam	10.16	457688	185370
Bharathapuzha	C-2	S4, S5, S6	Kuttippuram	61.83	2205735	1476540
Bharathapuzha	C-3	S7 LB, S8	Kuttippuram	75.18	4175318	1904010
Bharathapuzha	C-4	S9, S10 LB, S11, S12, S13	Kuttippuram	242.82	8667240	2945235
Chaliyar	C-5	S18, S19, S20, S21, S22	Mambad	13.22	290835	119220
Chaliyar	C-6	S23, S24, S25, S26	Mambad-Edavanna	7.53	200970	72840
Chaliyar	C-7	S27, S28, S29	Edavanna	6.28	98895	25515
Chaliyar	C-8	S30, S31, S32, S33, S34	Edavanna	12.05	199035	78285
Kadalundi	C-9	S39, S40, S41	Koottilangadi	0.83	25968	5112
Kadalundi	C-10	S42, S43, S44	Koottilangadi	1.89	54996	8988

River name	Contiguous cluster number	Cluster no	Number of sand mining site in the cluster	Distance between the cluster	Area (Ha)	Total sand (Tonne)	Mineable sand (Tonne)
Bharathapuzha	CG-1	C-1 to C-4	12	<2.5 km	389.99	15505980	6511155
Chaliyar	CG-2	C-5 to C-8	17	<2.5 km	39.08	789735	295860
Kadalundi	CG-3	C-9 to C-10	6	<2.5 km	2.72	80964	14100

The expert committee comprising experts from mining and geology, environment, revenue department and state high-level committee has evaluated the draft DSR of Malappuram district. Two sub-divisional committees (SDC) formulated by the district collector and visited all the identified sand mining sites mentioned in the above tables as per the clause 4.1.1 (o) of EMGSM-2020. The committee has provided inputs in their inspection report for Tirur and Perinthalmanna revenue divisions by analysing the suitability of mining for all the sites. Based on the SDC comments, the list of final potential sand mining sites along with the cluster and contiguous cluster details provided as separate annexure.

The total number of sand mining sites identified is 36. The total area of all the sand mining sites combined is 405.75 Ha. The total sand availability in all the identified sites combined is 99,07,484 m^3 while the mineable sand above summer water level is 3835954 m^3 (57,53,931 tonnes).

5.6 Replenishment studies

A replenishment study for riverbed sand is required in order to nullify the adverse impacts arising due to excessive sand extraction. Mining within or near the riverbed has a direct impact on the stream's physical characteristics, such as channel geometry, bed elevation, substratum composition and stability, in-stream roughness of the bed, flow velocity, discharge capacity, sediment transport capacity etc.

For sustainable river sand mining, it is necessary that the mine pits formed as a result of sand excavation are refilled with sand by the natural process of replenishment in a reasonable period of time so that the area is again available for mining. The rate of gross erosion is dependent upon many physical factors like climatic conditions, the nature of the soil, the slope of the area, topography and land use (DSR, Gondia, Maharashtra, 2018). The effect of any of these variables may vary greatly from one geographic location to another, and the relative importance of controlling factors often varies within a given land resource area (Dendy, 1976).

There is no denial of the fact that bed load changes from hour to hour, day to day, and year to year; estimating annual bed load rates is a dynamic process involving careful examination. Therefore, proper care has been taken before applying the empirical model to calculate the sediment yield from the watershed. However, as far as Kerala is concerned, the topography, geomorphology and soil are different from a typical plateau region. Hence, due weightage is given to actual field studies, and replenishment actually occurred on the stretches under consideration in the river. As a matter of fact, the modelling activity and replenishment studies are viewed from an angle of an add-on to the physical verification and rate of replenishment.

The estimation of sand replenishment is based on empirical and analytical approaches. There are many sediment transport equations as well as models which are suitable for use in the prediction of the replenishment rate of rivers/watersheds. The sedimentation models include SWAT, HEC-HMS etc. These models are developed based on the fundamental hydrological and sedimentological processes. They may provide detailed temporal and spatial

simulation but usually require extensive data input. Hourly/daily input values of meteorological and radiation variables are required for continuous simulations. Some of the empirical equations for estimating sediment transport are as follows.

i. Einstein (1950)
ii. Laursen (1958)
iii. Bagnold (1966)
iv. Engelund-Hansen equation (1967)
v. Yang equations (1973)
vi. Dendy- Bolton equation (1976)
vii. Modified Universal Soil Loss Equation (MUSLE) developed by Williams and Berndt (1977)
viii. Van Rijn (1984)
ix. Zanke (1987)

To estimate the transport capacity or the sediment load being conveyed by a water stream, one of the many transport equations that are available in the literature is frequently used. Einstein (1950) introduced statistical methods to represent the turbulent behaviour of the flow. Bagnold (1966) introduced an energy concept and related the sediment transport rate to work done by the fluid. Engelund and Hansen (1967) presented a simple and reliable formula for the total load transport in rivers. The Yang equation makes use of the total bed hydraulic radius, and studies show that it is good for estimating the sediment transport in the channel for the condition of dunes on the bed. MUSLE includes only one type of sediment yield (sheet and rill Erosion). Van Rijn (1984) solved the equations of motions of an individual bed-load particle and computed the saltation characteristics and the particle velocity as a function of the flow conditions and the particle diameter for plane bed conditions. The equations of Zanke and Van Rijn seem to be only moderately satisfactory in estimating the sediment transport in the channel for the condition of dunes on the bed. However, it appears that no single equation could provide reliable estimates of a total load of sediment transport for all of the bed forms that could occur sequentially or randomly in alluvial channels or natural water courses. The comparison of the equations for estimating sediment rate is given in **Table 5.7**

Table 5.7 Comparison of scientific equations

Sl.No	Sediment transport equation	Remarks
1	Einstein (1950)	Bed load function was determined for many but not all types of stream channels
2	Laursen (1958)	Laursen equation outperforms other transport equations in the silt range
3	Bagnold (1966)	Bagnold related the sediment transport rate to work done by the fluid
4	Engelund-Hansen equation (1967)	The original Engelund-Hansen relation (OEH) is based on a single characteristic grain size, which limits its applicability in sand-bed rivers

		with a wide GSD
5	Yang equations (1973)	It makes use of a total bed hydraulic radius
6	Dendy- Bolton equation (1976)	It uses both drainage area and means annual runoff for estimation of sediment yield. It calculates all types of sediment yield like sheet and rill erosion, gully erosion, channel bed and bank erosion and mass movement
7	Modified Universal Soil Loss Equation (MUSLE) developed by Williams and Berndt (1977)	MUSLE includes only one type of sediment yield (sheet and rill Erosion)
8	Van Rijn (1984)	Calculated equations of motions of an individual bed-load particle for plane bed conditions
9	Zanke (1987)	Zanke was found to be moderately satisfactory for the condition of the dunes on the bed.

In this study, the rate of gross silt production in the watershed and the ability of the stream system to transport the eroded material in a river have been carried out by the Dendy-Bolton equation. Dendy - Bolton formula is often used to calculate the sedimentation yield as it uses both drainage area and mean annual runoff as key parameters to give a yield value. Also, Dendy - Bolton equation calculates all types of sediment yield like sheet and rill erosion, gully erosion, channel bed and bank erosion and mass movement. Since the equations were derived from the average values of grouped data, 75% of the variation in average sediment yield was observed. However, a quick and rough approximation of mean sediment yields on a regional basis can be obtained. The main input parameter for Dendy – Bolton equation is runoff and catchment area, runoff for the analysis has been carried out using rational formula. Local variables like as soils, geology, terrain, land use, and vegetation may have a far greater impact on sediment output than flow or drainage area. The peak runoff rate for a specific period of uniform rainfall intensity can be calculated using the Rational Method, which employs an empirical linear equation (Young & Rome, 2009).

The procedure for the rational method to calculate peak stormwater runoff rate is,

$$Q = 0.0028\ CiA \text{ (S.I. units)}$$

Where,

A = the area of the watershed that drains to the point for which the peak runoff rate is needed (Unit: Ha)

C = runoff coefficient for drainage area A, which is a physical interpretation of the fraction of rainfall converting to runoff. (Dimensionless)

i = the intensity of the design storm for peak runoff calculation (mm/hr for S.I. units)

Q = the peak storm water runoff rate from the drainage area, A in m^3 /s

Kadalundy watershed

Kadalundi River is one of the four most important rivers flowing through Malappuram district in the Indian state of Kerala. The rainfall data for a period of six years, from 2015-2020 has been procured from the India Meteorological Department (IMD). The Kadalundy watershed consist of three rain gauge stations- Perinthalmanna, Angadipuram and Karippur (**Figure 5.14**). The rainfall data for all these stations has been sorted monthly and annually for the analysis. The different thematic maps used for the analysis are, land use/land cover map (LU/LC), contour map and Digital Elevation Model (DEM).

Kadalundi watershed is having an area of 1198.5 km^2 with an average annual rainfall of 2500 mm. The study objective is to estimate the runoff from the watershed for the sand replenishment studies. Rational formula was used for runoff calculation and Dendy-Bolton formula was used for sedimentation analysis. The input data requirements for rational formula includes rainfall data, coefficient of runoff for each land class, intensity of rainfall and the area of watershed.

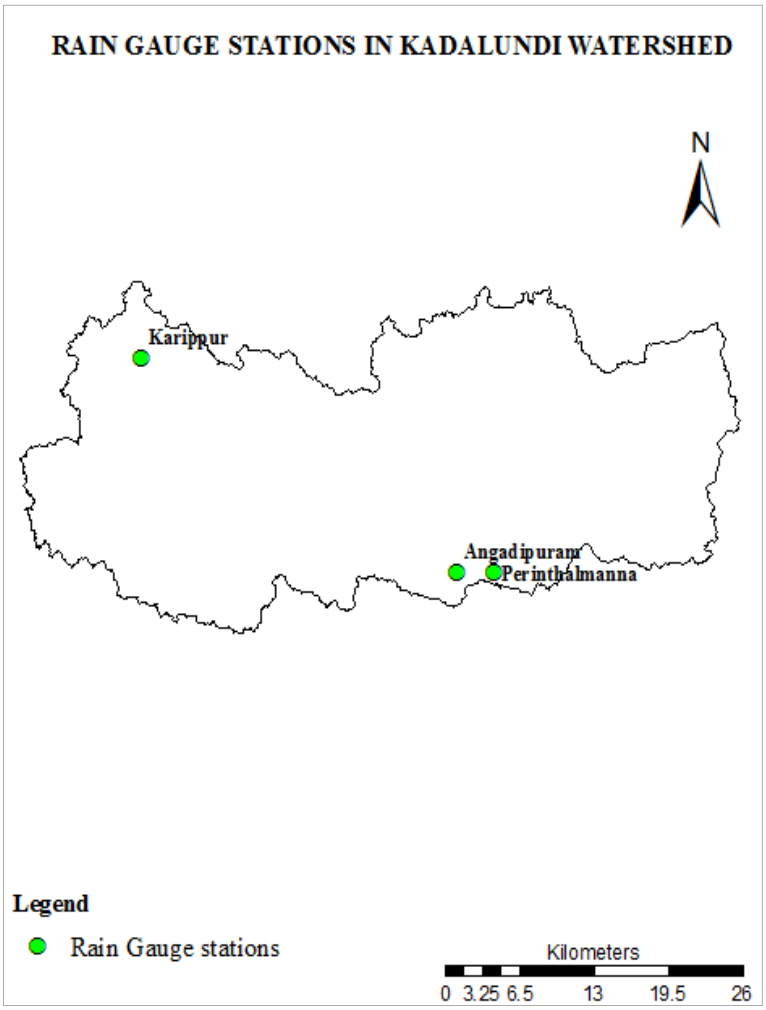


Figure 5.14: Rain gauge stations in Kadalundi watershed

Rainfall data from the given stations during the southwest monsoon season has been sorted out for the analysis. The average runoff Q from all these stations has been carried out using Rational equation.

Land use- Land cover analysis of Kadalundi watershed

Land use land cover information is an important factor that accounts the runoff from an area. The total Kadalundi watershed has been classified into 8 classes and the corresponding areas were calculated. The land profile of the area indicates that out of 8 classes, 56% of the area is covered by mixed vegetation and 35 % is covered by built-up land (**Figure 5.15**). The area of each classification is given in **Table 5.8** given below.

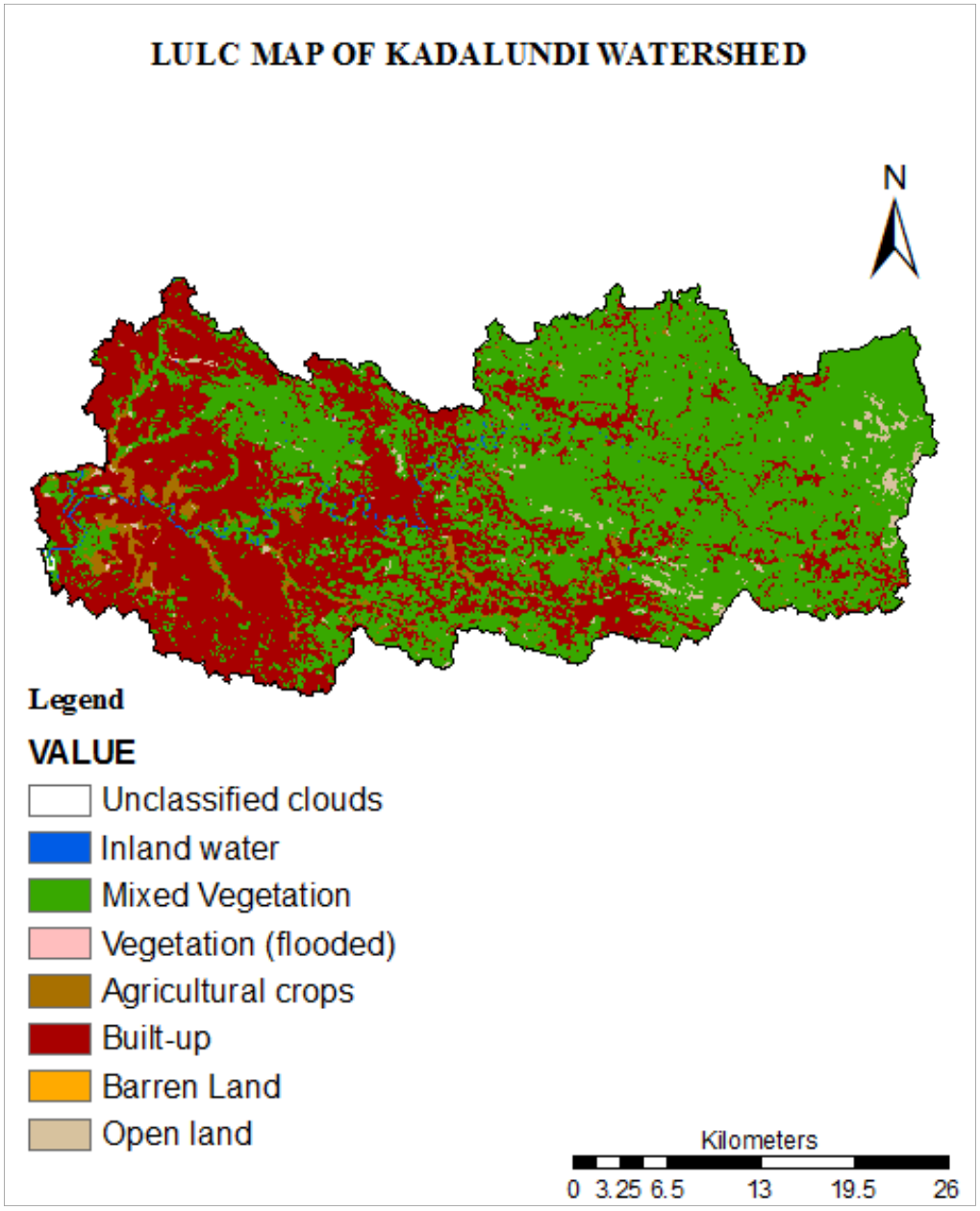


Figure 5.15: Land use- Land cover map of Kadalundi watershed

Table 5.8: Distribution of area for each land-use class, Kadalundi watershed

Sl.no	LULC class	Area (km^2)
1.	Inland water bodies	6.299
2.	Mixed vegetation	671.987
3.	Vegetation (Flooded)	0.282
4.	Agriculture field/crops	31.716
5.	Built-up	468.052
6.	Barren land	0.003
7.	Unclassified/clouds	0.008
8.	Range land /open land	20.149

Table 5.9: Runoff quantification for Kadalundi watershed for the year 2015

Classes	Area (Km^2)	C	i (mm/hr)	A (Ha)	Q (m^3/s)
Mixed vegetation	671.9871	0.4	0.889	67198.71	66.90
Vegetation (Flooded)	0.2824	0.85	0.889	28.24	0.059
Agriculture field/crops	31.7164	0.45	0.889	3171.64	3.552
Built-up	468.0522	0.9	0.889	46805.22	104.85
Barren land	0.0028	0.4	0.889	0.28	0.0002
Range land /open land	20.1494	0.6	0.889	2014.94	3.00

Table 5.10: Runoff values for Kadalundi watershed

Sl.no	Year	Rainfall (mm)	Runoff depth (mm)
1.	2015	2635.0	1118.8
2.	2016	1618.1	810
3.	2017	2517.3	1283.6
4.	2018	3560.7	1623
5.	2019	3179.2	1715
6.	2020	2570.8	1351

Calculation of sedimentation yield using Dendy- Bolton formula

Dendy- Bolton equation express the general relationships between sediment yield, runoff, and drainage area. It gives only a rough estimation of the sedimentation yield as precise topographical parameters of the area were not incorporated in the development of the equation. Based on the runoff, there are two equations used for the calculation and is given below.

For runoff less than 2 inches; $S=1280\ Q\ 0.26[1.43-0.26\ \log (A)]$

For, runoff more than 2 inches; $S=1965\ e^{-0.055Q}\ [1.43-0.26\log (A)]$

Where, S = Sediment yield (tons/km^2/yr.)

Q = Mean Annual runoff (mm)

A = Net drainage area (km^2)

As the runoff values from the Kadalundi watershed is greater than 2 inches, the second equation of Dendy-Bolton formula has been used for the sediment yield calculation. The annual sediment yield from the catchment is given in **Table 5.11**.

Table 5.11: Sedimentation yield from the Kadalundi watershed

Sl.no	Year	Sedimentation (M. tonnes/yr.)
1.	2015	53940.66
2.	2016	105271.84
3.	2017	37751.84
4.	2018	18103.64
5.	2019	14833.68
6.	2020	32625.34

The analytical method of sand replenishment studies shows that the average yield from the Kadalundi watershed accounts around 43754 M. tonnes/year and the accrued yield from past six years report to be 262527 M. tonnes.

Chaliyar watershed

Chaliyar is one of the major rivers in Kerala with a length of 169 km and it is ranked as fourth longest river in Kerala. The drainage area of the Chaliyar River is 3087 km^2, of which around 54% is in Malappuram. The rainfall stations coming in the catchment are Manjeri and Nilambur (**Figure 5.16**). The average annual rainfall of the region reports to be around 2563 mm. Rainfall data for six years (2015-2020) from two rain gauge stations maintained by the India Meteorological Department (IMD) were collected. This was followed by rainfall intensity calculation and LULC analysis for runoff generation.

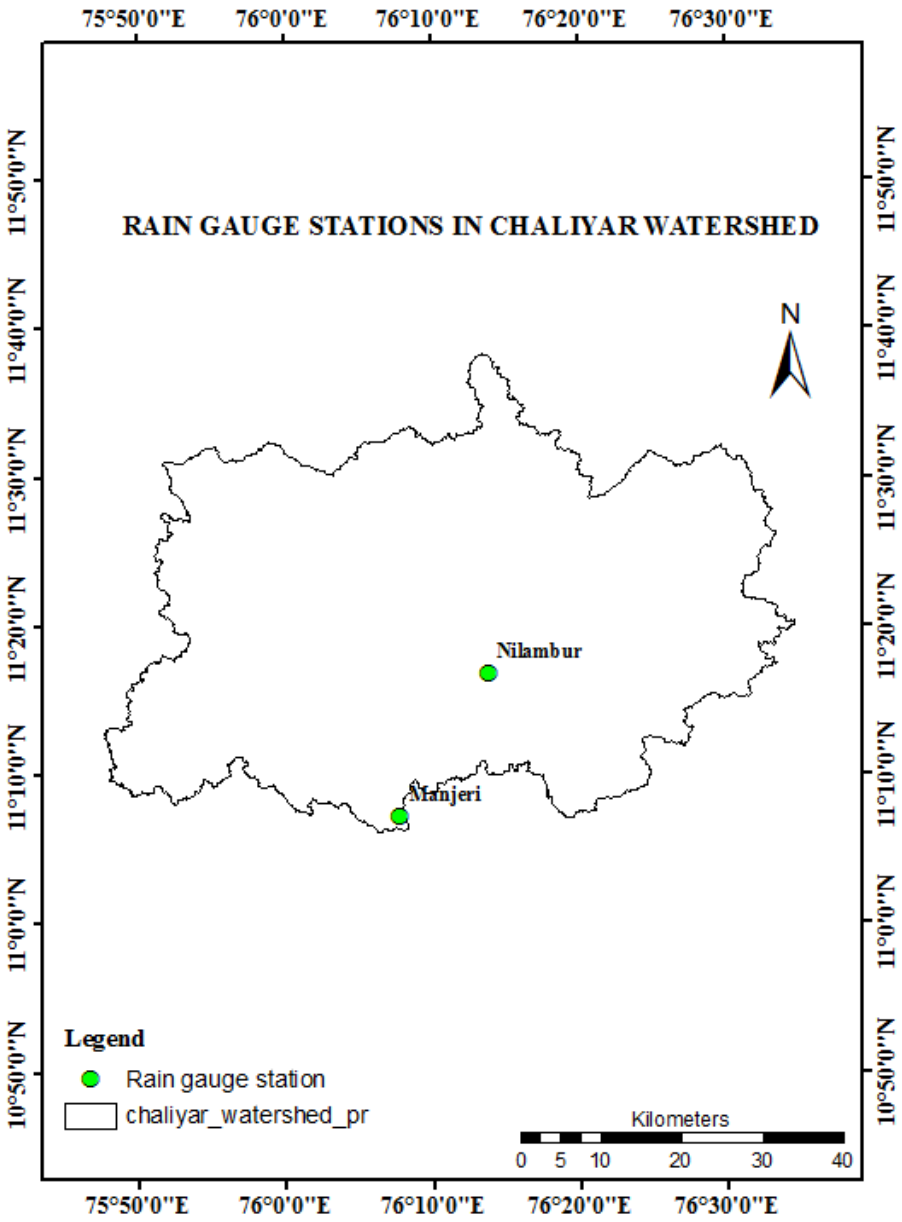


Figure 5.16: Rain gauge stations in Chaliyar watershed

Land use- Land cover analysis of Chaliyar watershed

The Chaliyar watershed has been classified into 8 classes using ArcGIS 10.3 software (**Figure 5.17**). The LULC analysis shows that major share of the catchment area constitutes mixed vegetation and built-up land. Area wise land distribution is given in **Table 5.12.**

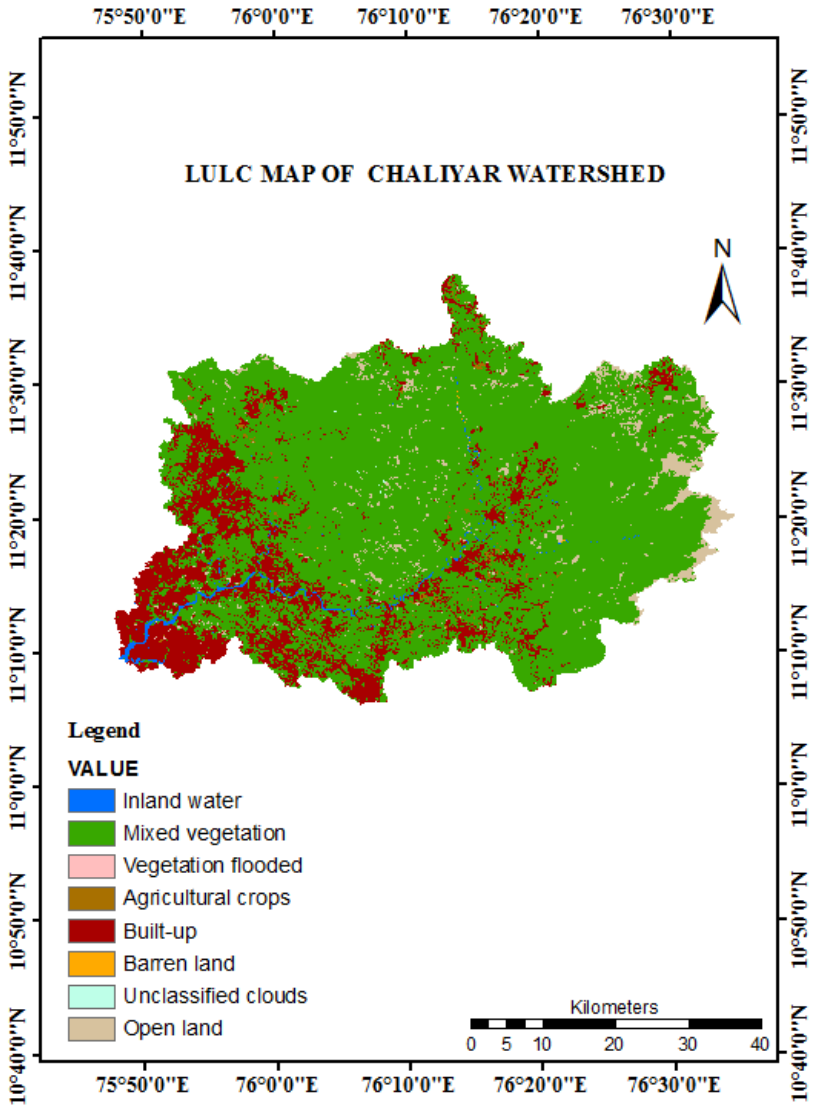


Figure 5.17: Land use- Land cover map of Chaliyar watershed

Table 5.12: Distribution of area for each land-use class, Chaliyar watershed

Sl.no	LULC class	Area (km^2)
1.	Inland water bodies	23.814
2.	Mixed vegetation	2378.758
3.	Vegetation (Flooded)	0.419
4.	Agriculture field/crops	19.341
5.	Built-up	535.538
6.	Barren land	0.558
7.	Unclassified/clouds	0.668
8.	Range land /open land	127.533

The resultant values of runoff from Chaliyar watershed calculated using rational method is given in **Table 5.13**.

Table 5.13: Runoff quantification for Chaliyar watershed for the year 2015

Classes	C	i (mm/hr)	A (Ha)	Q (m^3/s)
Mixed vegetation	0.4	0.756	237875.8	201.41
Vegetation (Flooded)	0.85	0.756	41.91	0.075
Agriculture field/crops	0.45	0.756	1934.18	1.84
Built-up	0.9	0.756	53553.87	102.02
Barren land	0.4	0.756	55.85	0.047
Range land /open land	0.6	0.756	12753	0.085

Runoff quantification of Chaliyar watershed during the period 2015 to 2020 has been carried out using rational formula and is given in **Table 5.14**.

Table 5.14: Runoff values for Chaliyar watershed during 2015-2020

Sl. no	Year	Rainfall	Runoff
1.	2015	2149.5	711
2.	2016	1361.2	595.4
3.	2017	2260.0	836.2
4.	2018	3962.7	1335.6
5.	2019	3181.2	1006.4
6.	2020	2082.0	866.2

Calculation of sedimentation yield using Dendy- Bolton formula

The runoff values from the catchment accounts more than 2 inches and hence second equation of Dendy- Bolton equation has been used for sediment estimation. The results of the analysis are given in **Table 5.15**.

Table 5.15: Sedimentation yield from the Chaliyar watershed

Sl.no	Year	Sedimentation (M. tonnes/yr.)
1.	2015	287210.67
2.	2016	368981.86
3.	2017	219056.6
4.	2018	74288.21
5.	2019	151530.49
6.	2020	205278.9

The analytical method of sand replenishment studies shows that the average yield from the Kadalundi watershed accounts around 217724.45 M. tonnes/year and the accrued yield from past six years report to be 1306346.73 M. tonnes.

Bharathapuzha watershed

The Bharathapuzha watershed is the largest river basin among the west flowing river basins in the Kerala state of India with a total catchment area of 6253 km^2. One third of the Bharathapuzha watershed lies in the Tamil Nādu region and remaining in the Kerala. The Kerala region of Bharathapuzha catchment includes three districts- Palakkad (53%), Malappuram (9%) and, Thrissur (6%). Rainfall data for a period of six years from 2015 to 2020 was procured from IMD and using rational formula, runoff calculations were made. The LULC map for the analysis has been made available from the ESRI website.

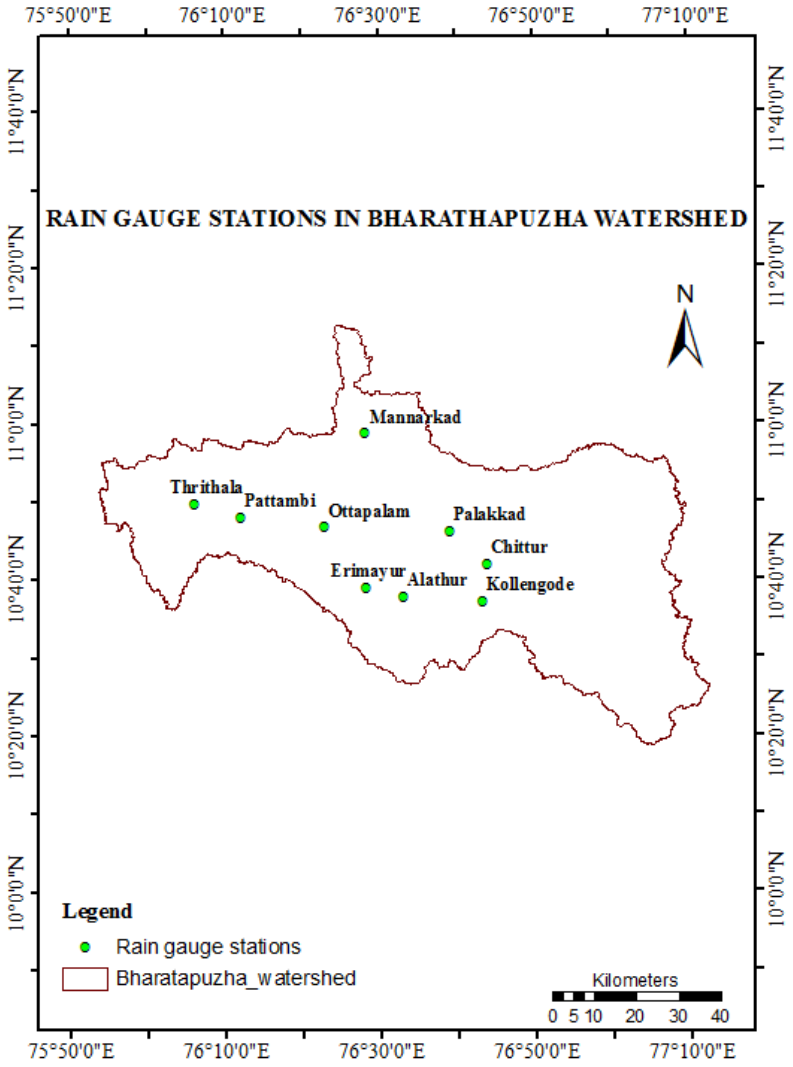


Figure 5.18: Rain gauge stations in Bharathapuzha watershed

The total catchment area of Bharathapuzha consists of nine rain gauge stations from which the rainfall data was procured (**Figure 5.18**). The data was then sorted for monsoon season (JJASO) and using the number of rainy days, rainfall intensity has been calculated. The LULC classification was carried out using the thematic map downloaded from ESRI website (**Figure: 5.19**). The area-wise distribution of the map is given in **Table 5.16**. The sample runoff calculation for the study area is given in **Table 5.17**.

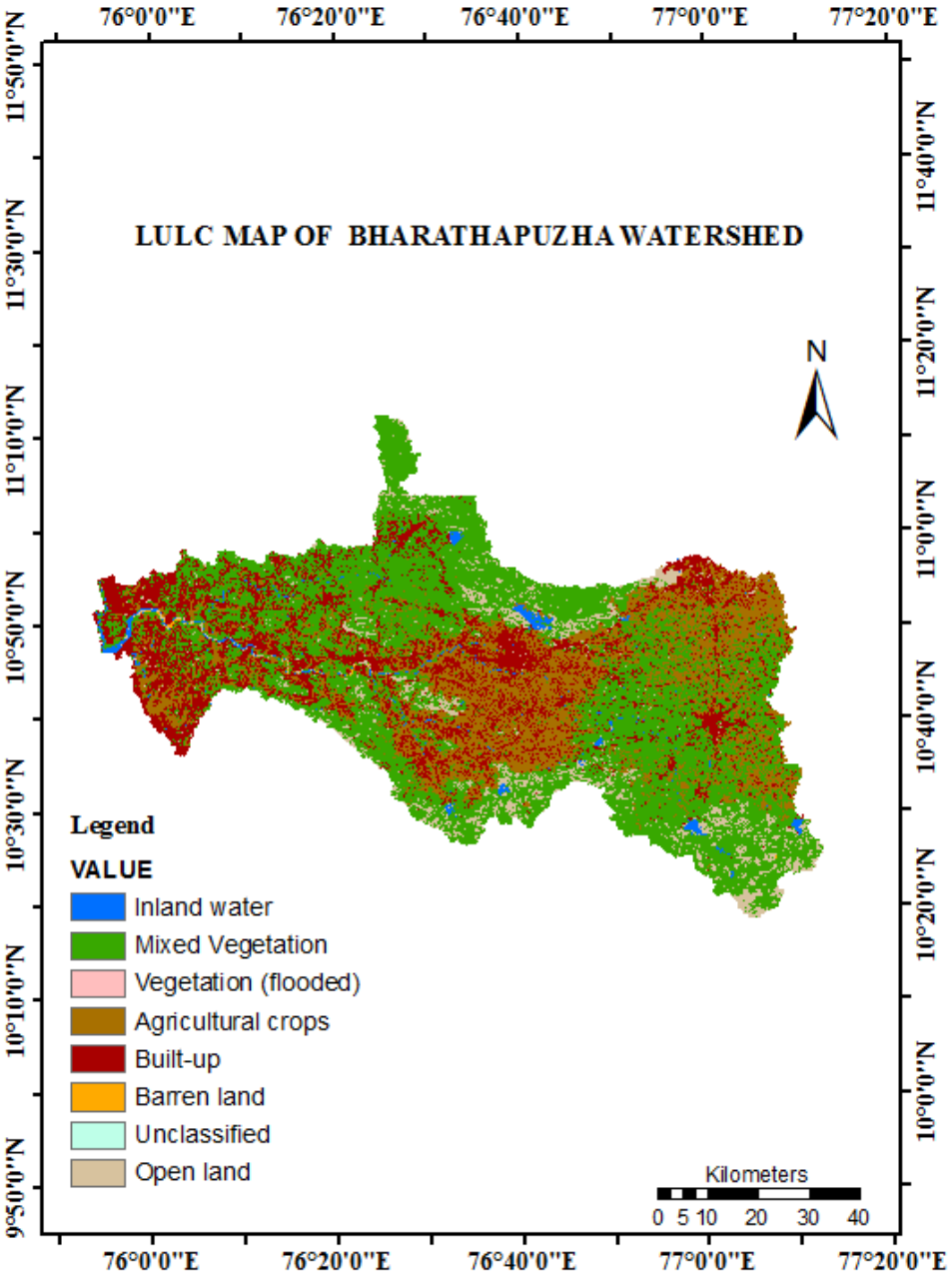


Figure 5.18: Land use- Land cover map of Bharathapuzha watershed

Table 5.16: Distribution of area for each land-use class, Bharathapuzha watershed

Sl.no	LULC class	Area (km^2)
1.	Inland water bodies	23.814
2.	Mixed vegetation	2378.758
3.	Vegetation (Flooded)	0.419
4.	Agriculture field/crops	19.341
5.	Built-up	535.538
6.	Barren land	0.558
7.	Unclassified/clouds	0.668
8.	Range land /open land	127.533

Table 5.17: Runoff quantification for Bharathapuzha watershed for the year 2015

Classes	C	i (mm/hr)	A (Ha)	Q (m^3/s)
Mixed vegetation	0.4	0.766	307082.98	263.45
Vegetation (Flooded)	0.85	0.766	122.37	0.22
Agriculture field/crops	0.45	0.766	140870.73	135.96
Built-up	0.9	0.766	129968.21	250.88
Barren land	0.4	0.766	700.58	0.60
Range land /open land	0.6	0.766	37335.82	48.04

The obtained runoff was then converted to runoff depth and sediment yield has been calculated.

Calculation of sedimentation yield using Dendy- Bolton formula

The runoff values from the catchment accounts more than 2 inches and hence second equation of Dendy- Bolton equation has been used for sediment estimation of Bharathapuzha. The results of the analysis are given in **Table 5.18**.

Table 5.18: Sedimentation yield from the Bharathapuzha watershed

Sl.no.	Year	Rainfall (mm)	Runoff (mm)	Sedimentation (M. Tons/yr.)
1.	2015	2004.6	705.17	514974.33
2.	2016	1348.9	584.38	668677.65
3.	2017	1986.4	843.7	381374.72
4.	2018	3046.6	1263.5	153663.73
5.	2019	2726.4	1234.5	163622.5
6.	2020	2036.4	971	289493.49

The analytical method of sand replenishment studies using empirical equation shows that the average yield from the Bharathapuzha watershed accounts around 361967.74 M. tonnes/year and the accrued yield from past six years report to be 2171806.42 M. tonnes.

Table 5.19: Replenishment in last three years as per the field survey in Bharathapuzha stretch situated in Malappuram district

Sr.no	Volume of total sand (m^3)		Difference in volume of sand (m^3)	Average per year deposition (m^3)	Average per year deposition (Tonnes)***
	Feb- 2020*	Jan 2023**			
1	76,48,014.16	1,06,11,950	29,63,935.8	9,87,978	14,81,967

**Taken from the previous sand audit reports prepared by ILDM*
***As per the field survey conducted by NIIST*
**** Bulk density worked out as 1.5 gm/cc and measured by NIIST (IS 2386 Part-3 & Kim H. Tan, 2nd Edition)*

There is a significant deposition of sand in this particular stretch of Bharathapuzha river in last three years. Taking the total volume of sand in Feb 2020 as the base value, the replenishment rate is 13% per year. As the prime objective of the DSR preparation is to limit the rate of extraction to rate of replenishment, the mining plan shall be prepared in accordance with rate of replenishment.

Table 5.20 below shows the replenishment in Chaliyar river. Needless to say, as the watershed of Chaliyar is smaller than the Bharathapuzha, the rate of replenishment is low.

Table 5.20: Replenishment in last three years as per the field survey in Chaliyar River situated in Malappuram district

Sr.no	Volume of total sand (m^3)		Difference in volume of sand (m^3)	Average per year deposition (m^3)	Average per year deposition (Tonnes)***
	Feb- 2020*	Jan 2023**			
1	8,32,766	8,82,180	49,414	16,471	24706.5

**Taken from the previous sand audit reports prepared by ILDM*
***As per the field survey conducted by NIIST*
**** Bulk density worked out as 1.5 gm/cc and measured by NIIST (IS 2386 Part-3 & Kim H. Tan, 2nd Edition)*

The rate of replenishment in Chaliyar river is only 2% from the base value of February 2020. The mining plan shall be prepared in accordance with the rate of replenishment.

The details of sand auditing conducted for Kadalundi river in year 2020 and 2023 is presented below in Table 5.21

Table 5.21: Replenishment in last three years as per the field survey in Kadalundi River situated in Malappuram district

Sr.no	Volume of total sand (m^3)		Difference in volume of sand (m^3)	Average per year deposition (m^3)	Average per year deposition (Tonnes)***
	Feb- 2020*	Jan 2023**			
1	2,74,893	65,976	(-) 208917	-	-

**Taken from the previous sand audit reports prepared by ILDM*
***As per the field survey conducted by NIIST*
**** Bulk density worked out as 1.5 gm/cc and measured by NIIST (IS 2386 Part-3 & Kim H. Tan, 2nd Edition)*

CHAPTER – 6

ENVIRONMENTAL SAFEGUARDS IN RIVER SAND MINING

6.0 General

Sand mining from river bodies must be controlled and done with the adoption of necessary environmental measures. The District Survey Report is prepared in a way that not only identifies the mineral-bearing region but also defines the mining and no-mining zones while considering a variety of environmental and social aspects. Identification of sand mining sources, quantification of the resources, and mining viability are evaluated in light of various environmental factors, including proximity to protected areas, wetlands, creeks, and forests, as well as other elements like significant buildings, sites of archaeological interest, habitation, and restricted areas.

6.1 Protection of existing structures or Infrastructure

The identification of areas of mining and proximity to infrastructural structures and installations where mining shall be prohibited is an important objective of the District Survey Report. The distance of the mining area from the protected area, forest, bridges, important structures, habitation etc., is defined based on the area of sensitivity. The existence of permanent structures, such as tower lines, bridges, and monuments, if any, in the vicinity of the proposed mining site shall be verified by the DMG/Mining department prior to sanctioning of mining lease. Mining is not permitted in mining leases located in the 200-500 meter bridge subjected to a minimum of 250 metres on the upstream side and 500 metres on the downstream side, 200 metres upstream and downstream of the water supply/irrigation plan, 100 metres from the National Highway's side and railway line, 50 metres from a reservoir, canal, or structure, 25 metres from the State Highway's side and 10 metres from the margin of other routes***(Enforcement & Monitoring Guidelines for Sand Mining, MoEF&CC 2020).***

The list of identified infrastructural structures and protected areas like a forest, bridges, important structures, forests, bridges, important structures, habitation, water intake structures, etc., within 100m from the river banks of Chaliyar, Kadalundi and Bharathapuzha are given in **Table 6.1**

Table 6.1 List of existing structures or Infrastructure

Sl No	Stretch /Kadavu	Structure Name	Latitude & Longitude
1	Bharathapuzha	Pump house	10º 50’28.303” 76º 3’47.279”

6.2 Sustainable sand mining extraction methods

After water, the most exploited natural resource in the world is sand, gravel, and other building aggregates. The demand for these aggregates is increasing as a result of population increase, urbanization, and infrastructure development; thus, it is anticipated that this trend will continue. Due to the rising demand and the shift in extraction places away from urban and industrial centres, existing ecosystems are being significantly impacted, leading to problems with social and environmental sustainability on a local as well as global level. The important extraction methods of sand are given below.

a) Instream Mining

Instream sand mining is the extraction of sand and gravel from a river's active course. Instream sand requires less processing than other types of sand. Instream sand mining occurs in a variety of fluvial subsystems, including bars, point bars, and active channels. In most cases, instream sand extraction occurs first, followed by sand mining from other alluvial sources.

Figure 6.1 Representative picture of Instream mining

b) Floodplain Mining

The floodplain is the area directly behind the levee that is mostly filled with water during floods. Floodplains are typically areas formed by sediment deposition during the migratory periods of river channels. Floodplain sediments are made up of channel sand at the bottom, floodplain silt and clay at the top, and floodplain sand at the bottom. Floodplain mining is the removal of sand from the layer that represents channel sand in floodplain environments.

c) Bar scalping or skimming

The extraction of riverbed materials, particularly sand and gravel, from the tops of the bars is known as bar scalping or skimming. This technique will smooth any surface irregularities in the sand bar, and material extraction will be limited to what can be taken above an imaginary line sloping upwards and away from the water from a specified level above the river's water surface at the time of extraction. Depending on the pace of silt deposition, bar skimming is normally done once a year. The preferred approach of bar skimming is currently to keep the top one-third of the bar untouched in order to retain the hydraulic control exerted upstream by the riffle head. Mining is limited to a two-thirds area of the bar's downstream end.

d) Dry pit channel mining

Mechanical (i.e., bulldozers, scrapers, loaders, etc.) or hand sand excavation inside the active channel of dry intermitted or ephemeral stream beds. Upstream margins of dry pits are frequently abrupt. During high-flow seasons, these abrupt margins operate as head cuts, propagating upstream and inflicting damage to natural and man-made structures/features linked with river channels.

e) Wet pit channel mining

The excavation of a pit in an active channel below the surface water of a perennial stream or below the alluvial groundwater table is known as wet pit mining. This type of mining usually necessitates the use of a dragline or hydraulic excavator to extract sand and gravel from beneath the water's surface.

f) Bar excavation

At the downstream end of the bar, a pit is dug as a source of aggregate and a place to store sand and gravel. The pit may be connected to the channel at its downstream end after sand and gravel mining is completed to offer side-channel habitat.

g) Instream sand and gravel traps

For habitat enhancement, sand and gravel traps or bed load traps have been utilized to restrict sand flow in downstream waterways. If the quantity collected is commercially viable, these traps could be potential sources of commercial aggregate. The trap has the advantage of concentrating mining impacts to a single location, where heavy equipment can take sand and gravel without causing significant damage to riparian vegetation or other natural channel characteristics. Sand and gravel extraction can be done on an annual basis once the gravel traps are put up.

h) Channel-wide instream mining

During the dry season, channel-wide instream mining involves extracting sand and gravel from the whole active channel. This type of mining is done in rivers with highly varying flow regimes. The bed is levelled and lowered evenly. Because of worries about habitat damage, many developed countries do not promote this practice.

i) Manual and Mechanical Mining

Mining for river sand is done both manually and mechanically. Mining by hand is more environmentally friendly, and the amount of mining is nearly non-existent. Many developing and underdeveloped countries with small rivers and limited riverbed resources use this strategy. In manual mining methods, country boats and particularly constructed equivalent sand scoopers are typically utilized to extract sand. Sand is extracted from active river channels and floodplains using high-powered jet pumps and heavy machinery in mechanical mining.

Figure 6.2 Manual and Mechanical Mining

6.3 Transportation routes

River sand mining is a prevalent technique since human settlements are concentrated around rivers, and mining areas are chosen near markets or along transit routes to save transportation costs. The Guidelines include effective process re-engineering, transportation, and monitoring of the amount of extracted material. No river sand mining is allowed during the rainy season, and sand shall be extracted across the entire active channel during the dry season. The dispatch routes must avoid heavily populated areas and must enhance vehicle circulation on the road in accordance with IRC norms and the road's carrying capacity. In case of the non-availability of a dedicated transport route, an alternate path for mining movement shall be found and favoured to reduce disruption to the surrounding ecosystem. The total permitted dispatch is determined based on the production capacity by volume/weight and carrying capacity of the dispatch link roads, thereby regulating the production.

6.4 Criteria adopted for arriving at potential sand mining sites

The following criteria were adopted to declare potential sand mining sites based on the Sustainable Sand Mining Management Guidelines (SSMMG-2016) along with Enforcement and Monitoring Guidelines for Sand Mining (EMGSM-2020)

1. Sand-bearing sites are selected by defining the area of sensitivity by ascertaining the distance of the mining area from the protected area, forest, bridges, important structures, habitation etc.
2. The total sand reserves available in the river stretch were computed based on resource estimation using cross-section data, and the mineable sand volume is estimated based on the sand available above the Summer Water Level (SWL)/River Water Level.
3. The areas with mineable sand volume are demarcated as potential sand mining sites.
4. A buffer of 250m upstream and 500m downstream from any bridge and check dam, 300m on either side of water intake structures or pump house is left as no mining zone.
5. No sand mining shall be allowed within 15 m from the riverbanks.
6. During operation, the depth of mining shall not exceed 3 m depth from the riverbed level or river water level, whichever is less.

6.5 Anticipated impacts and mitigation measures

From an ecosystem perspective, sand is an important abiotic component which provides a habitat for many aquatic animals **(Kondolf et al., 2002)**. Sand and other sediment particles serve a critical role in minimizing the hungry water impact of river flows under high flow regimes in the active portion of the channels. This vast amount of material cannot be extracted and used without having a substantial environmental impact. Extraction has an influence on biodiversity, water turbidity, water table levels, and the terrain, as well as on the climate via carbon dioxide emissions from transportation. The goal of impact identification is to develop an Environmental Management Plan (EMP) to minimise any potential negative consequences that may emerge during project operations to the greatest degree feasible. This section discusses the impacts of the project activities on the environmental receptors that stand to get affected adversely by the project.

As per the sustainable sand mining guidelines, 2016 and India Meteorological Department (IMD), the normal dates of onset and withdrawal of SW monsoon in Kerala are 1st June and 15th October, respectively. With the above recommendation, the period of non-rainy days may be considered from 15th October to 31st May. The potential sand mining sites are identified on both halves of the river, and considering the environmental angle to reduce the cumulative impact of mining, it is recommended that the adjacent mines be operated phase-wise based on area and location with respect to other mine sites. The recommended period of duration for mining in the Bharathapuzha River of Malappuram district is given below:

Table 6.2 Recommended duration of sand mining in the Bharathapuzha stretch of Malappuram district

Sl.no	Sand Mining Sites (Bharathapuzha)	Recommended Months
1.	S4, S9, S11	October- November
2.	S7, S12, S13	December-January
3.	S1, S2, S3, S5, S6, S10	February- March
4.	S8	April-May

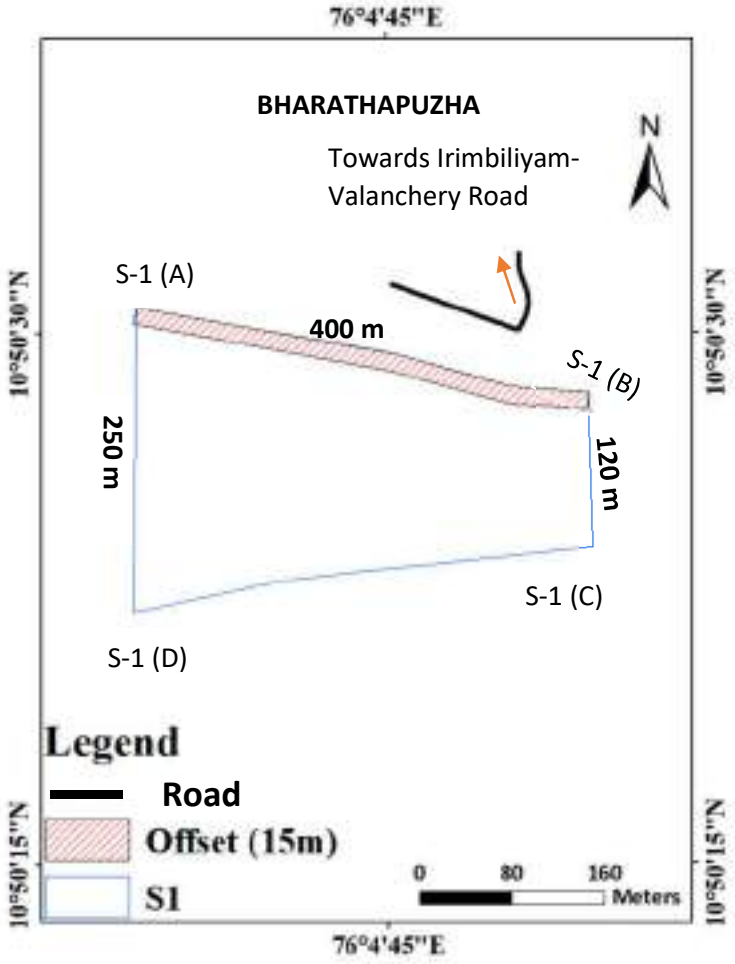
Table 6.3 Broad anticipated environmental impacts and mitigation measures

Impact category	Impact description	Mitigation/Recommendation measures
Identification and preparation of mining site	Mining should be carried out only in the identified stretches/kadavus where sand is available	▪ The lease area boundary shall be marked with pillars, and its geo coordinates made available in the mining plan. ▪ Mining should not be done in no-mining zones or prohibited areas demarcated in the DSR/mining plan.
Air pollution and dust management	▪ Mining operations generate dust and exhaust emissions from the machinery used for extraction ▪ Exhaust and fugitive emissions during the transportation of mined mineral is a significant source of air pollution	▪ All the machinery and tippers used during mining and transportation should be PUC certified and regularly maintained. ▪ The mineral transportation vehicle should be covered using tarpaulin and shall not be overloaded. ▪ The tippers for transporting the mined material should avoid the densely populated village haul roads.
Noise management	Noise pollution due to mining operations and transportation may affect the labour working and surrounding habitation	▪ All the machinery and tippers used during mining and transportation should be regularly maintained. ▪ The operators of heavy mining machinery and labour engaged should be provided with ear plugs and PPE. ▪ Sand mining activity should be functioned only between 7 am to 4 pm (as per The Kerala Protection of Riverbanks and Regulation of Removal of Sand Act, 2001), as amended in 2013 and the transporting vehicles should not be parked inside the mine lease area during night time.
Water quality	▪ Depth of mining in the riverbed shall be determined based on the summer water level to prevent the lowering of the groundwater table	▪ The ultimate working depth shall be up to 3.0 m or water level, whichever is less.

	▪ During mining operations, the turbidity of the river may increase if not taken care off	▪ Mining is not allowed during the monsoon season (June to October, as per IMD) and on heavy rainy days. ▪ Regular monitoring of turbidity is necessary, and in case the turbidity exceeds the standard, the mining operation shall halt until it reaches below standard level. ▪ No watercourse shall be diverted for sand mining purposes. Mining operations do not hinder any natural water stream or water supplies. ▪ There shall be no spillage of oil or waste into the river from the operating machinery or tippers.
Bio-diversity protection	▪ Alteration or modification of the stream's physical characteristics may cause an impact on the ecological equilibrium of the riverine regime, disturbance in channel configuration and flow paths, and ultimately the in-stream biota and riparian habitats	▪ Spring sources shall not be affected due to mining activities. ▪ Greenbelt development should be encouraged by the mine lease owner to restore the affected flora, if any. ▪ Mining should be avoided within eco-sensitive zones and breeding habitats
Management of instability and erosion	▪ Improper mining techniques may cause the instability of the river bank and erosion ▪ Bank erosion and change in the morphology of the river can destroy the riparian vegetative cover	▪ To maintain the safety and stability of riverbanks, a buffer of 1/4th of width (case-to-case basis) from the bank shall be maintained. ▪ No extraction of sand/boulders in landslide-prone areas. ▪ Based on the requirement-controlled clearance of riparian vegetation shall be undertaken.
Protection of infrastructure	Sand mining activity may cause damage to permanent structures, flood protection works, and places of cultural, religious, historical, and archaeological importance	▪ There shall be no quarrying of sand in any riverbed or adjoining area which is located within a 500-metre radial distance from the location of any bridge, water supply system, infiltration well or pumping installation.

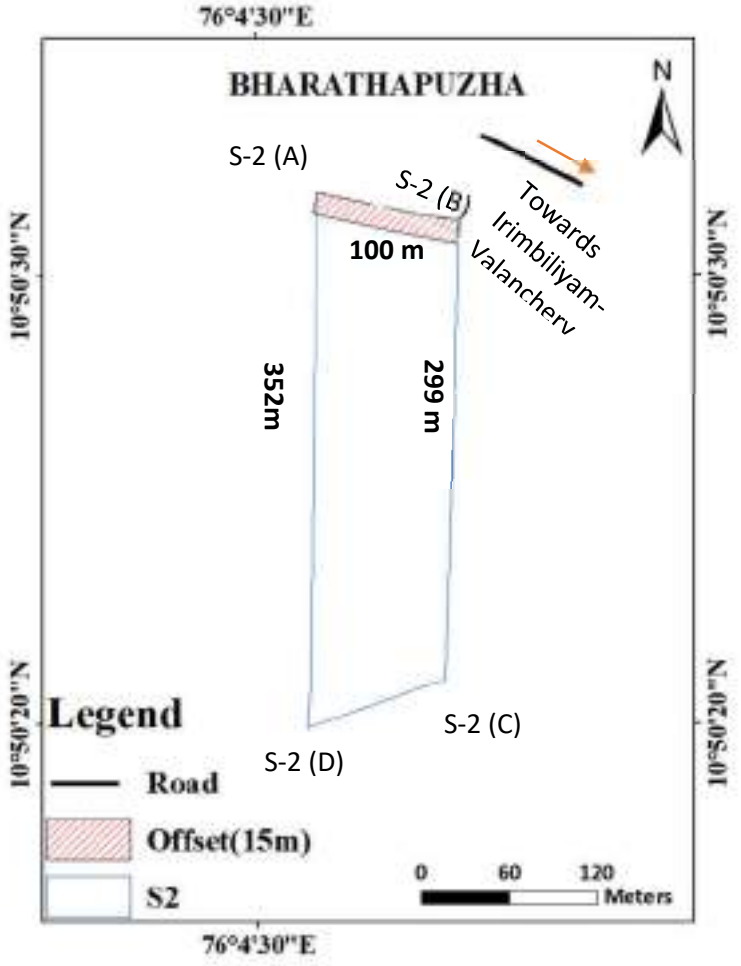
		▪ However, an appropriate safety zone (not less than 250 metres) should be worked out on a case-to-case basis, taking into account the structural parameters, location aspects and flow rate.
Enhancing road safety	During the transportation of mined material, the road may get damaged, and there is a possibility of accidents too	▪ The leaseholder shall ensure that the tippers used for the transportation of mined material have fitness and PUC certificates. ▪ The approach road's intersection with the main road should be correctly designed, with the necessary width and shape for safe traffic flow. ▪ The speed of the vehicle shall not exceed 30 km/h, and no stacking is allowed on the roadside along National Highways.
Health and safety	There may be respiratory complications caused by inhaling fine particles from the large amounts of dust generated by mining activities	▪ The workers engaged in mining activities shall be provided by PPE. ▪ The transportation of minerals should not be done through villages/habitation. ▪ Mining should be avoided in landslide-prone areas. ▪ There shall be periodical medical examinations of the workers engaged and records to be maintained.
Monitoring the mining of minerals and their transportation	▪ Environmental or ecological damage caused due to illegal mining and unscientific mining ▪ In addition to influencing groundwater recharge, it damages the habitat of aquatic creatures and microorganisms.	▪ The mine leaseholder is required to maintain accurate records of the amount of mineral extracted, how it was transported from the mine, its registration number, the driver, and the mine plan. ▪ Access to each mining lease site should be managed in such a way that vehicles transporting minerals from that region are traced and accounted for. ▪ The State/District Level Committee should monitor the weight of minerals being taken out of the lease area~~,~~ and the number of trucks moving out with the mineral using IT-enabled services.

		▪ The tippers used for transportation should be registered tippers with GPS capability, and the transportation route should be clearly defined for simple monitoring, control over tipper overloading, control over mineral spillage, and so on. ▪ Regular monitoring of mined minerals, as well as their transit and storage, must be assured, and all information must be documented in a centralized database to allow for simple tracking of illegal material.
Mineral conservation	▪ Excessive sand mining can disrupt the river bed, cause it to shift course, destroy banks, and cause flooding.	To alleviate stress on the natural ecosystem, substitute materials such as M-sand should be advocated in place of natural River sand.



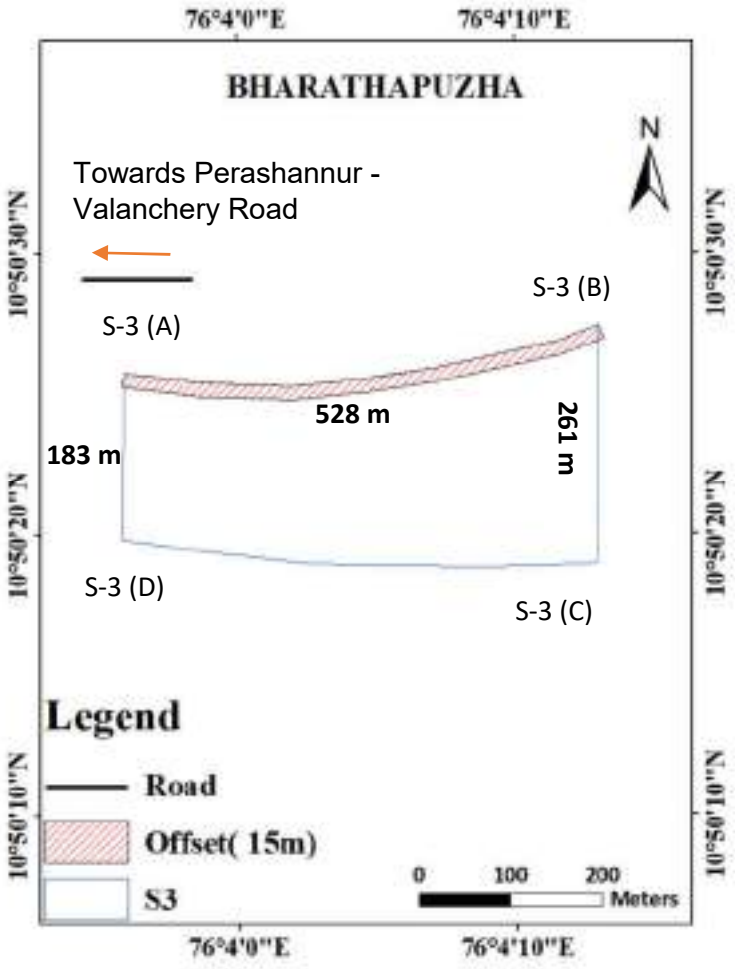
S-1	
AREA (Ha)	7.078
TOTAL SAND (m^3)	163465
MINEABLE SAND (m^3)	43670
MINEABLE SAND (Tonnes)	65505

	Geographical Coordinates	
Point	Latitude	Longitude
S-1 (A)	10.84187104	76.07714427
S-1 (B)	10.84119127	76.08072779
S-1 (C)	10.83997806	76.08076395
S-1 (D)	10.83948273	76.07711244



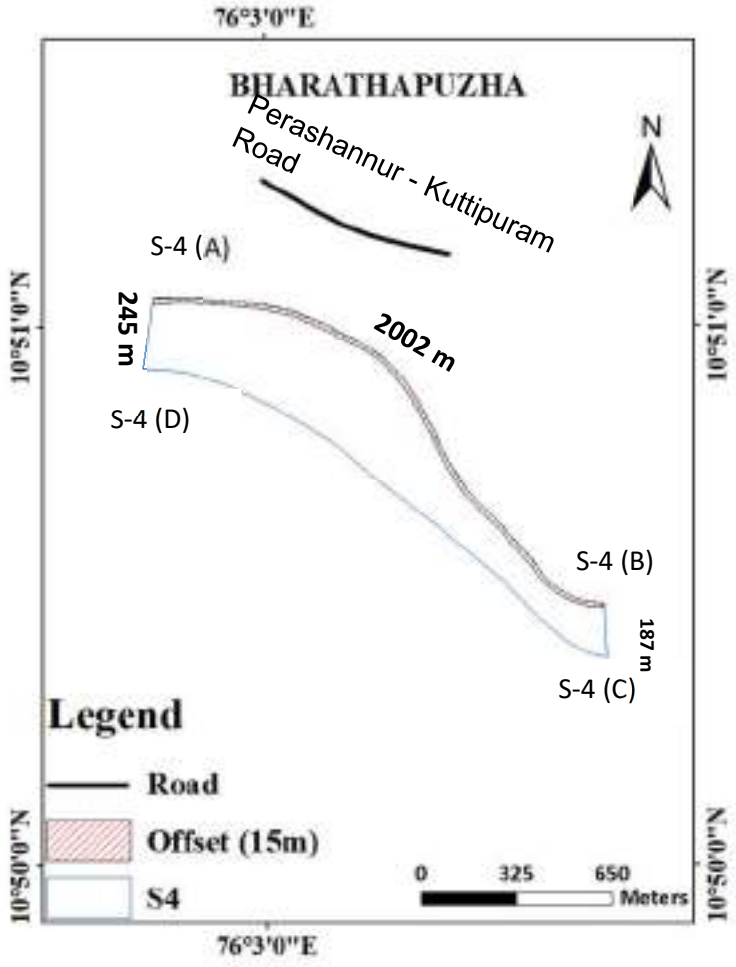
S-2	
AREA (Ha)	3.085
TOTAL SAND (m^3)	141660
MINEABLE SAND (m^3)	79910
MINEABLE SAND (Tonnes)	119865

	Geographical Coordinates	
Point	Latitude	Longitude
S-2 (A)	10.84217833	76.07534246
S-2 (B)	10.84199941	76.07623787
S-2 (C)	10.83916342	76.07613597
S-2 (D)	10.83886414	76.0752735



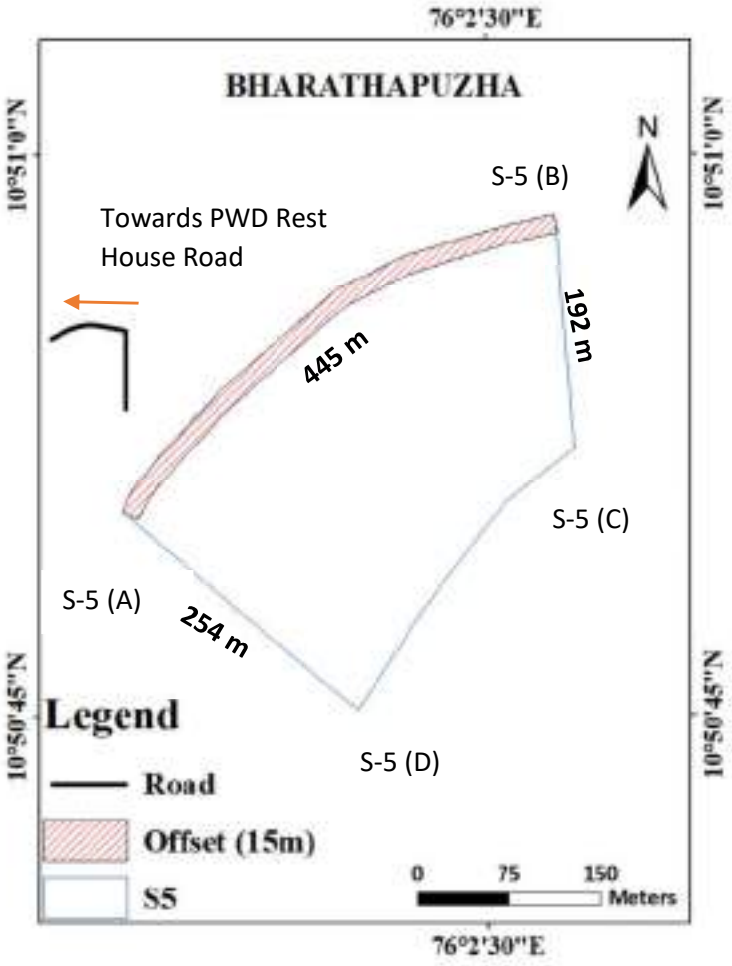
S-3	
AREA (Ha)	10.093
TOTAL SAND (m^3)	274630
MINEABLE SAND (m^3)	49340
MINEABLE SAND (Tonnes)	74010

	Geographical Coordinates	
Point	Latitude	Longitude
S-3 (A)	10.84048981	76.06548786
S-3 (B)	10.84095587	76.07023964
S-3 (C)	10.83859549	76.07021574
S-3 (D)	10.83883688	76.06546555



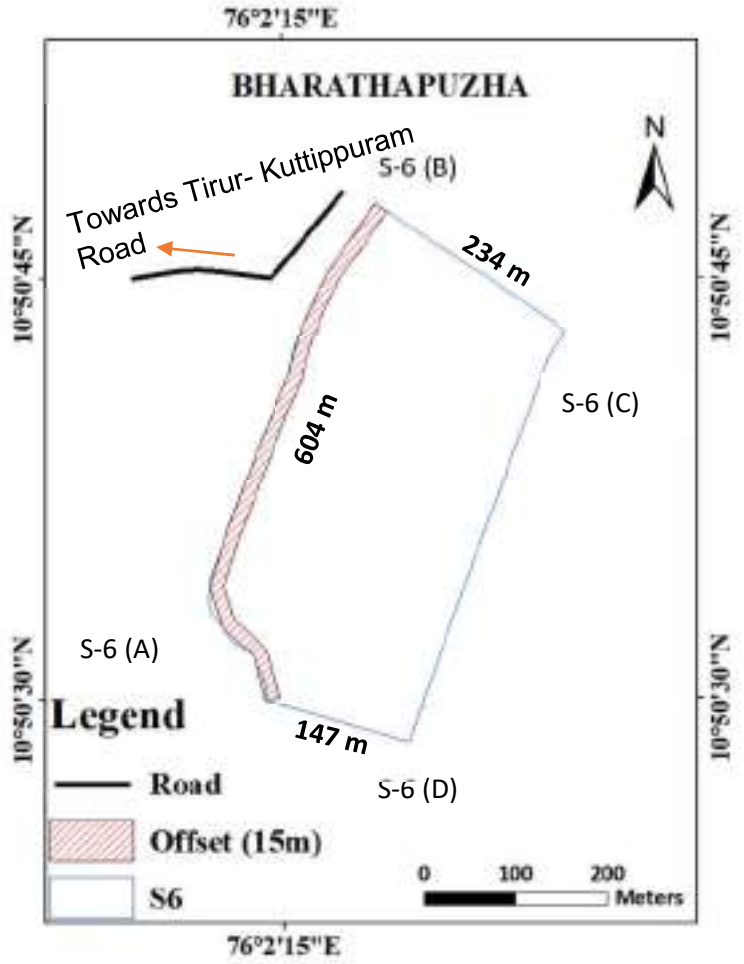
S-4	
AREA (Ha)	41.995
TOTAL SAND (m^3)	1105720
MINEABLE SAND (m^3)	650450
MINEABLE SAND (Tonnes)	975675

	Geographical Coordinates	
Point	Latitude	Longitude
S-4 (A)	10.85087914	76.04645256
S-4 (B)	10.84140923	76.06055433
S-4 (C)	10.83972439	76.06061495
S-4 (D)	10.84868661	76.04613402



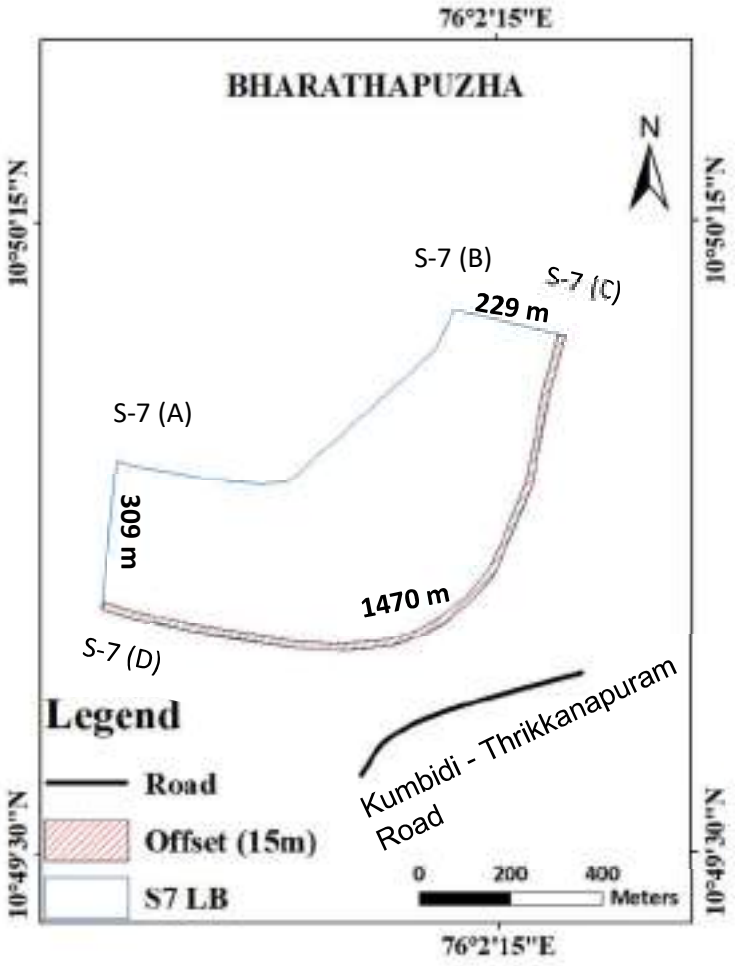
S-5	
AREA (Ha)	7.593
TOTAL SAND (m^3)	154340
MINEABLE SAND (m^3)	123480
MINEABLE SAND (Tonnes)	185220

	Geographical Coordinates	
Point	Latitude	Longitude
S-5 (A)	10.84735525	76.03888833
S-5 (B)	10.84954825	76.04213419
S-5 (C)	10.84782237	76.04228996
S-5 (D)	10.84588192	76.04066407



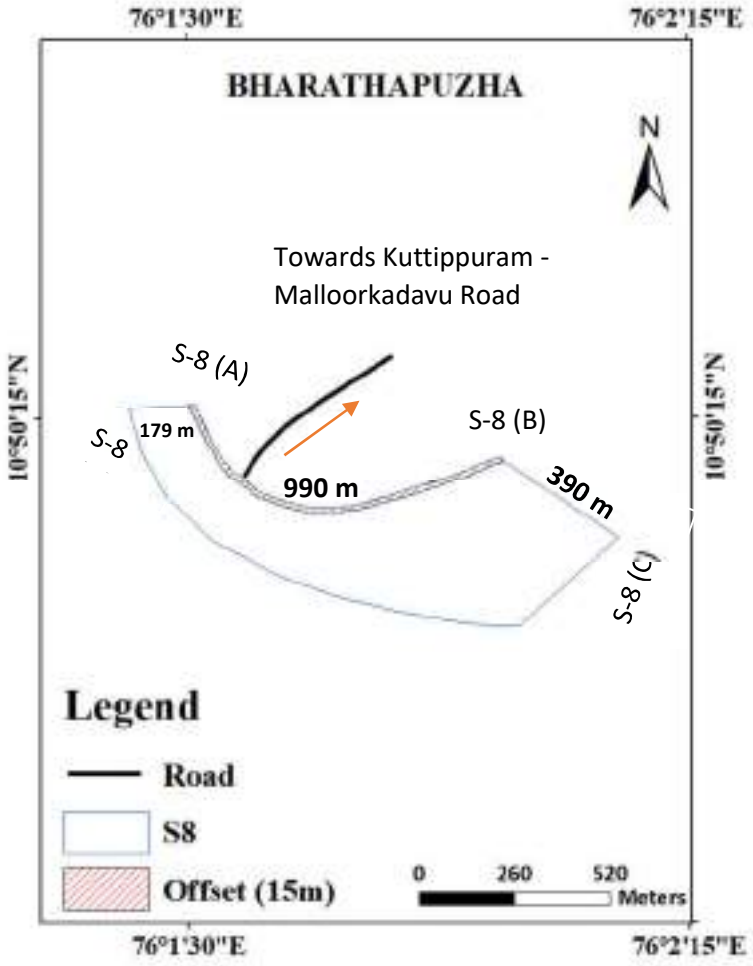
S-6	
AREA (Ha)	12.238
TOTAL SAND (m^3)	210430
MINEABLE SAND (m^3)	210430
MINEABLE SAND (Tonnes)	315645

	Geographical Coordinates	
Point	Latitude	Longitude
S-6 (A)	10.84165575	76.03729124
S-6 (B)	10.84658072	76.03840735
S-6 (C)	10.8453003	76.04028215
S-6 (D)	10.8412515	76.03872518



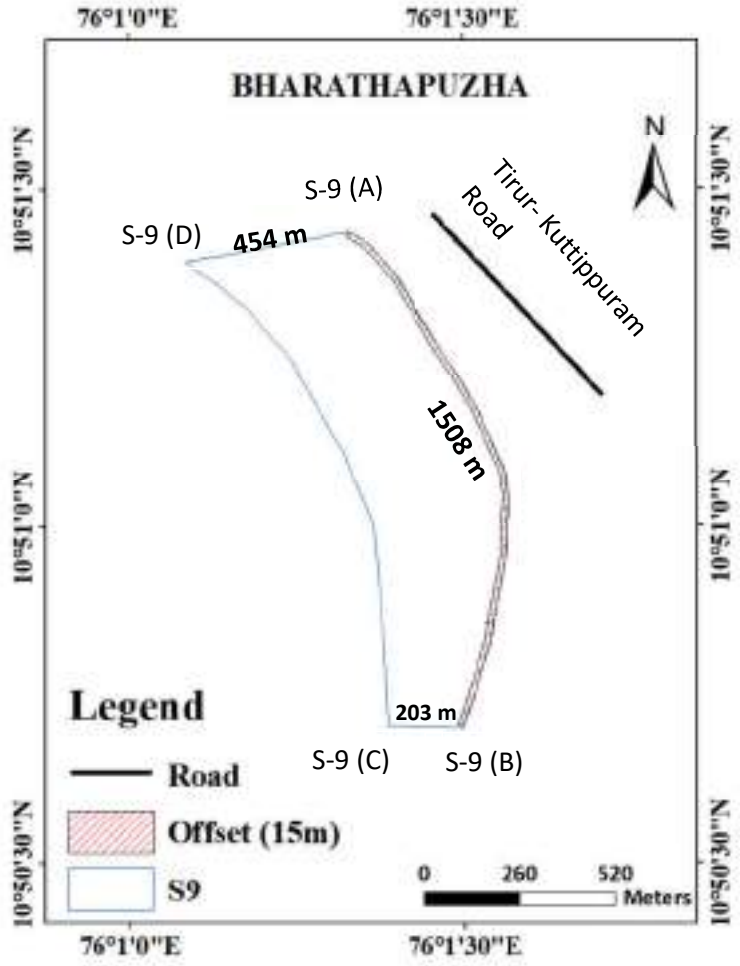
S-7	
AREA (Ha)	40.251
TOTAL SAND (m^3)	1569315
MINEABLE SAND (m^3)	639740
MINEABLE SAND (Tonnes)	959610

	Geographical Coordinates	
Point	Latitude	Longitude
S-7 (A)	10.83277106	76.02985711
S-7 (B)	10.83574704	76.0366473
S-7 (C)	10.83523517	76.03881927
S-7 (D)	10.82985417	76.02955703



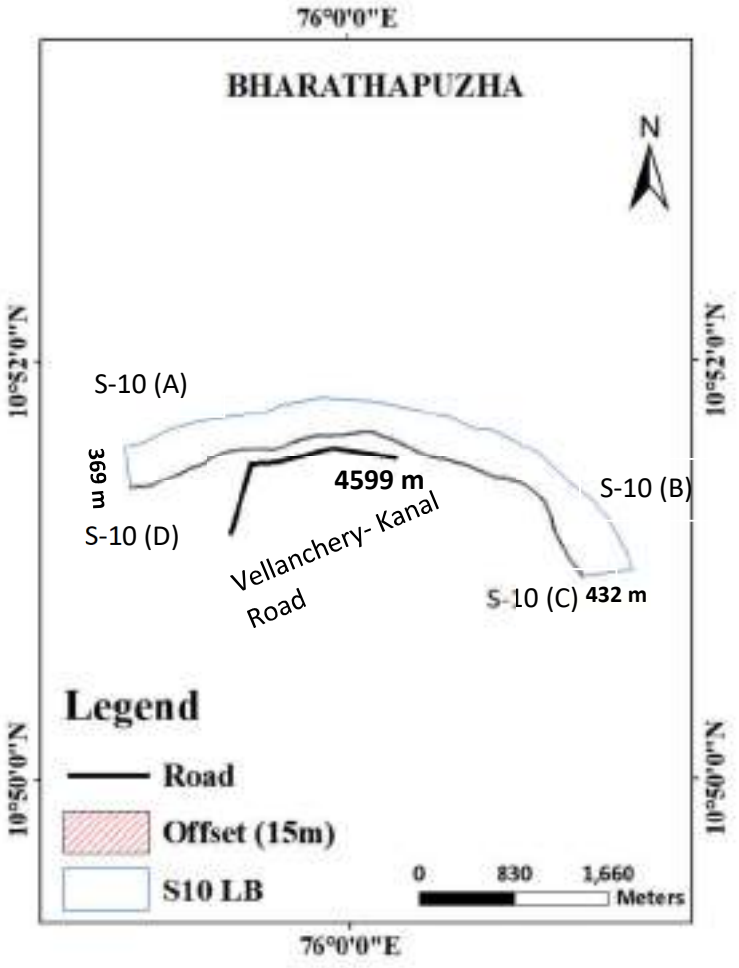
S-8	
AREA (Ha)	34.926
TOTAL SAND (m^3)	1214230
MINEABLE SAND (m^3)	629600
MINEABLE SAND (Tonnes)	944400

	Geographical Coordinates	
Point	Latitude	Longitude
S-8 (A)	10.83781202	76.02517117
S-8 (B)	10.83650037	76.03278367
S-8 (C)	10.83452864	76.035737
S-8 (D)	10.83771365	76.02353998



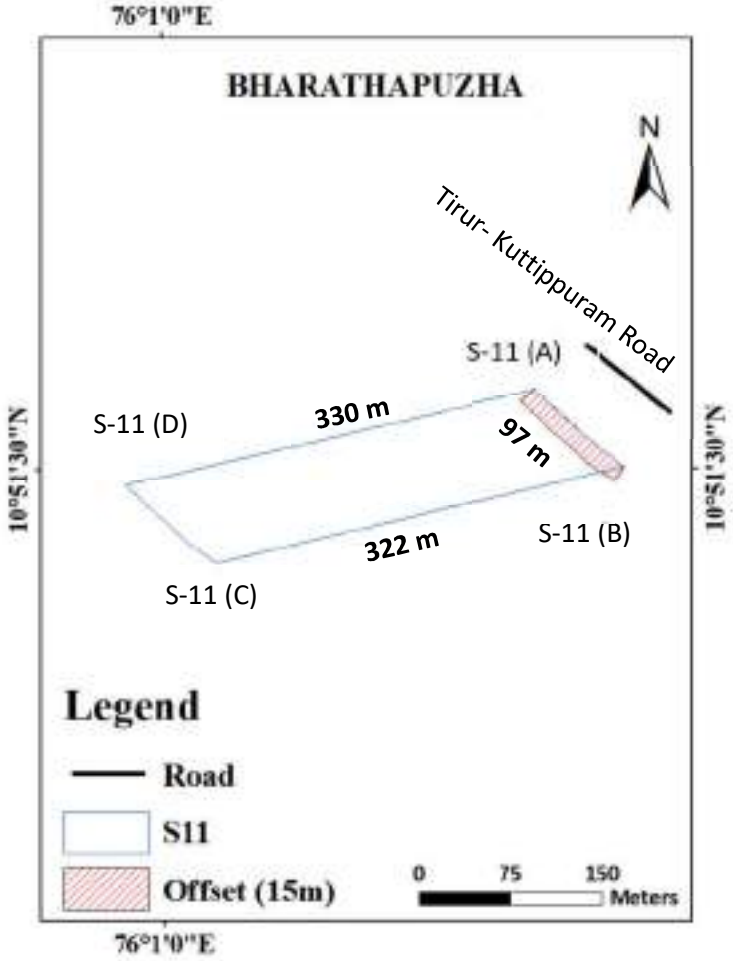
S-9	
AREA (Ha)	47.928
TOTAL SAND (m^3)	1387450
MINEABLE SAND (m^3)	653710
MINEABLE SAND (Tonnes)	980565

	Geographical Coordinates	
Point	Latitude	Longitude
S-9 (A)	10.85730983	76.02212143
S-9 (B)	10.84501209	76.02493966
S-9 (C)	10.84504915	76.02308487
S-9 (D)	10.85654736	76.01804935



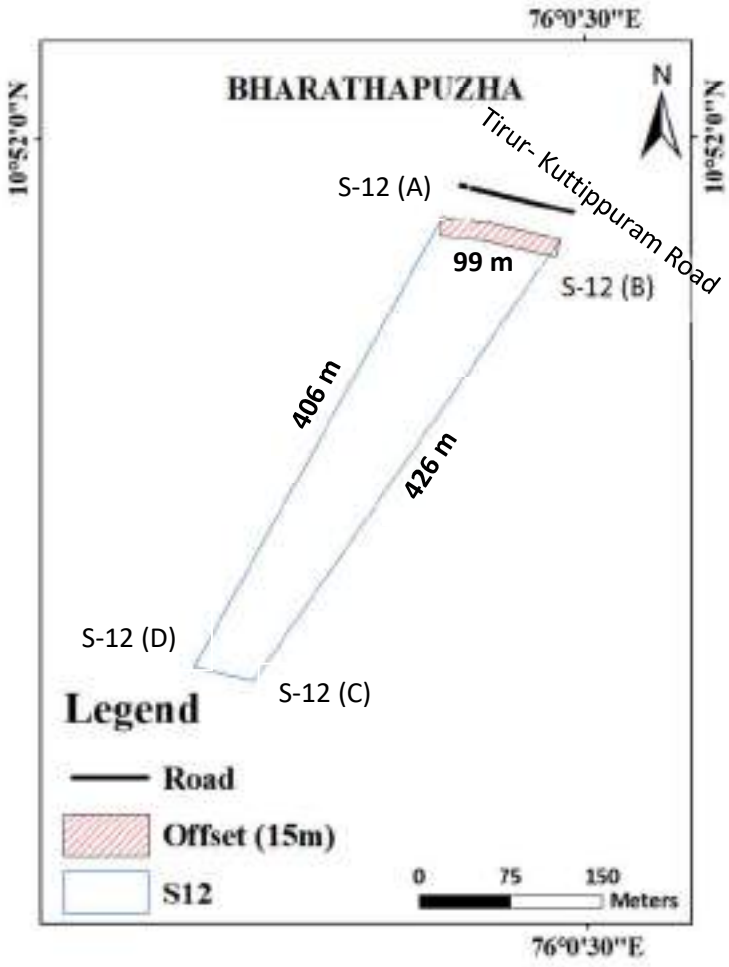
S-10	
AREA (Ha)	165.489
TOTAL SAND (m^3)	3638750
MINEABLE SAND (m^3)	1124410
MINEABLE SAND (Tonnes)	1686615

	Geographical Coordinates	
Point	Latitude	Longitude
S-10 (A)	10.85990613	75.98198594
S-10 (B)	10.84996806	76.02272315
S-10 (C)	10.84946302	76.01864538
S-10 (D)	10.85646419	75.9824273



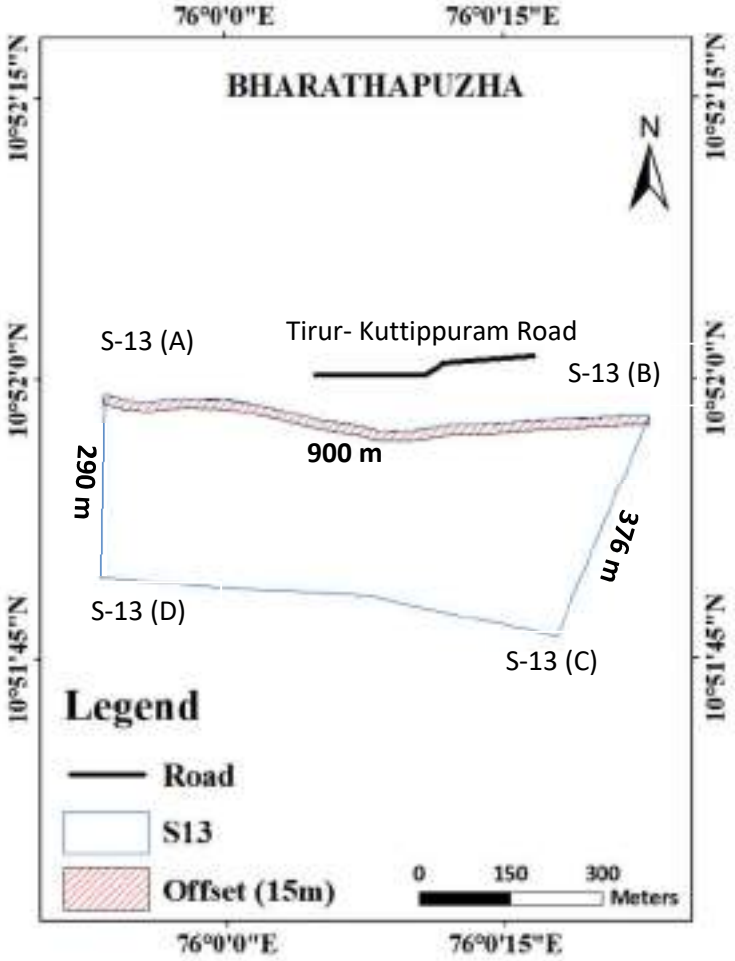
S-11	
AREA (Ha)	2.560
TOTAL SAND (m^3)	63580
MINEABLE SAND (m^3)	12720
MINEABLE SAND (Tonnes)	19080

	Geographical Coordinates	
Point	Latitude	Longitude
S-11 (A)	10.85891091	76.01941622
S-11 (B)	10.85835073	76.02008457
S-11 (C)	10.85763062	76.01702723
S-11 (D)	10.85822011	76.01635061



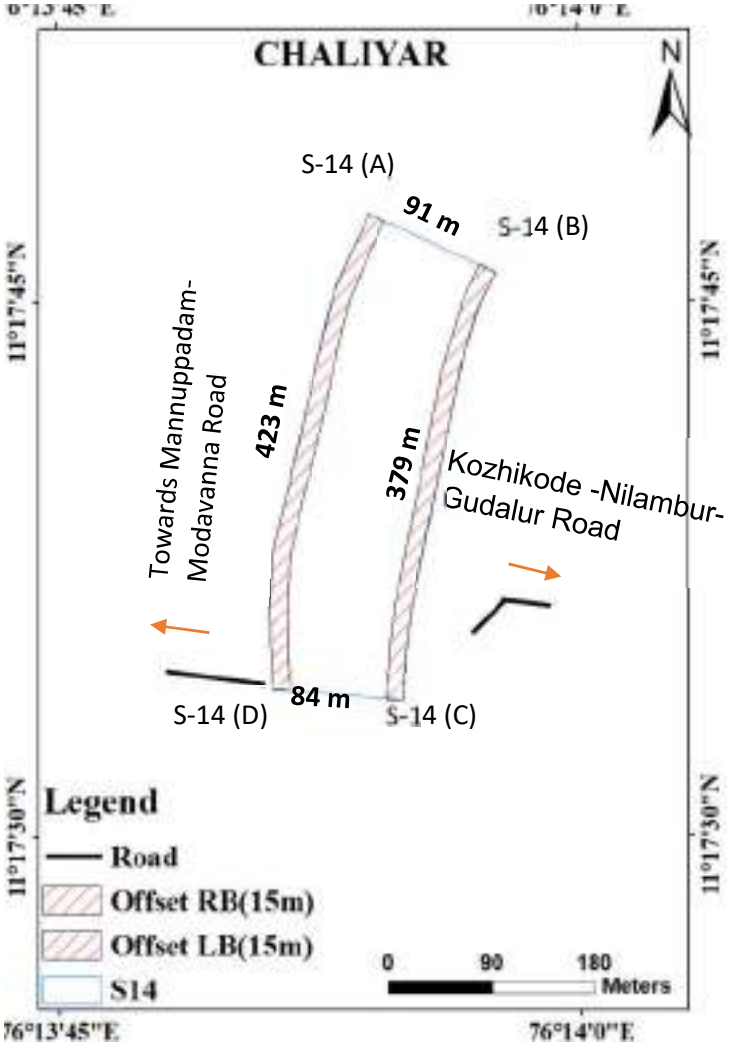
S-12	
AREA (Ha)	2.878
TOTAL SAND (m^3)	77110
MINEABLE SAND (m^3)	22390
MINEABLE SAND (Tonnes)	33585

	Geographical Coordinates	
Point	Latitude	Longitude
S-12 (A)	10.8660846	76.00722631
S-12 (B)	10.86591801	76.00811667
S-12 (C)	10.86264951	76.00580408
S-12 (D)	10.86274691	76.0053543



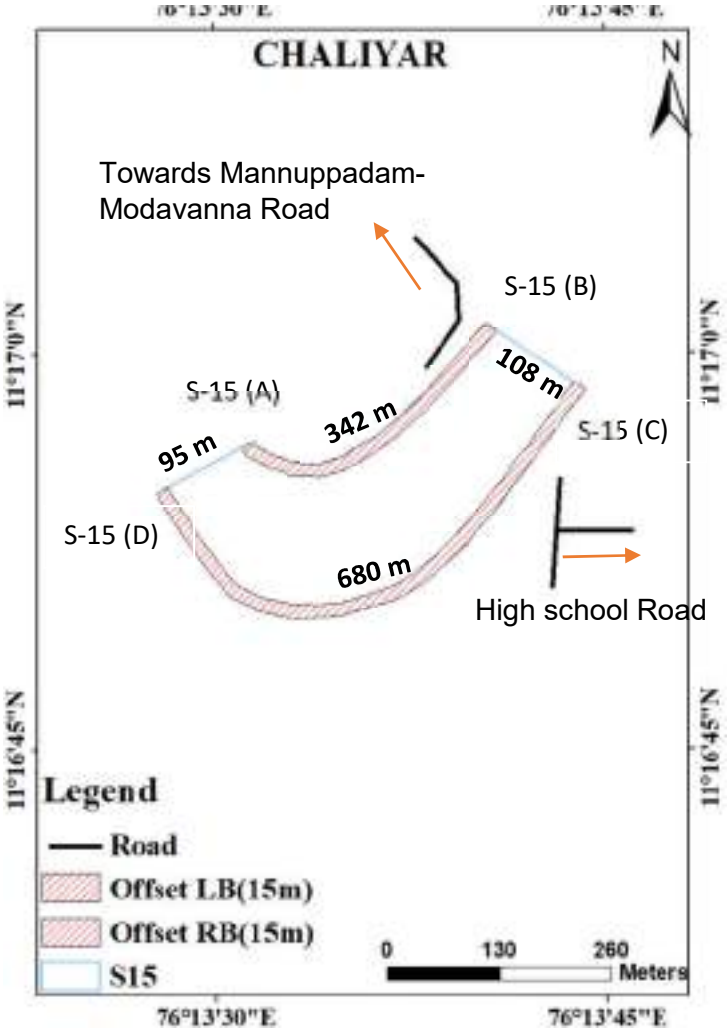
S-13	
AREA (Ha)	23.963
TOTAL SAND (m^3)	611270
MINEABLE SAND (m^3)	150260
MINEABLE SAND (Tonnes)	225390

	Geographical Coordinates	
Point	Latitude	Longitude
S-13 (A)	10.86644414	75.99815515
S-13 (B)	10.86611375	76.00630569
S-13 (C)	10.86284179	76.0049307
S-13 (D)	10.86373805	75.99808689



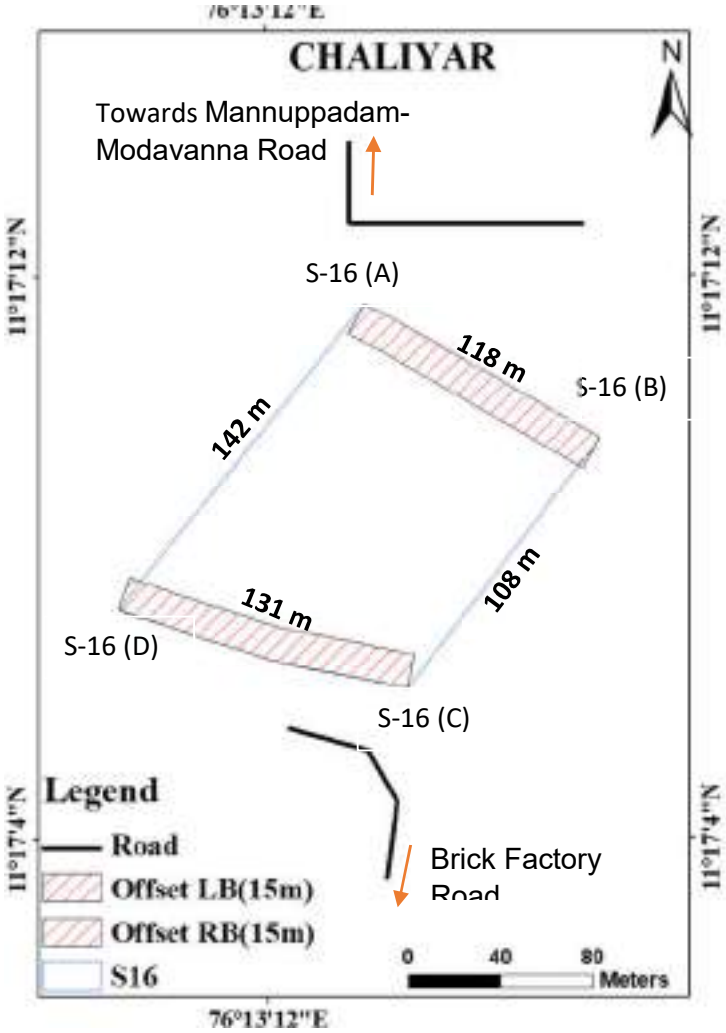
S-14	
AREA (Ha)	3.738
TOTAL SAND (m^3)	74950
MINEABLE SAND (m^3)	13420
MINEABLE SAND (Tonnes)	20130

	Geographical Coordinates	
Point	Latitude	Longitude
S-14 (A)	11.2928135	76.23086556
S-14 (B)	11.29650778	76.23164575
S-14 (C)	11.29605447	76.2326481
S-14 (D)	11.29272714	76.23190119



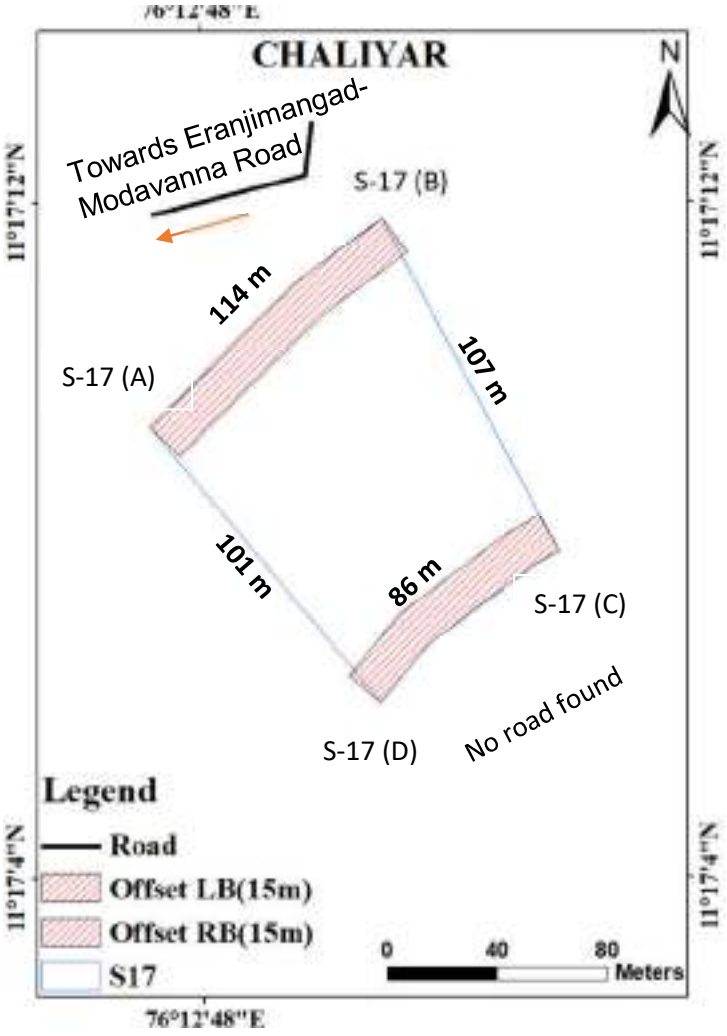
S-15	
AREA (Ha)	6.49309
TOTAL SAND (m^3)	130330
MINEABLE SAND (m^3)	43420
MINEABLE SAND (Tonnes)	65130

	Geographical Coordinates	
Point	Latitude	Longitude
S-15 (A)	11.2823996	76.22537076
S-15 (B)	11.28364479	76.22788484
S-15 (C)	11.28295015	76.22892779
S-15 (D)	11.28186864	76.22436337



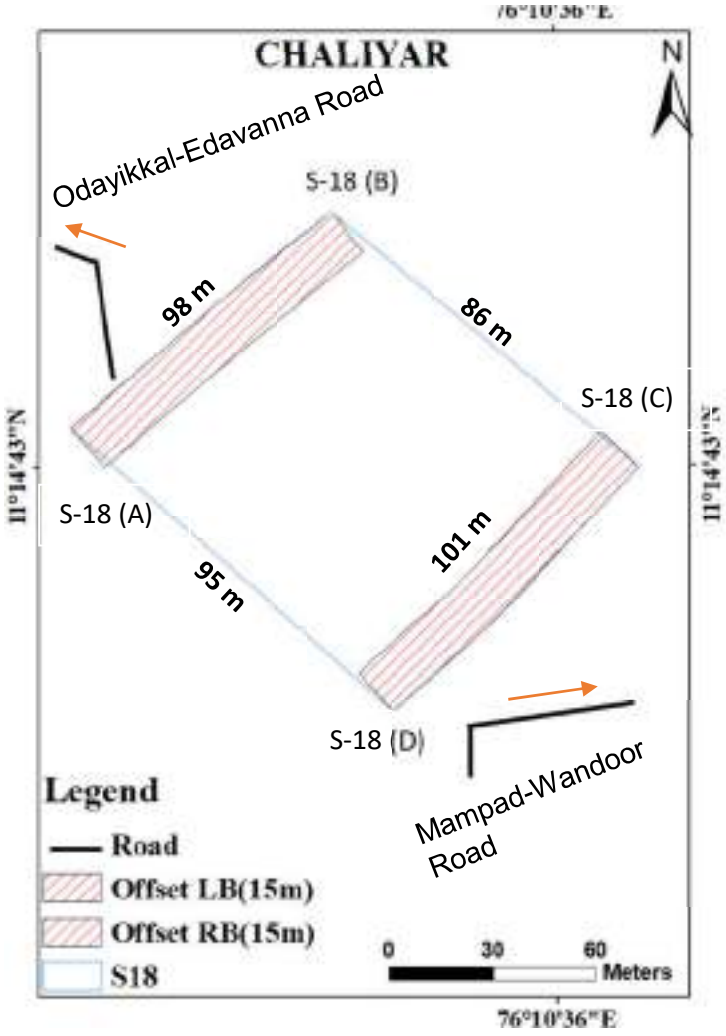
S-16	
AREA (Ha)	1.495494
TOTAL SAND (m^3)	21010
MINEABLE SAND (m^3)	21010
MINEABLE SAND (Tonnes)	31515

	Geographical Coordinates	
Point	Latitude	Longitude
S-16 (A)	11.2865557	76.22036862
S-16 (B)	11.28602599	76.22130766
S-16 (C)	11.28503829	76.22053715
S-16 (D)	11.28534989	76.2193816



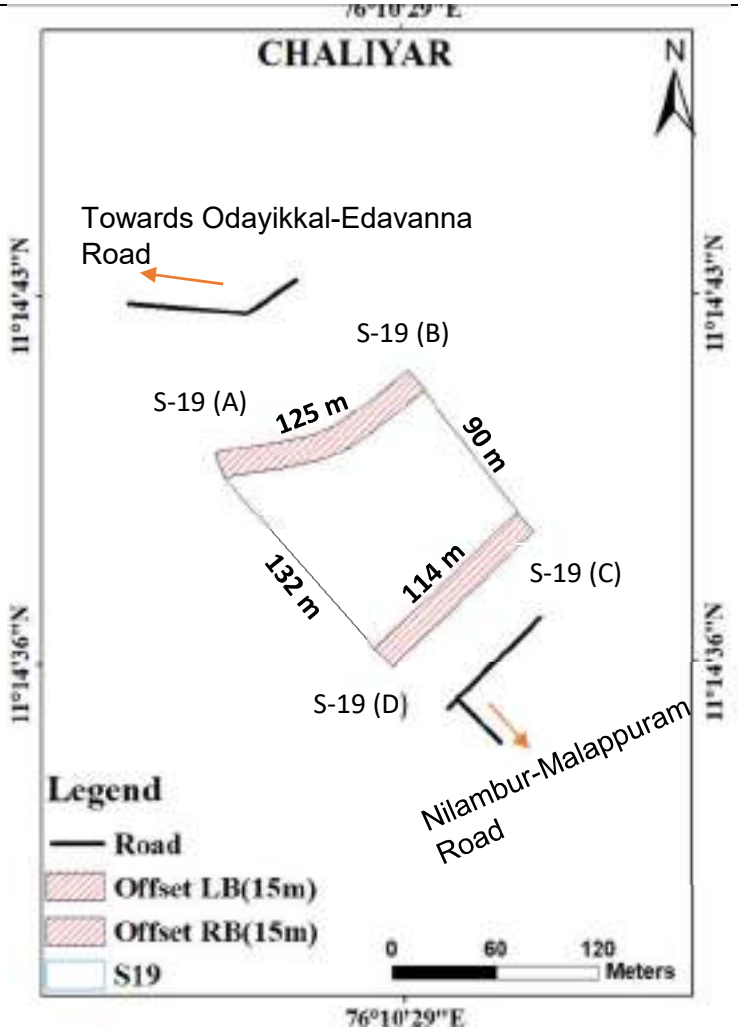
S-17	
AREA (Ha)	1.00
TOTAL SAND (m^3)	8720
MINEABLE SAND (m^3)	3450
MINEABLE SAND (Tonnes)	5175

	Geographical Coordinates	
Point	Latitude	Longitude
S-17 (A)	11.28592862	76.21313586
S-17 (B)	11.28661287	76.21391088
S-17 (C)	11.28551449	76.2144954
S-17 (D)	11.28502229	76.21389971



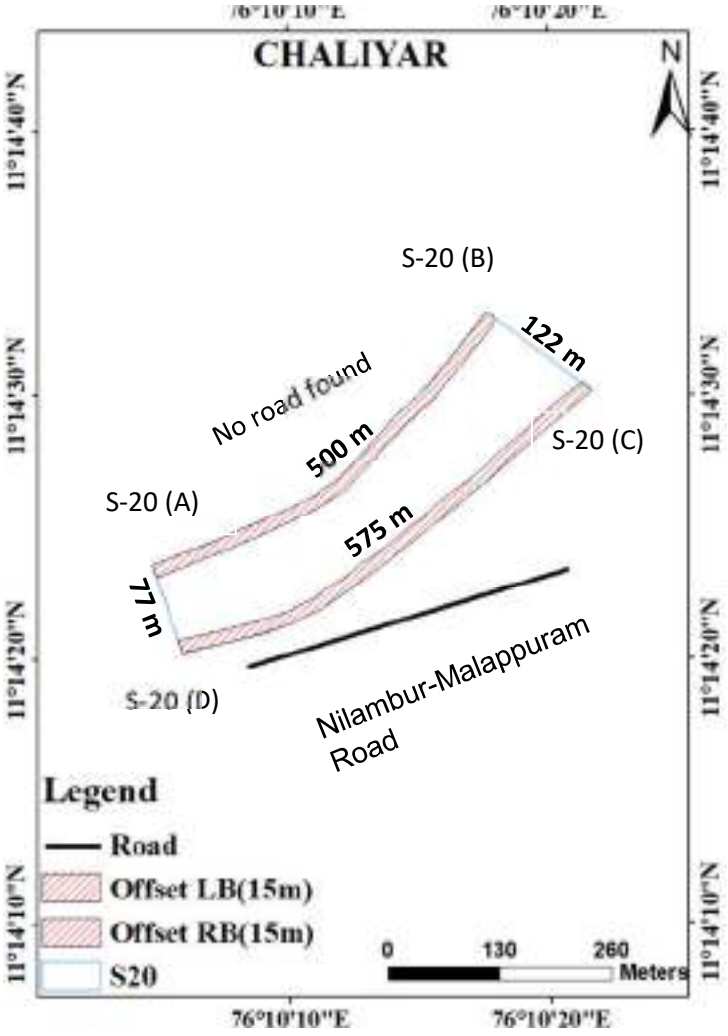
S-18	
AREA (Ha)	0.90564
TOTAL SAND (m^3)	15650
MINEABLE SAND (m^3)	3700
MINEABLE SAND (Tonnes)	5550

	Geographical Coordinates	
Point	Latitude	Longitude
S-18 (A)	11.24538069	76.17535239
S-18 (B)	11.24594527	76.17604262
S-18 (C)	11.2452758	76.17686156
S-18 (D)	11.244633	76.17620802



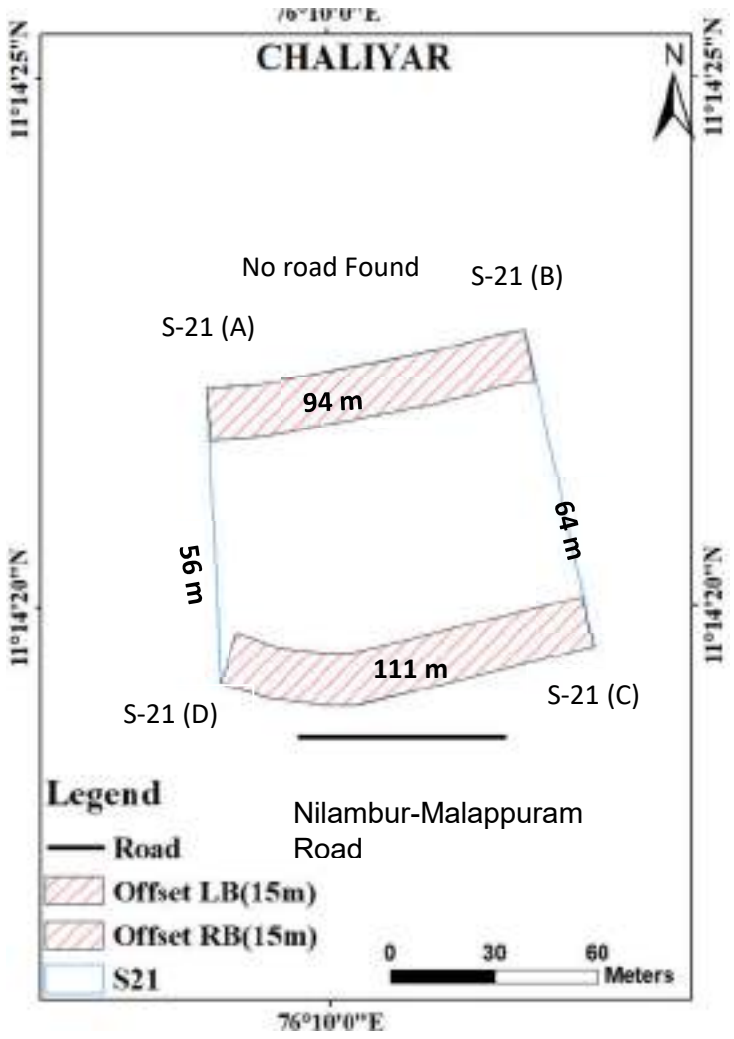
S-19	
AREA (Ha)	1.154592
TOTAL SAND (m^3)	14400
MINEABLE SAND (m^3)	14400
MINEABLE SAND (Tonnes)	21600

	Geographical Coordinates	
Point	Latitude	Longitude
S-19 (A)	11.24444841	76.1736942
S-19 (B)	11.24486809	76.17472238
S-19 (C)	11.24402982	76.1753795
S-19 (D)	11.24332168	76.174639



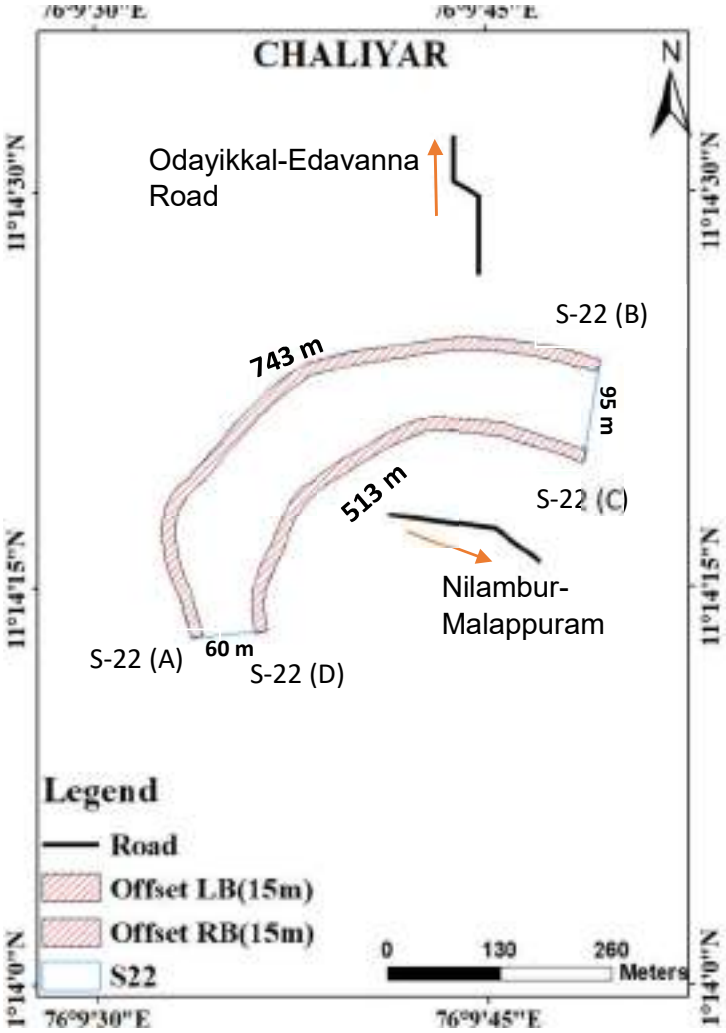
S-20	
AREA (Ha)	4.974194
TOTAL SAND (m^3)	69230
MINEABLE SAND (m^3)	16370
MINEABLE SAND (Tonnes)	24555

	Geographical Coordinates	
Point	Latitude	Longitude
S-20 (A)	11.23988024	76.16796062
S-20 (B)	11.24253391	76.17153308
S-20 (C)	11.24170304	76.17264538
S-20 (D)	11.23896031	76.16827837



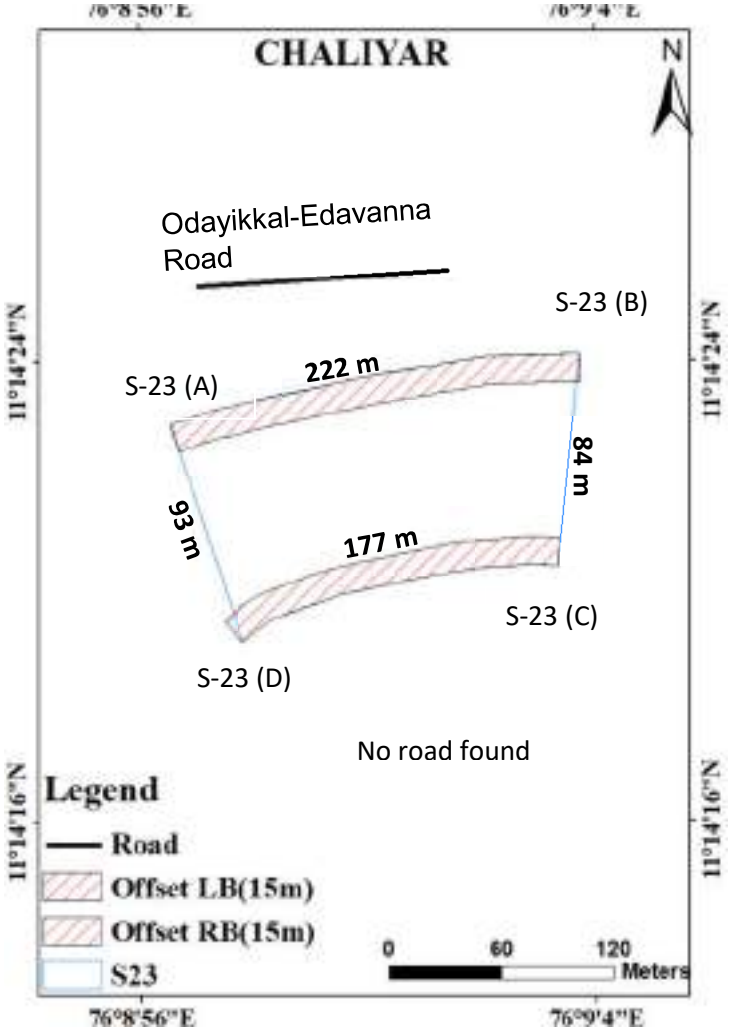
S-21	
AREA (Ha)	0.658703
TOTAL SAND (m^3)	5380
MINEABLE SAND (m^3)	920
MINEABLE SAND (Tonnes)	1380

	Geographical Coordinates	
Point	Latitude	Longitude
S-21 (A)	11.23945921	76.16631702
S-21 (B)	11.23961426	76.16716273
S-21 (C)	11.2387815	76.16734201
S-21 (D)	11.23869017	76.16634916



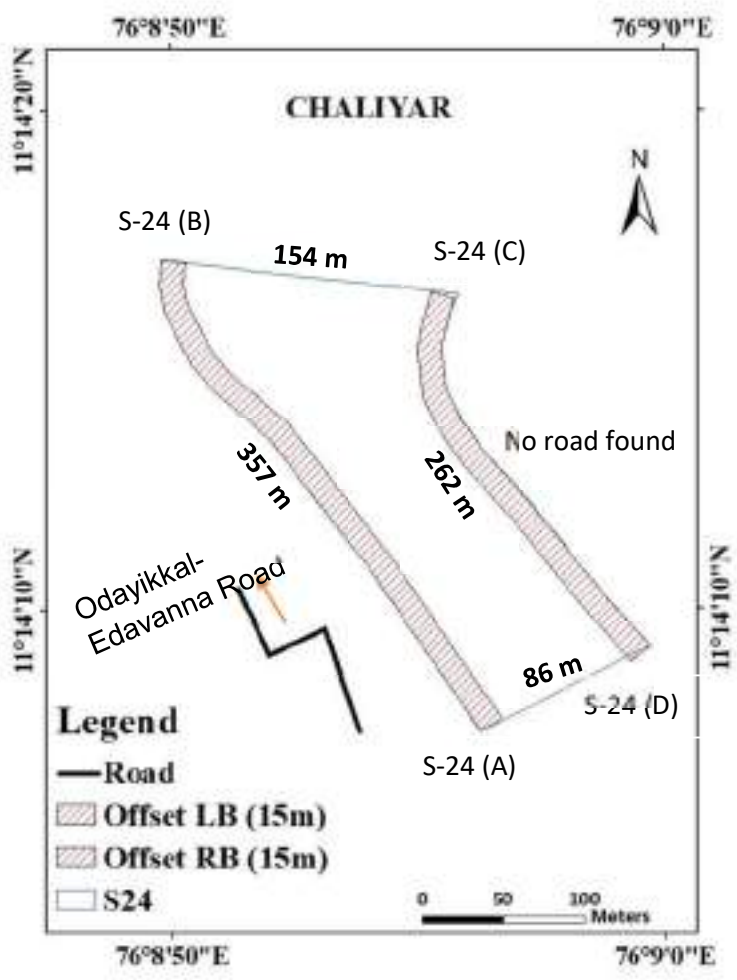
S-22	
AREA (Ha)	5.523645
TOTAL SAND (m^3)	89230
MINEABLE SAND (m^3)	44090
MINEABLE SAND (Tonnes)	66135

	Geographical Coordinates	
Point	Latitude	Longitude
S-22 (A)	11.23697547	76.1593211
S-22 (B)	11.23989111	76.16369168
S-22 (C)	11.23881746	76.16351366
S-22 (D)	11.2370554	76.16013448



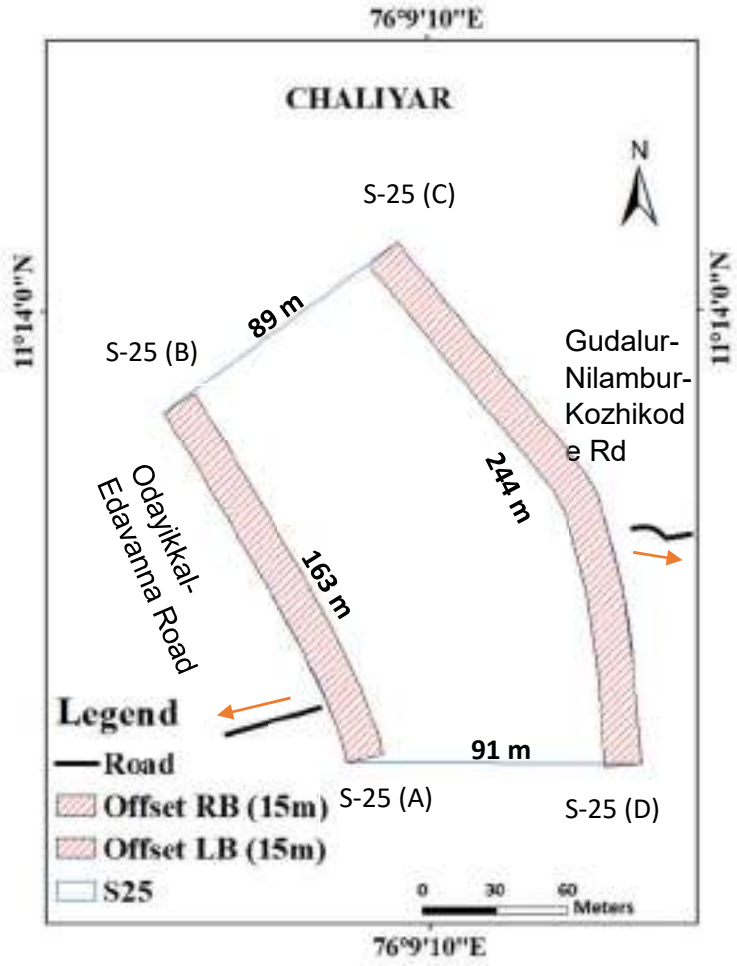
S-23	
AREA (Ha)	1.643374
TOTAL SAND (m^3)	12090
MINEABLE SAND (m^3)	3130
MINEABLE SAND (Tonnes)	4695

	Geographical Coordinates	
Point	Latitude	Longitude
S-23 (A)	11.2396927	76.14901151
S-23 (B)	11.24002997	76.15100849
S-23 (C)	11.23900675	76.15090516
S-23 (D)	11.23864297	76.1493576



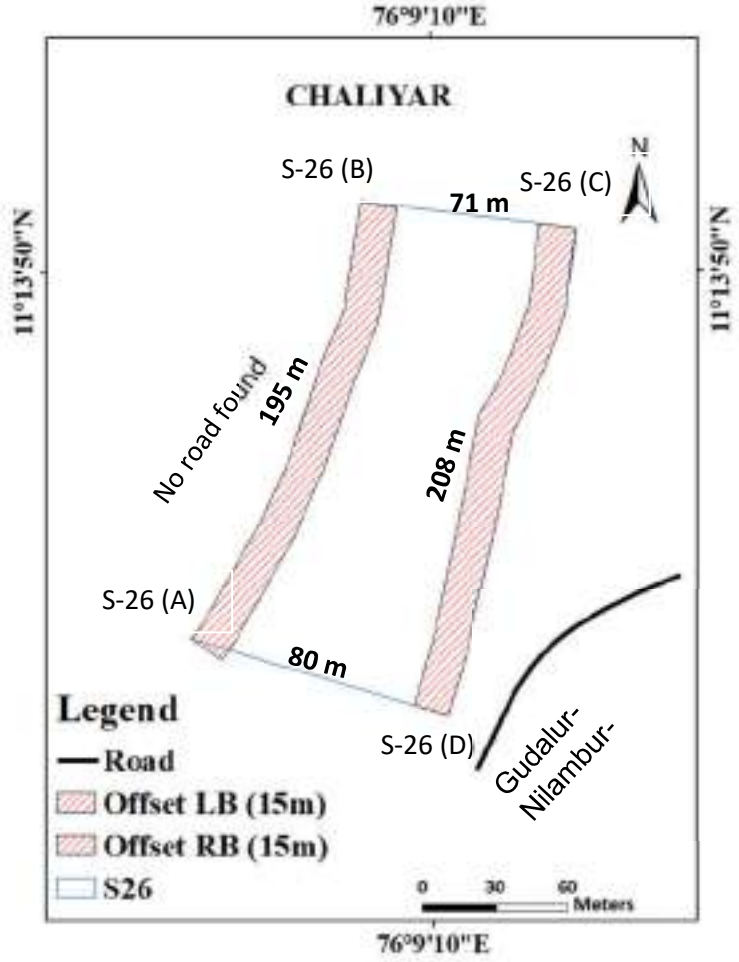
S-24	
AREA (Ha)	2.683266
TOTAL SAND (m^3)	21100
MINEABLE SAND (m^3)	4810
MINEABLE SAND (Tonnes)	7215

	Geographical Coordinates	
Point	Latitude	Longitude
S-24 (A)	11.23542656	76.14893667
S-24 (B)	11.23803922	76.14714976
S-24 (C)	11.23786429	76.14880823
S-24 (D)	11.23590835	76.14988028



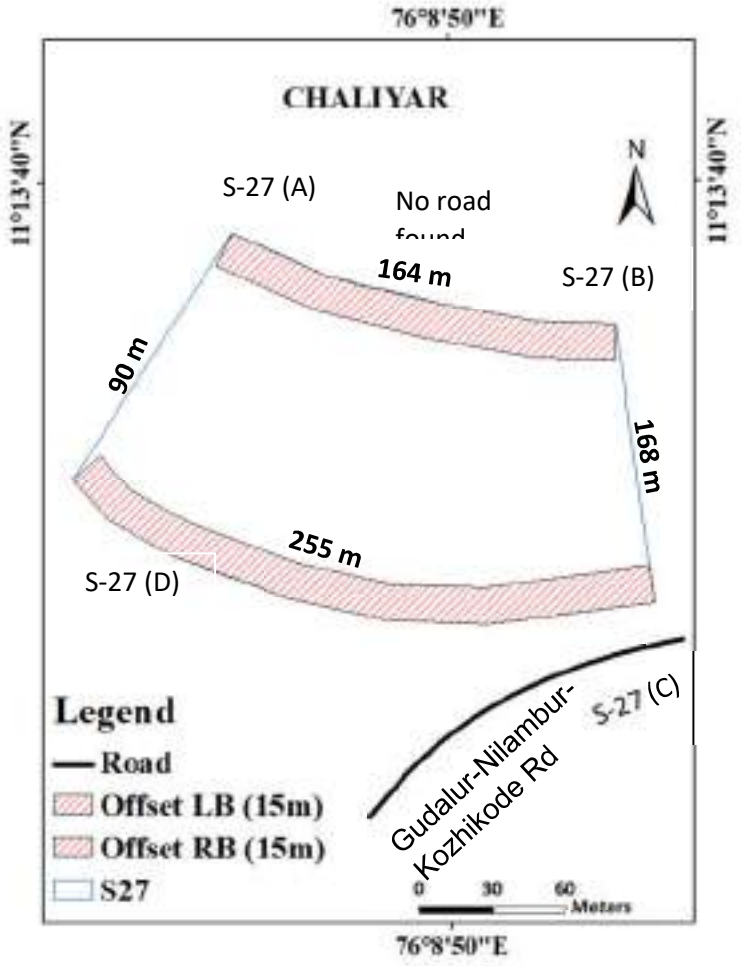
S-25	
AREA (Ha)	1.978395
TOTAL SAND (m^3)	70410
MINEABLE SAND (m^3)	29360
MINEABLE SAND (Tonnes)	44040

	Geographical Coordinates	
Point	Latitude	Longitude
S-25 (A)	11.23165676	76.1524418
S-25 (B)	11.23295268	76.15175525
S-25 (C)	11.23358027	76.15263678
S-25 (D)	11.23164637	76.15354527



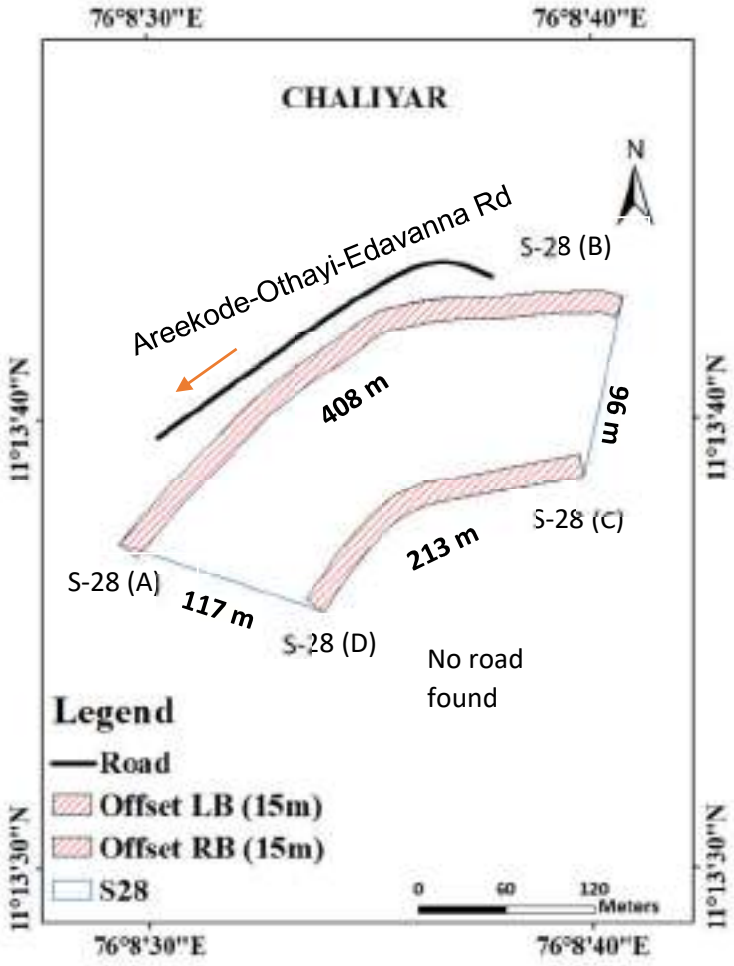
S-26	
AREA (Ha)	1.229615
TOTAL SAND (m^3)	30380
MINEABLE SAND (m^3)	11260
MINEABLE SAND (Tonnes)	16890

	Geographical Coordinates	
Point	Latitude	Longitude
S-26 (A)	11.22919067	76.15184668
S-26 (B)	11.23080795	76.15248698
S-26 (C)	11.23071126	76.15329446
S-26 (D)	11.22890396	76.15281034



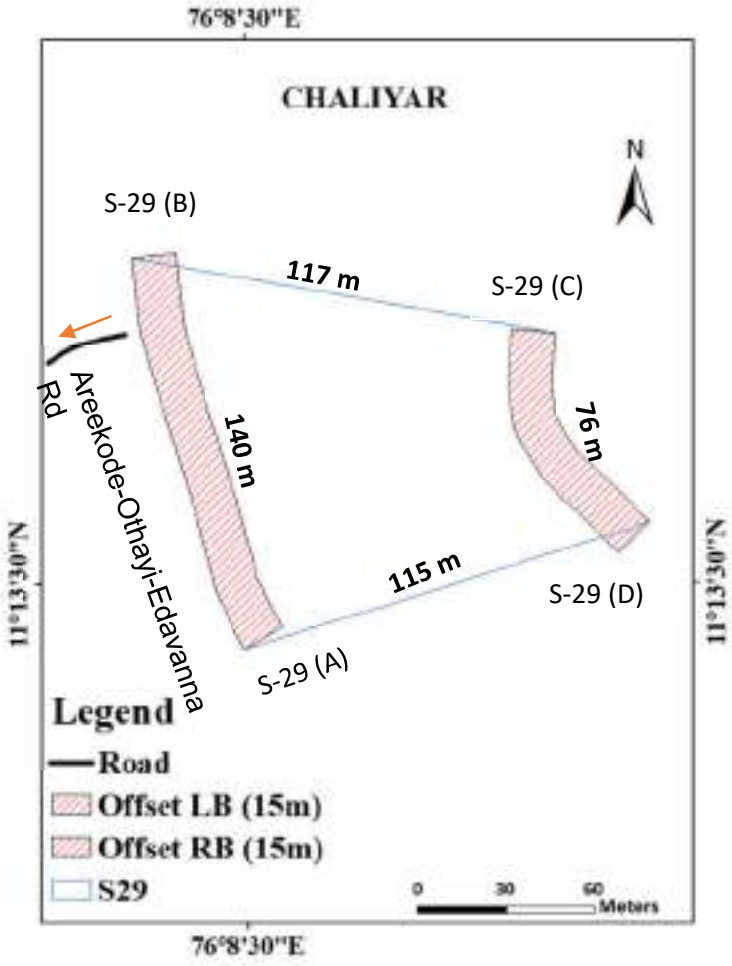
S-27	
AREA (Ha)	2.026941
TOTAL SAND (m^3)	11820
MINEABLE SAND (m^3)	930
MINEABLE SAND (Tonnes)	1395

	Geographical Coordinates	
Point	Latitude	Longitude
S-27 (A)	11.22758336	76.14637557
S-27 (B)	11.22724933	76.14781766
S-27 (C)	11.22621811	76.14795768
S-27 (D)	11.22667942	76.14577576



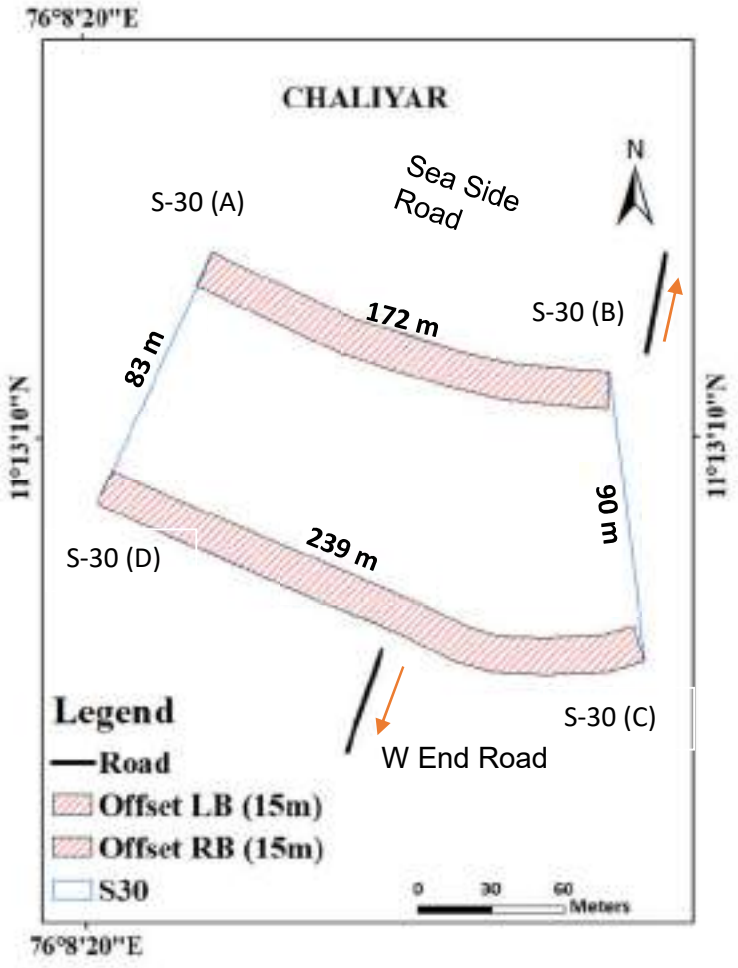
S-28	
AREA (Ha)	3.151973
TOTAL SAND (m^3)	10050
MINEABLE SAND (m^3)	310
MINEABLE SAND (Tonnes)	465

	Geographical Coordinates	
Point	Latitude	Longitude
S-28 (A)	11.2270076	76.14145834
S-28 (B)	11.22853192	76.14460786
S-28 (C)	11.22741727	76.14436995
S-28 (D)	11.22658492	76.14273256



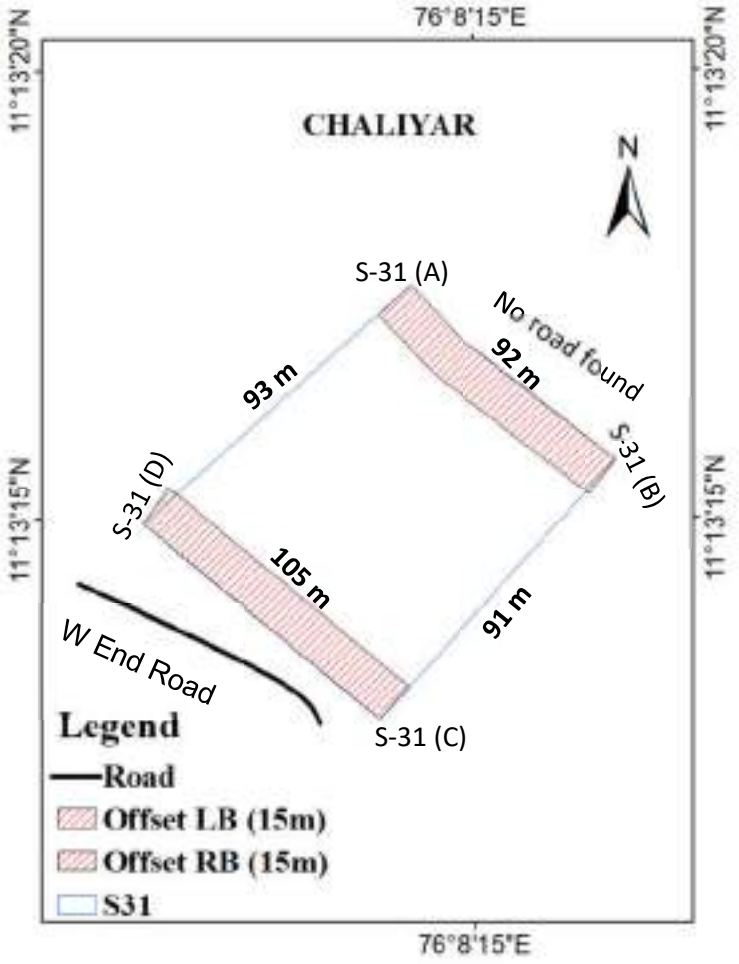
S-29	
AREA (Ha)	1.103321
TOTAL SAND (m^3)	44060
MINEABLE SAND (m^3)	15770
MINEABLE SAND (Tonnes)	23655

	Geographical Coordinates	
Point	Latitude	Longitude
S-29 (A)	11.22479417	76.14163288
S-29 (B)	11.22600078	76.14128112
S-29 (C)	11.22576877	76.14260491
S-29 (D)	11.22517842	76.14289451



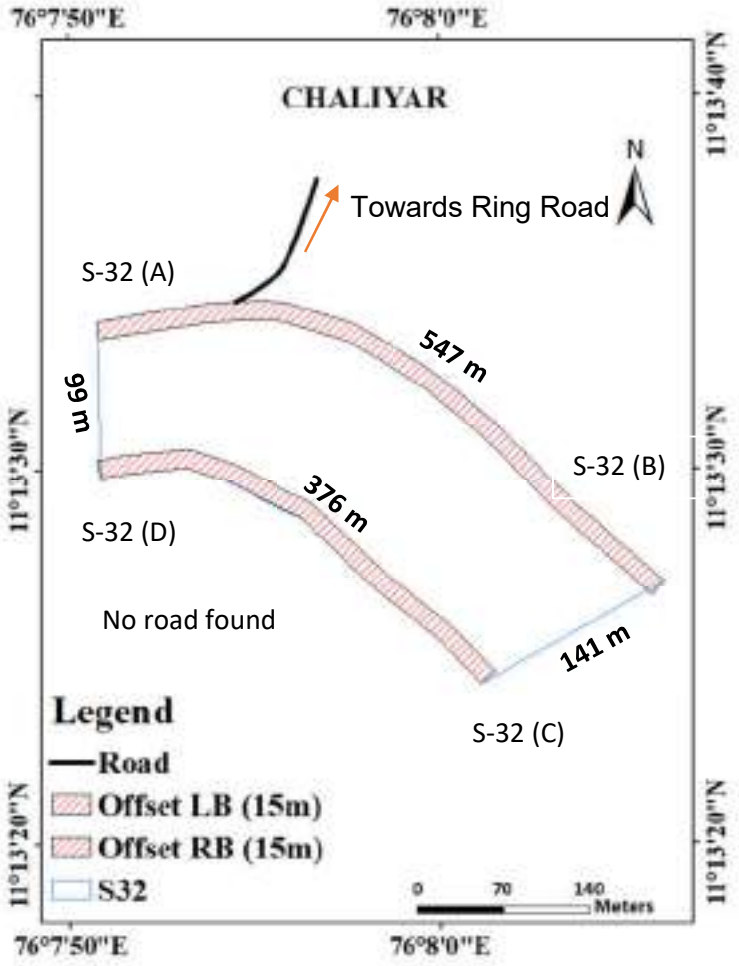
S-30	
AREA (Ha)	1.801206
TOTAL SAND (m^3)	49450
MINEABLE SAND (m^3)	33240
MINEABLE SAND (Tonnes)	49860

	Geographical Coordinates	
Point	Latitude	Longitude
S-30 (A)	11.22012345	76.13934761
S-30 (B)	11.21968344	76.14083223
S-30 (C)	11.2186094	76.14095946
S-30 (D)	11.21920358	76.13891206



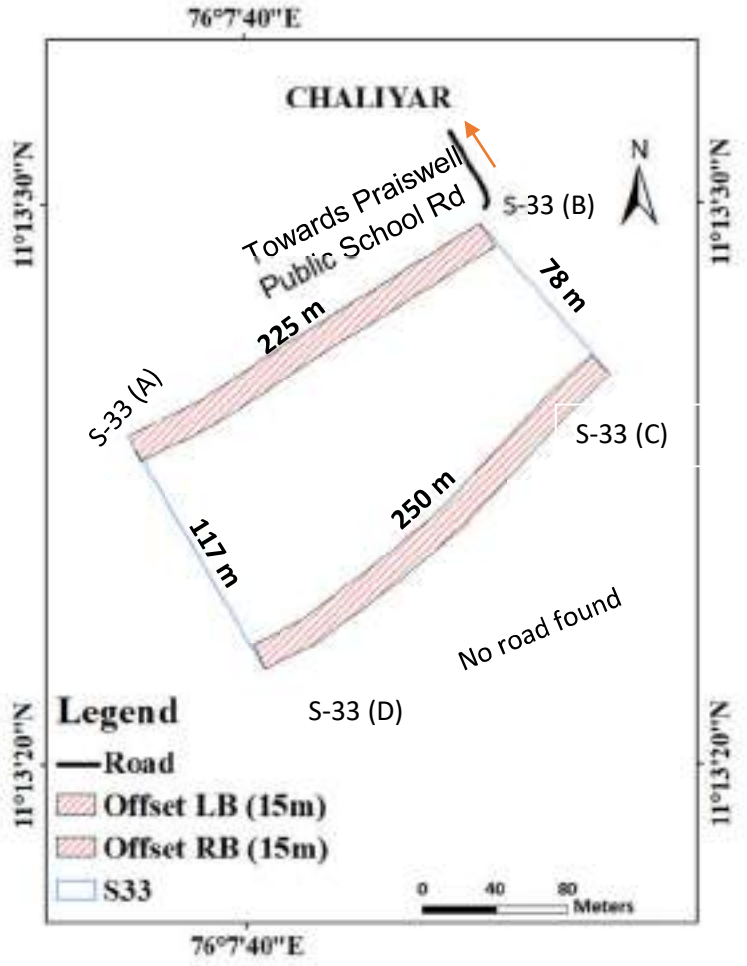
S-31	
AREA (Ha)	0.881006
TOTAL SAND (m^3)	11950
MINEABLE SAND (m^3)	2730
MINEABLE SAND (Tonnes)	4095

	Geographical Coordinates	
Point	Latitude	Longitude
S-31 (A)	11.22154993	76.13727432
S-31 (B)	11.22101995	76.13791641
S-31 (C)	11.22021178	76.13717343
S-31 (D)	11.22081755	76.1364332



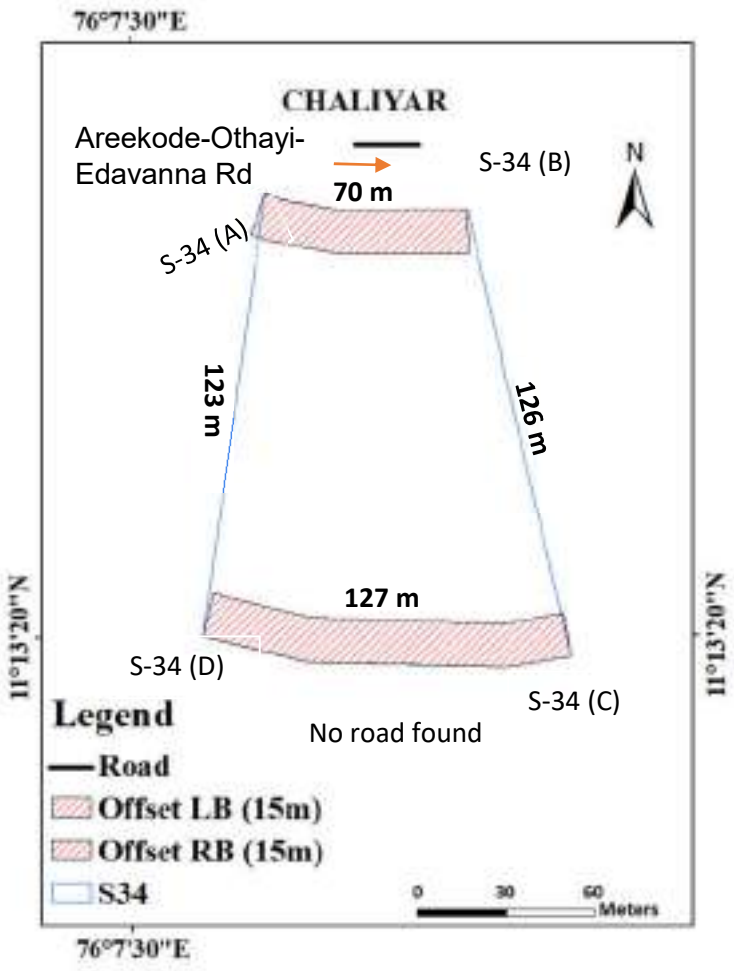
S-32	
AREA (Ha)	5.70181
TOTAL SAND (m^3)	15890
MINEABLE SAND (m^3)	450
MINEABLE SAND (Tonnes)	675

	Geographical Coordinates	
Point	Latitude	Longitude
S-32 (A)	11.22609584	76.130735
S-32 (B)	11.22417347	76.1349737
S-32 (C)	11.22340752	76.13361722
S-32 (D)	11.22493928	76.13076242



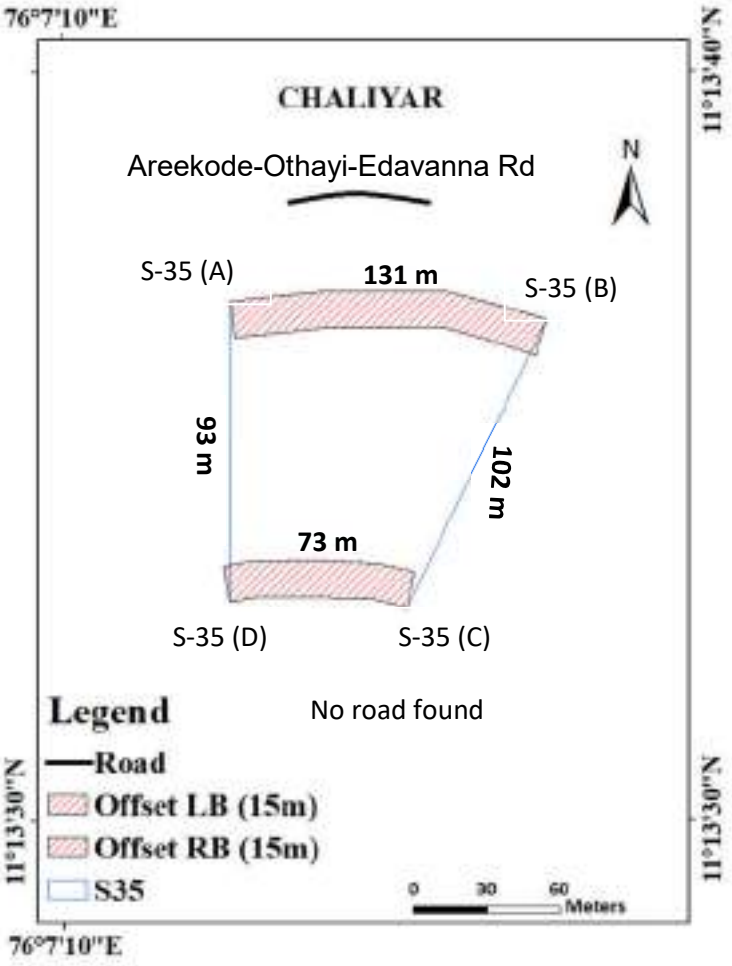
S-33	
AREA (Ha)	2.438881
TOTAL SAND (m^3)	32000
MINEABLE SAND (m^3)	10270
MINEABLE SAND (Tonnes)	15405

	Geographical Coordinates	
Point	Latitude	Longitude
S-33 (A)	11.2238535	76.12716556
S-33 (B)	11.2248953	76.12892783
S-33 (C)	11.22415321	76.12957364
S-33 (D)	11.22269933	76.1278406



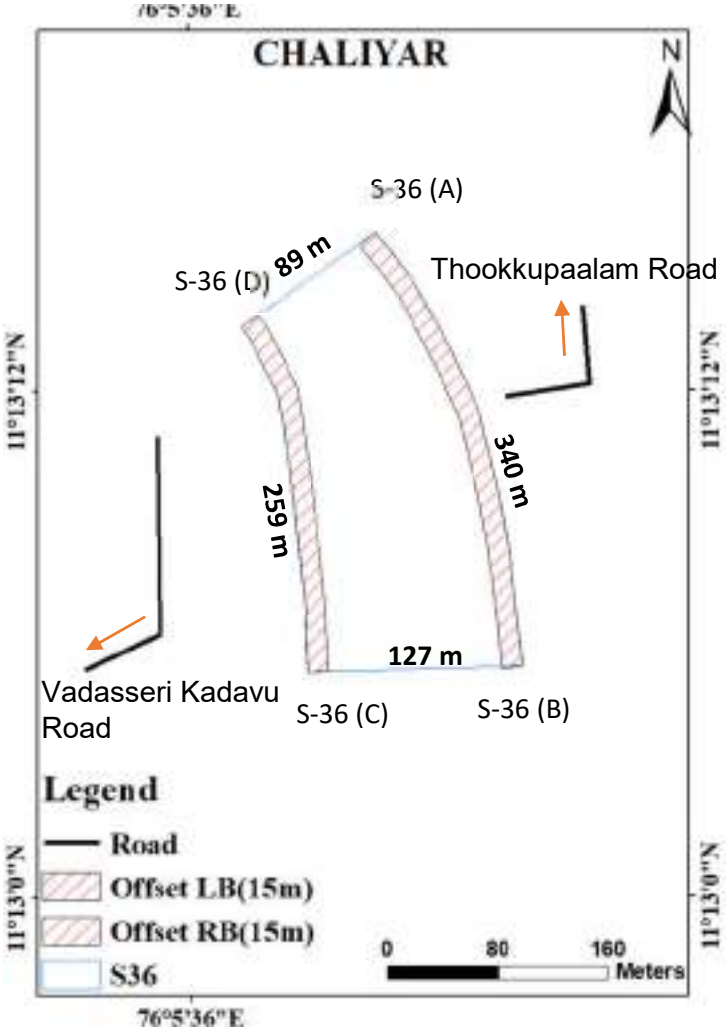
S-34	
AREA (Ha)	1.228133
TOTAL SAND (m^3)	23400
MINEABLE SAND (m^3)	5500
MINEABLE SAND (Tonnes)	8250

	Geographical Coordinates	
Point	Latitude	Longitude
S-34 (A)	11.223589	76.12539751
S-34 (B)	11.22354158	76.12602615
S-34 (C)	11.22215657	76.12634213
S-34 (D)	11.22222641	76.12519261



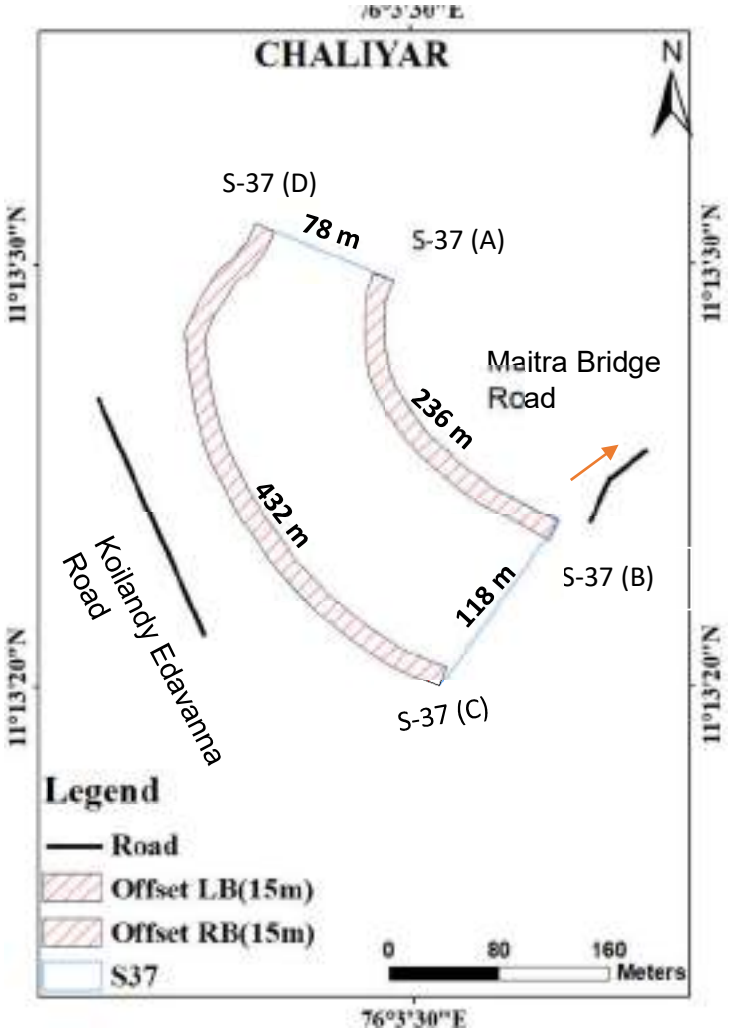
S-35	
AREA (Ha)	0.985554
TOTAL SAND (m^3)	28730
MINEABLE SAND (m^3)	4690
MINEABLE SAND (Tonnes)	7035

	Geographical Coordinates	
Point	Latitude	Longitude
S-35 (A)	11.22692197	76.12004765
S-35 (B)	11.22685537	76.12123138
S-35 (C)	11.22579025	76.1207054
S-35 (D)	11.22581289	76.12004301



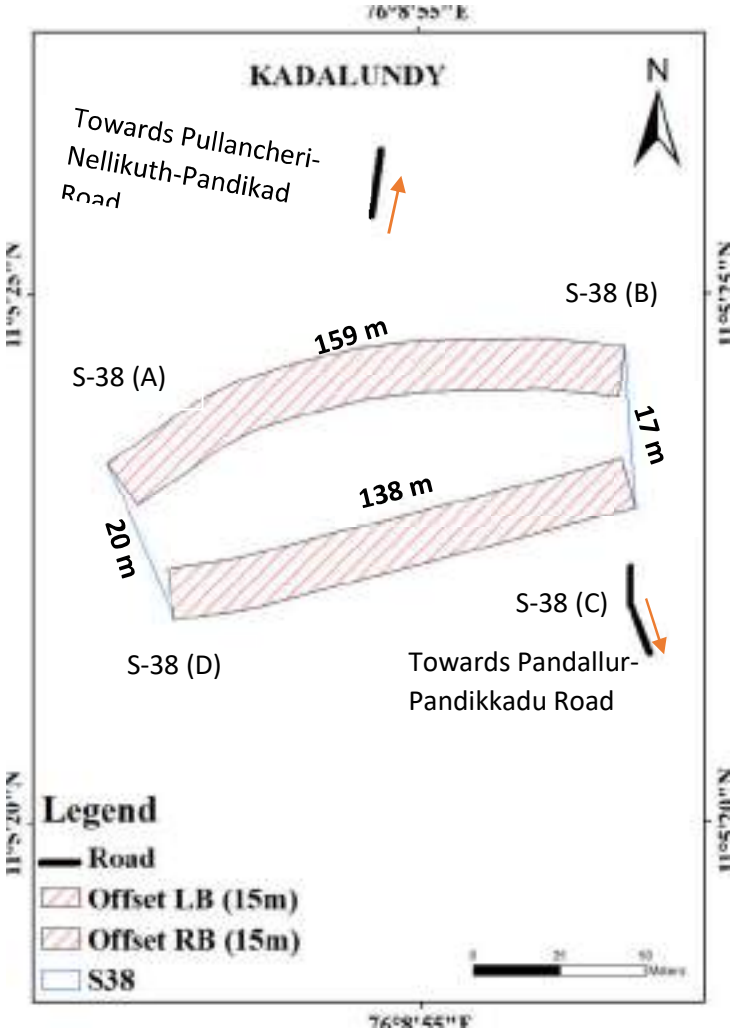
S-36	
AREA (Ha)	3.321486
TOTAL SAND (m^3)	23520
MINEABLE SAND (m^3)	5110
MINEABLE SAND (Tonnes)	7665

	Geographical Coordinates	
Point	Latitude	Longitude
S-36 (A)	11.22103043	76.0945467
S-36 (B)	11.21817772	76.09552197
S-36 (C)	11.21814861	76.09409185
S-36 (D)	11.22041598	76.09365794



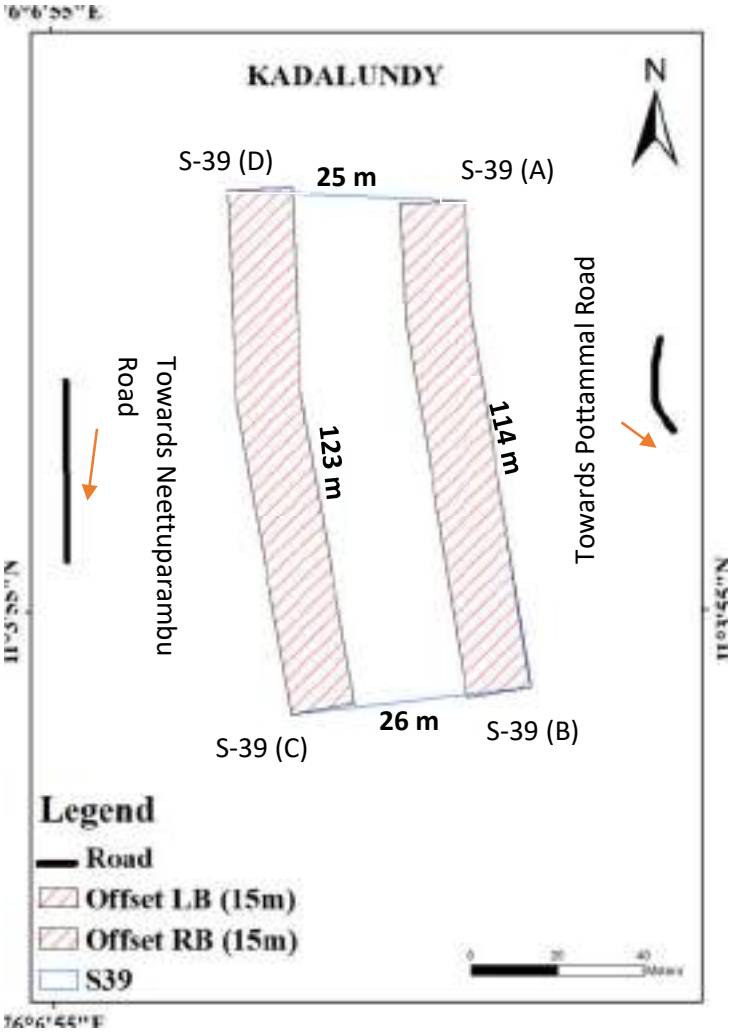
S-37	
AREA (Ha)	3.711156
TOTAL SAND (m^3)	68430
MINEABLE SAND (m^3)	7340
MINEABLE SAND (Tonnes)	11010

	Geographical Coordinates	
Point	Latitude	Longitude
S-37 (A)	11.22489435	76.05817525
S-37 (B)	11.22330115	76.05926728
S-37 (C)	11.22221957	76.05848804
S-37 (D)	11.22527108	76.05727074



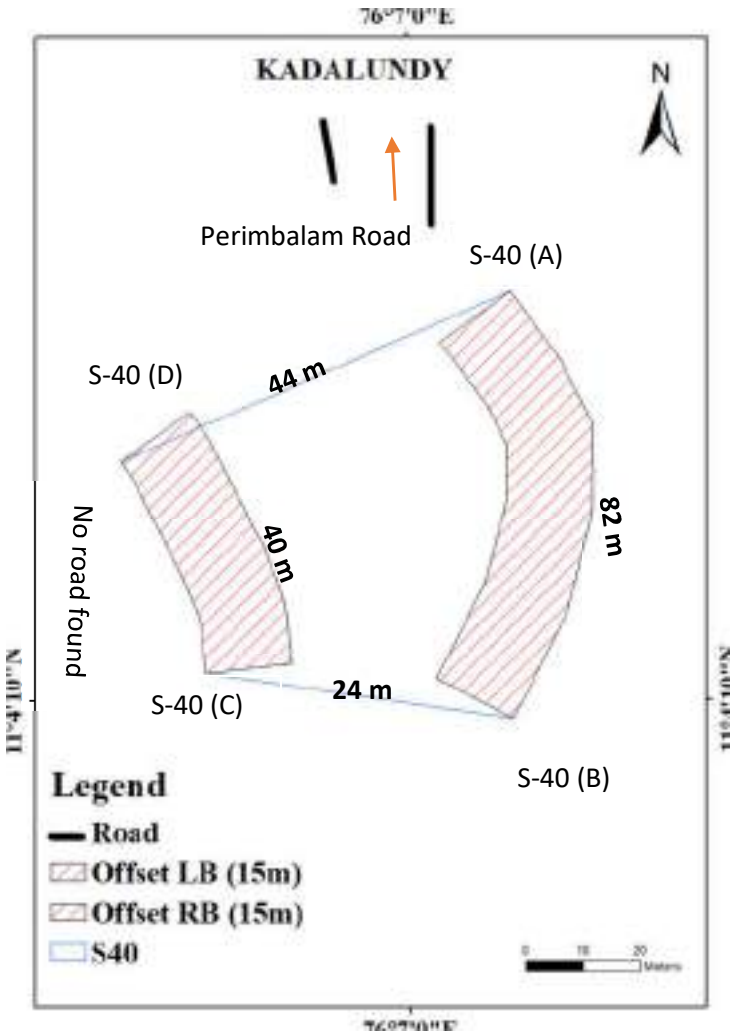
S-38	
AREA (Ha)	0.444
TOTAL SAND (m^3)	12000
MINEABLE SAND (m^3)	3096
MINEABLE SAND (Tonnes)	4644

	Geographical Coordinates	
Point	Latitude	Longitude
S-38 (A)	11.08983581	76.14774337
S-38 (B)	11.0901397	76.14911673
S-38 (C)	11.08971394	76.14914672
S-38 (D)	11.08942075	76.14792057



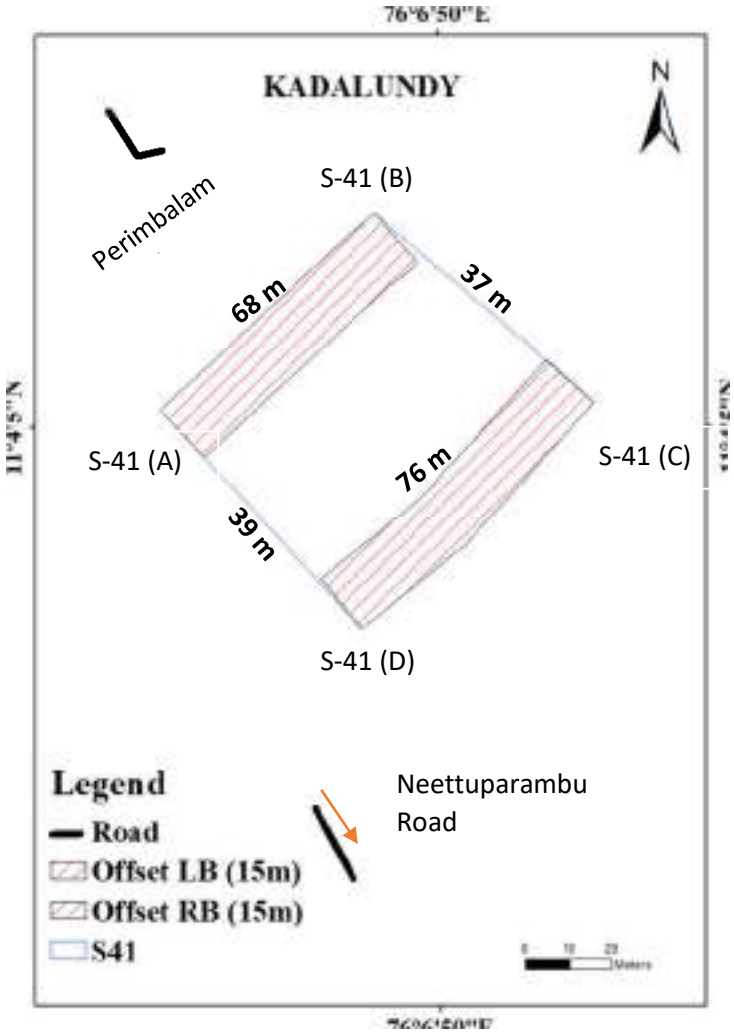
S-39	
AREA (Ha)	0.3099
TOTAL SAND (m^3)	6112
MINEABLE SAND (m^3)	792
MINEABLE SAND (Tonnes)	1188

	Geographical Coordinates	
Point	Latitude	Longitude
S-39 (A)	11.06613671	76.1161173
S-39 (B)	11.06511565	76.11625551
S-39 (C)	11.06506204	76.11574546
S-39 (D)	11.06616119	76.11561367



S-40	
AREA (Ha)	0.2333
TOTAL SAND (m^3)	6496
MINEABLE SAND (m^3)	1768
MINEABLE SAND (Tonnes)	2652

	Geographical Coordinates	
Point	Latitude	Longitude
S-40 (A)	11.07008714	76.11678811
S-40 (B)	11.06941314	76.11679282
S-40 (C)	11.06948877	76.11630357
S-40 (D)	11.06982241	76.11616846



S-41	
AREA (Ha)	0.2857
TOTAL SAND (m^3)	4704
MINEABLE SAND (m^3)	848
MINEABLE SAND (Tonnes)	1272

	Geographical Coordinates	
Point	Latitude	Longitude
S-41 (A)	11.06808897	76.11326449
S-41 (B)	11.06849273	76.11371339
S-41 (C)	11.06809754	76.11417567
S-41 (D)	11.06762619	76.11368673

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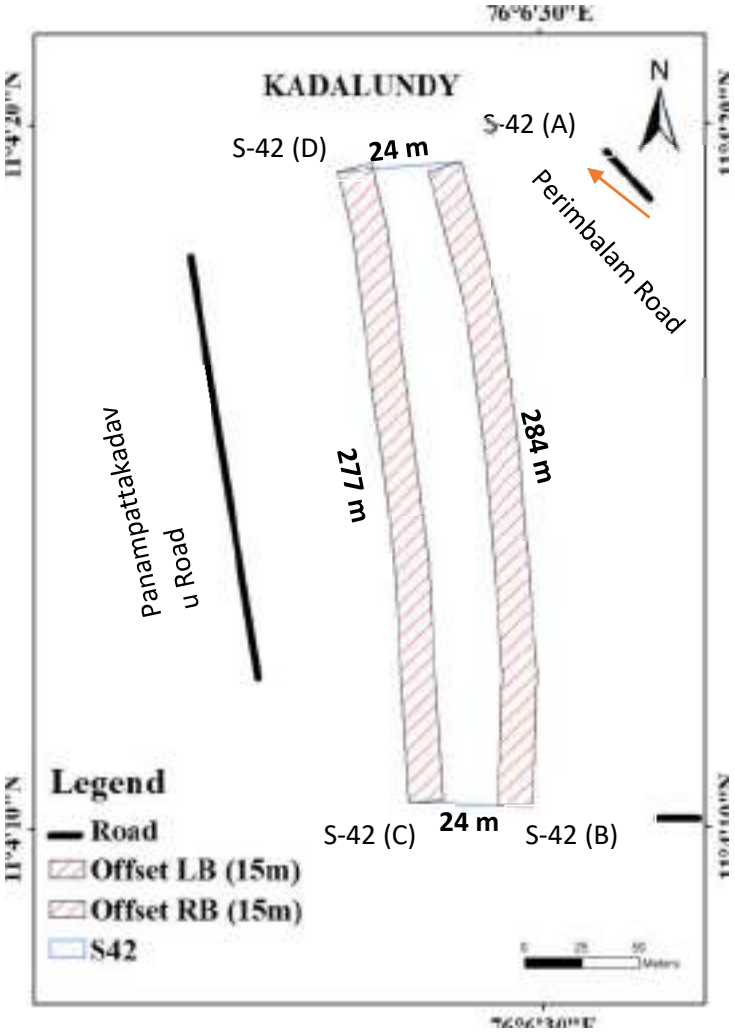
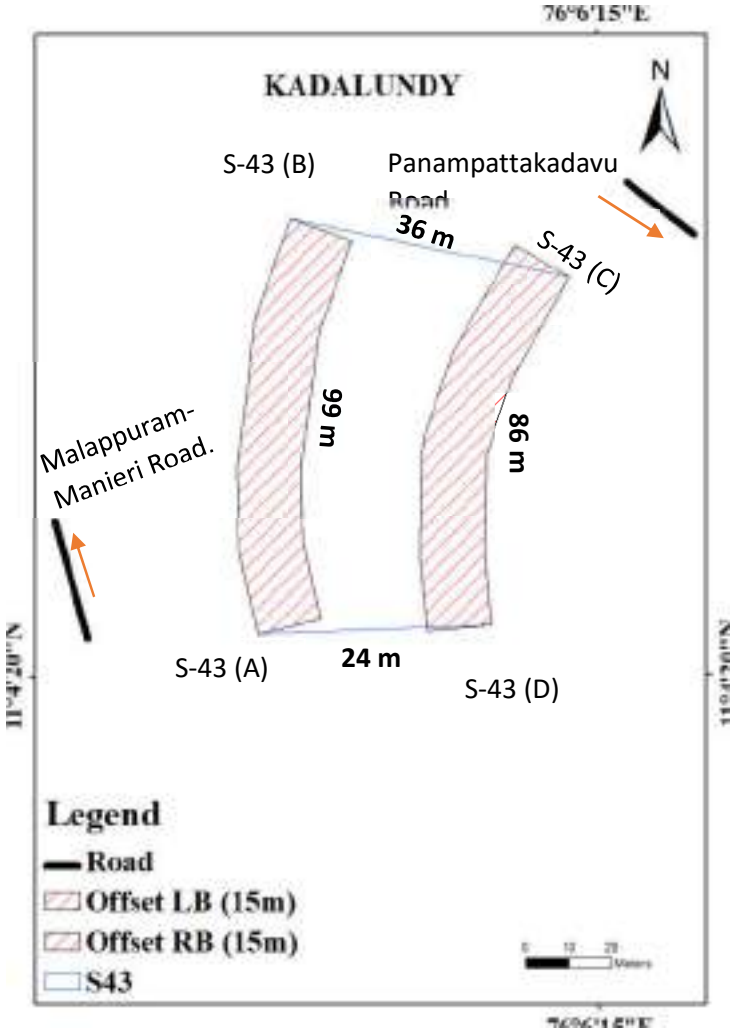


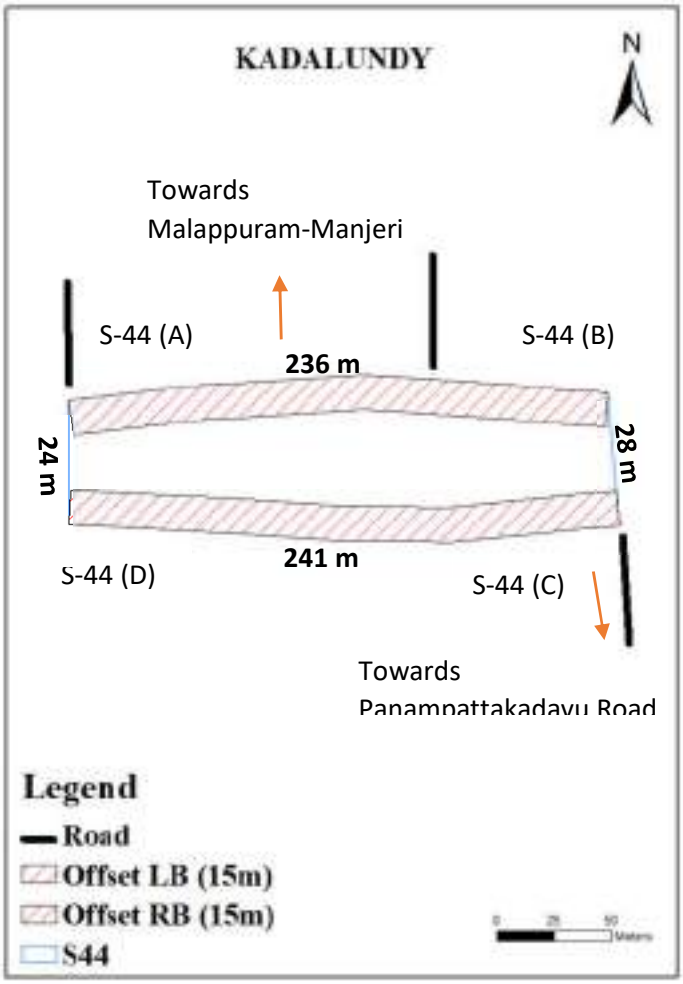
S-42	
AREA (Ha)	0.7864
TOTAL SAND (m^3)	15480
MINEABLE SAND (m^3)	2720
MINEABLE SAND (Tonnes)	4080

	Geographical Coordinates	
Point	Latitude	Longitude
S-42 (A)	11.07206155	76.10797469
S-42 (B)	11.06953176	76.10825369
S-42 (C)	11.06954265	76.10776281
S-42 (D)	11.07202073	76.10748206



S-43	
AREA (Ha)	0.2626
TOTAL SAND (m^3)	4664
MINEABLE SAND (m^3)	744
MINEABLE SAND (Tonnes)	1116

	Geographical Coordinates	
Point	Latitude	Longitude
S-43 (A)	11.07230496	76.1034084
S-43 (B)	11.07317918	76.10347622
S-43 (C)	11.07305394	76.10406705
S-43 (D)	11.07232288	76.10389453



S-44	
AREA (Ha)	0.8455
TOTAL SAND (m^3)	16520
MINEABLE SAND (m^3)	2528
MINEABLE SAND (Tonnes)	3792

	Geographical Coordinates	
Point	Latitude	Longitude
S-44 (A)	11.06941725	76.10185927
S-44 (B)	11.06945198	76.10401383
S-44 (C)	11.06892468	76.10405923
S-44 (D)	11.06893185	76.10186225

6.6 Mining methodology

Riverbed or sand will be mined manually without any drilling or blasting and loaded manually into tippers/tractors. Prior to mining, the area of the mining lease should be marked off, and pucca pillars will be set up on the ground to allow for systematic mining. Mining should begin in the centre and progress uniformly to the river's banks. A buffer of 10% of the river width or 15 m, whichever is less, shall be left undisturbed towards the bank side. Mining depth should be restricted to river water level as per the approved mining plan. The dry pit mining method shall be used; that is, mining will always be done above the water level of a flowing riverbed, with no mining done when the water is above the bed level. No mining activities are allowed close to any bridges or embankments.

6.7 General sand mining regulations in Kerala

The Kerala Protection of Riverbanks and Regulation of Removal of Sand Act, 2001, specifies the rules and regulations associated with sand mining in Kerala. As per the act, the general conditions for the sand removal operations in a Kadavu are as follows:

1. The grama panchayat or the municipality concerned shall, before carrying out the sand removal operation, obtain passes from the geology department which shall issue them on the recommendation of the District Expert Committee for a period of one month in advance, on payment of royalty as provided for in the law applicable for the payment of royalty.
2. No sand removal operation shall be carried out in a Kadavu before 7 am and after 4 pm.
3. Removal of sand shall be permitted only from the riverbed, and no sand removal operation shall be done within 15 metres of the river bank.
4. No sand removal operation shall be done within a distance of 500 metres from any bridge or any irrigation project.
5. The vehicle for loading sand shall be parked at a distance of at least 25 metres from the riverbank, and no vehicle shall be brought to the riverbank for loading.
6. No sand removal shall be done in a Kadavu or riverbank in excess of the quantity fixed by the District Expert Committee.
7. No ‘kollivala’, pole scooping, or any mechanized method shall be carried out in the sand removal operation.
8. No sand removal shall be done where there is a likelihood of saline water mixing with river water.
9. No sand removal shall be done in a river or on any riverbank where Government have expressly prohibited the same by general or special order.
10. The grama panchayat or municipality concerned shall, subject to the other provisions of this Act and the rules made there under, make necessary arrangements to carry out the sand removal operations.

6.8 Risk assessment studies

6.8.1 Risk Assessment

Risk Assessment is the study to assess the risks of major disasters with the potential to cause damage to life and property and to provide a scientific basis for decision-makers to be confident in the safety levels of the operations to be carried out. This section deals with the types of risks, magnitude and impact on the environment associated with riverbed or sand mining activities in the district of Malappuram.

6.8.2 Methodology of Risk Assessment

The following steps are involved in the risk assessment procedure.

- Hazard identification
- Assessment of risks
- Risk control measures
- Monitor and review

6.8.3 Risk in riverbed or sand mining activities

Riverbed or sand will be mined manually. Mining activities cause no land degradation because they are limited to the riverbed surface. Due to the sand being exposed in the riverbed, there won't be any overburden (OB) or waste generation, and neither a dumping area nor a stockpiling area is needed.

The hazards which may result in hazardous working conditions when mining sand (minor minerals) from riverbeds are as follows:

a) Riverbed inundation/flooding
b) Damage to riverbank due to access of ramps
c) Accident during a sand/mineral loading, transportation and stacking
d) Accident due to vehicular movement
e) Occupational injuries
f) Quicksand condition

6.8.4 Preventive & mitigation measures

The mining activity shall be carried out as per Sustainable Sand Mining Management Guidelines (SSMMG-2016), Enforcement and Monitoring Guidelines for Sand Mining (EMGSM-2020) & River Banks and Regulation of Removal of Sand Act, 2001, Government of Kerala.

a) Riverbed inundation/flooding

- Sand mining is allowed only in non-monsoon season, and during heavy rains, mining operations are to be ceased.
- When operating the mines, accurate weather information, especially regarding rain and heavy discharges from upstream, should be kept so that preventative measures can be taken.

b) Damage to riverbank due to access of ramps

- Riverbanks shall not be excavated to form access ramps.
- To create access ramps, only excavated river gravel should be deposited against the riverbank.
- Riverbank areas shall be protected by avoiding unauthorised gravel excavation along rivers, which may cause riverbank instability.
- Distance of mining from the bank should be 10% of the river width or 15 metres whichever is less.
- Overloading the truck may cause damage to the access ramps along the riverbank and should be avoided.

c) Accident during a sand/mineral loading, transportation and stacking

- The excavated mineral will be loaded in the trucks manually
- Mining operations shall take place during daylight only.
- During the loading process, the truck would be lowered to a lower level so that the loading operation would be more ergonomic for the workers.
- When the sand is filled in, the trucks will stand near the loading equipment and fully brake.
- To avoid hurting the loaders, the side covers (pattas) should be opened carefully and with caution.
- The trucks shall be maintained and covered with tarpaulin to stop any spills.

d) Accident due to vehicle movement

- All areas where lorries reverse should be made as man-free as possible to reduce risk when doing so, especially at tipping points and embankments.
- The possibility of overloading the trucks may endanger the general public.
- The vehicles must be kept PUC certified and go through a thorough inspection at least once per week.
- Rash driving is prohibited, and the maximum permissible speed limit should be ensured.
- Proper signboards are to be provided while traversing through the village/habitation until the main road/junction.

e) Occupational injuries

- Personal protective equipment (PPE) like safety helmets, safety gloves, safety shoes etc., shall be provided to the workers.
- Workers shall be provided with first aid and sanitation facilities to ensure a sanitary working environment.
- Training shall be provided to the workers on how to handle the equipment.

f) Quicksand condition

- The quicksand zone and deep water zone shall be clearly marked, and all mine workers will be informed of their location.
- Mining depth should be restricted to 1.5 metres from the riverbed surface as per the approved mining plan.

- Deep water areas must be identified, and no-go zones shall be clearly marked.

6.9 Disaster Management Plan

A Disaster Management Plan is an action plan for all necessary tasks that must be completed in order to prepare for, respond to, and manage emergencies. It outlines the emergency response team, the resources available (internal and external), and the precise actions that must be taken in the event of various emergencies that might arise during river sand mining. The disaster management plan can be divided into the following steps:

1. Emergency preparedness plan
2. Resource availability
3. Response action was taken during an emergency.

The purpose of a disaster management plan is to restore normalcy in order to resume mining operations as soon as possible after an unexpected, sudden occurrence that causes abnormalities in the course of mining activity, posing a serious risk to workers, machinery, or the environment. Any emergency starts as a small incident which may become a major incident with the passage of time. If it can be dealt with the available resources, then it may be classified as an on-site emergency. When an emergency becomes catastrophic and evacuation beyond the mine lease area, it is considered an off-site emergency, wherein the district administration plays a significant role in managing.

6.9.1 On-site emergency response plan

The shallow depth of the activities in riverbed mining does not involve high-risk accidents due to side falls/collapses. The entire mining operation shall be managed and controlled by experienced and qualified individuals. Proper coordination with the Irrigation Department will be maintained so that when water is released from the dam, appropriate warning/information is provided in advance. While working in areas of geological weakness, such as those where a slip or fault exists, the appropriate safety measures must be taken with special attention.

a) System of communication

All supervisory personnel will be provided with adequate communication facilities. For any emergency, the phone numbers and addresses of adjacent mines, rescue stations, police stations, fire stations, local hospitals, electricity supply agencies, and sub-divisional committee members are kept on file.

b) Sub-divisional committee

A Sub-Divisional Committee shall visit each site and make recommendations for environmentally safe depth of mining and safeguards of banks. The Committee will comprise of Sub-Divisional Magistrate, Officers from the Irrigation department, State Pollution Control Board or Committee, Forest department, Geology or mining officer.

c) Facilities and Accommodation

Lessee shall provide rest shelters for mine workers with amenities like resting, drinking water, restrooms, and site-specific anti-venom supplies, among other things. In addition, first-aid facilities should also be available. To address any situation, a clearly defined transport control system shall be made available.

d) First Aid & medical facilities

In the event of any emergency, the mine management should have a first aid/medical centre. First aid will be given to all casualties after they have been registered. The centre will have resources for transportation, resuscitation, first aid, and minor treatment. It will be equipped with a suitable telephone and wireless system for prompt communication with hospitals where ~~the~~ complex cases are to be sent.

6.9.2 Off-site emergency response plan

An off-site emergency plan defines the various steps to handle any off-site emergencies that may have an impact on the project's surrounding areas after thorough final consultation with local panchayat and revenue officials.

The district authority shall be responsible for implementing the off-site emergency response plan. In case of river sand mining Inundation/Flooding, major accidents during mineral loading or transport, natural hazards like landslides, subsidence, and seismic activities shall be considered under off-site emergency response. Mining depth is restricted to 1.5 m below the riverbed surface, thus the chance of failure of the pit slope is marginal. Kerala has been placed in Zone III, where the maximum expected intensity is VIII on the MM scale or 5.6 M on the Richter scale. However, there may be flash floods in some parts of the district due to heavy rains, and mining operations shall be stalled during heavy monsoon.

Any disastrous off-site situation must be dealt with right away, with the assistance of the Collector and other officials.

CHAPTER-7

SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.0 Summary and conclusion

- District Survey Report of Malappuram for river sand mining is prepared in accordance with the Sustainable Sand Mining Management Guidelines, 2016 and Enforcement and Monitoring Guidelines for Sand Mining, 2020.
- Previous sand audit reports prepared by ILDM has been taken as the base for administrative boundaries and areas of aggradations where sand is deposited.
- NIIST has hired Tropical School of Ecological Sciences (TIES), Kottayam for carrying out cross-sections survey at the identified locations.
- It has been observed that almost whole stretch of Bharathapuzha has depositions of sand.
- The number of sand mining sites observed in Bharathapuzha stretch of Malappuram are 11, Chaliyar are 19 and Kadalundi are 6 with a total of 36 sand mining sites in Malappuram district.
- The total area of all the potential sand bearing sites combined is 405.75 Ha. The total sand availability across all sites is 99,07,484 m^3, with 38,35,954 m^3 (57,53,931 tonnes) of mineable sand above summer water level.
- The average bulk density is worked out as 1.5 gm/cc and the analysis were carried out as per the IS 2386 Part-3 & Kim H. Tan, 2nd Edition.
- As far as the number of sand mining sites from area perspective is concerned, there are 26 sand mining sites that are less than 5 ha, 6 sand mining sites between 5-25 ha and 3 sand mining sites between 25-100 Ha. 1 sand mining site >100 Ha.
- The rate of replenishment for the Bharathapuzha stretch is 13% each year considering the total sand volume in the February 2020 as the base value. The rate of replenishment for the Chaliyar River is 2% each year considering the total volume of sand in February 2020
- The replenishment studies are carried out using empirical model and by measuring the difference between previous and present sand volumes from audit reports. The replenishment study was carried out for whole Bharathapuzha watershed. Bharathapuzha watershed only shares 9 % of its area in Malappuram district.

7.1 Recommendations

- Letter of intent shall be granted for a location which has more potential for mining and feasible for environment-friendly mining.
- Mining must be done within the mining lease area in accordance with an approved mining plan or a mining plan that has the approval of other regulatory authorities.
- Replenishment studies must be conducted frequently to maintain a balance between deposition and extraction.

- A sub-divisional committee may be established, and after visiting the potential mining sites, it will determine whether they are suitable for mining.
- The final list of sand mining sites shall be recommended in accordance with the comments received during the public consultation and presented to the sub-divisional committee for active consideration.
- The lease agreement must include the sand mining process, production, and compliance with the imposed conditions by regulatory authority (environmental clearance or mine plan) be audited annually by the authority responsible for leasing the land.
- The river's flood discharge capacity could be preserved in areas where there is a significant flood hazard to existing structures or infrastructure.
- Prior to the start of mining, the mining area should be demarcated with pillars and geo-referenced.
- NABET accredited consultant may be engaged for Environment Audit and during the course of the audit, a three-member committee nominated by District Magistrate shall be associated.
- The environmental damages caused or exacerbated by illegal mining shall be assessed by a committee appointed by the district administration and comprised of experts from relevant fields, as well as independent representation from locals and the State Pollution Control Board.
- The districts sharing the boundary shall constitute the combined task force for monitoring of mined materials, mining activity and inputs in DSR.

ANNEXURES

ANNEXURE-I

Estimation of Bulk density and grain size distribution analysis

Annexure-I

Estimation of bulk density

Type of Sample:

- Cohesionless soil
- Fine sand
- Disturbed sample

Possible methods for analysing bulk density:

1. Core cutter method: This method cannot be adopted since it is not suitable for cohesionless soil
2. Sand replacement method: This method cannot be adopted since field measurements are required
3. IS 2386- Part 3 - Methods of test for aggregates of concrete: It is related to the quality of sand as a fine aggregate

Since Bulk density of soil is dry weight of soil per unit volume of soil, for the specific sample we can adopt the method specified in the book - “Soil Sampling, Preparation, and Analysis” by Kim H. Tan, 2nd Edition.

Procedure:

1. Take a 100ml volume sampler and measure its weight in grams - W1
2. Fill the soil sample to the sampler in layers after filling each layer sampler is tapped at the bottom until it reaches 100ml marking, weight of sample + sampler is taken in grams as - W2
3. Air dry the soil sample or oven dry for two hours at 105^{0}C
4. Weight of dry sample + sampler is taken in grams as - W3
5. Bulk density of soil = weight of soil solids/volume of soil
   = (W3 - W1)/V

Method & Calculations:

Volume of sampler = 100ml

Sl No	Name of Sample	Weight of Sampler (g) - A	Volume of Sampler (ml) - B	Weight of (sampler+dry soil) (g) - C	Weight of dry soil (g) D = C-A	Bulk density (g/ml or g/cc) E = D/B
1	Mayannoor Check dam	47.090	100	171.029	123.939	1.239
2	Cheruthuruthy Bridge	47.093	100	196.765	149.672	1.496
3	Chengamamkunu Reservoir	47.092	100	160.528	113.436	1.134
4	Kuttippuram Bridge	46.346	100	192.314	145.968	1.459
5	Velliyamkallu Reservoir	46.353	100	193.599	147.246	1.472
6	Pattambi Bridge	46.350	100	198.712	152.362	1.523
7	V K Kadavu	46.351	100	204.149	157.798	1.577

	(Based on the local name)					
8	Tavanur Left Bank Ending point	46.356	100	188.713	142.357	1.423
9	Tirunavaya	46.351	100	147.213	126.077	1.260
10	Near KWA Thirunavaya	46.849	100	181.711	134.862	1.348

Conclusions:

Soil bulk density is the mass of dry soil per unit of bulk volume. It is an indicator of soil compaction and is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. It is typically expressed in g/cc. Bulk density is dependent on soil texture and the densities of soil mineral (sand, silt, and clay) and organic matter particles, as well as their packing arrangement. As a rule of thumb, most rocks have a bulk density of 2.65 g/cm3 so ideally, a medium textured soil with about 50 percent pore space will have a bulk density of 1.33 g/cm3. The general relationship between soil texture and bulk density is shown in the table below:

Soil texture	**Ideal bulk densities (g/cm^3)**
sands, loamy sands	<1.60
sandy loams, loams	<1.40
sandy clay loams, loams, clay loams	<1.40
silts, silt loams	<1.30
silt loams, silty clay loams	<1.40
sandy clays, silty clays, clay loams with 35- 45%clay	<1.10
clays (>45% clay)	<1.10

As per references, the calculated values of bulk densities come under the standard range.

Annexure-I

Particle size analysis – Sieve Analysis as per ASTM D6913 (4.75mm-75 micron)

The characteristics of particle such as bulk density, physical stability, permeability and many more are decided by its size, so the determination of particle size has high importance in Civil Engineering. Sieve analysis is an effective method to identify the size distribution of the particles. The objective of this study is to analyse the grain size distribution and to prepare the grain size distribution curve for a given soil sample for identifying the soil characteristics. The sieve analysis is adopted for fine sand which is having size in between 4,75mm and 75 micron. So as a part of the procedure, we can identify the percentage of fine sand present in the collected sample.

EQUIPMENTS:

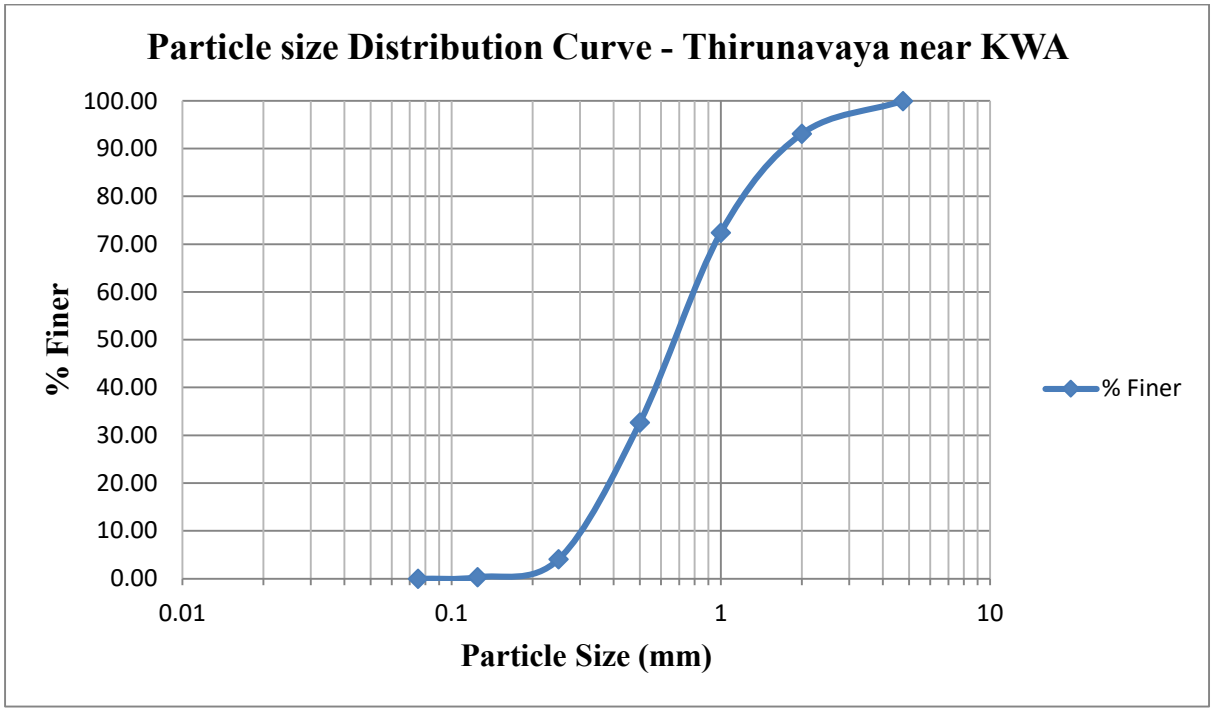
- Stack of sieves with a cover and pan
- Sample container
- Balance, sensitive to 0.1 g
- Oven
- Mechanical sieve shaker
- Brush

PROCEDURE:

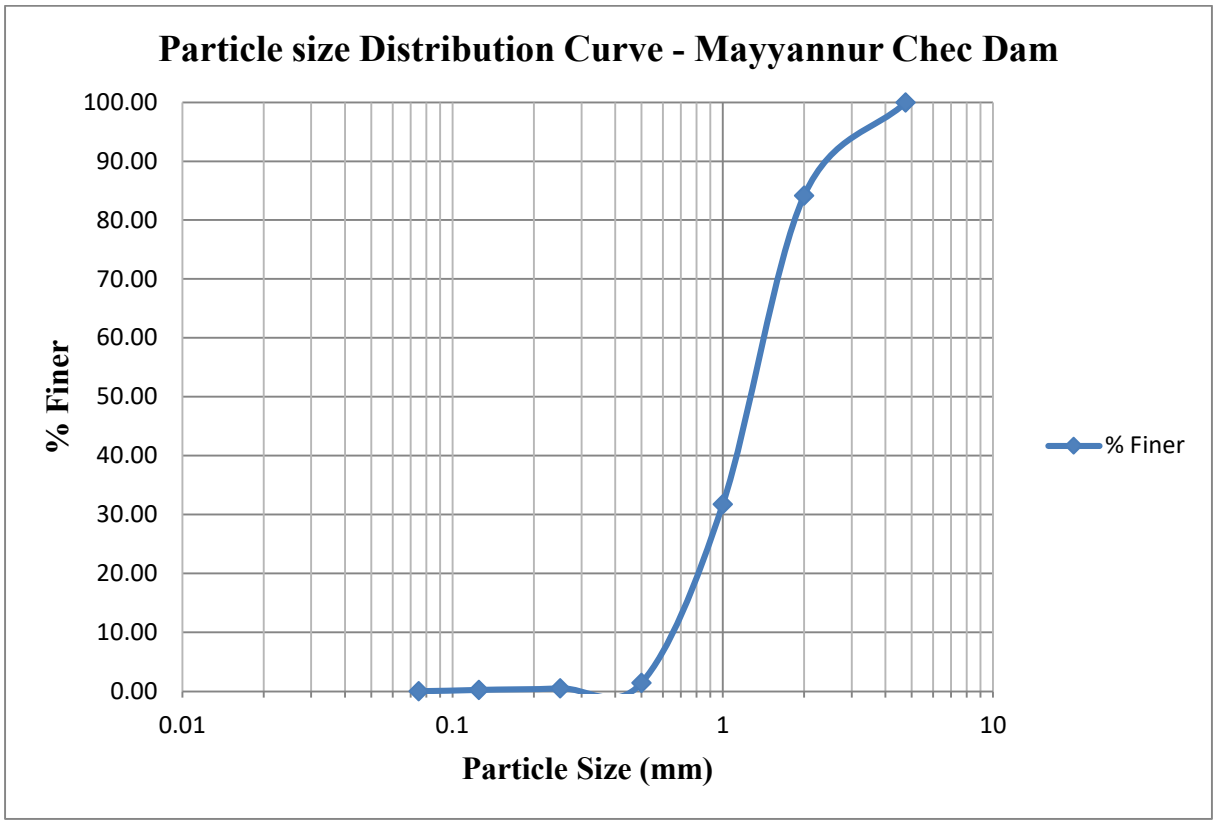
1. Obtain a representative oven-dried soil sample
2. Pulverize the soil sample as finely as possible
3. Separate fine sand and coarse sand by passing the sample through 4.75mm sieve. The portions that are retained in the sieve are considered to be coarser parts and those passing are fine sand which is further used for sieve analysis.
4. Obtain a soil sample of about 500 g and determine its mass in grams
5. Stack the sieves so that those with larger openings are placed above those with smaller openings. Place a pan under the last sieve to collect the portion of soil passing through it. The sieve no.4 (4.75mm) and sieve no.200 (75 micron) sieves should always be included in the stack.
6. Make sure the sieves are clean, if soil particles are stuck in the openings; use a brush to poke them out.
7. Weigh the pan and all of the sieves separately.
8. Pour the soil from above into the stack of sieves and place the cover on it. Put the stack in the sieve shaker, affix the clamps, set a timer for 10 minutes, and start the shaker
9. Stop the sieve shaker and measure the mass of each sieve and retained soil

OBSERVATIONS & RESULTS:

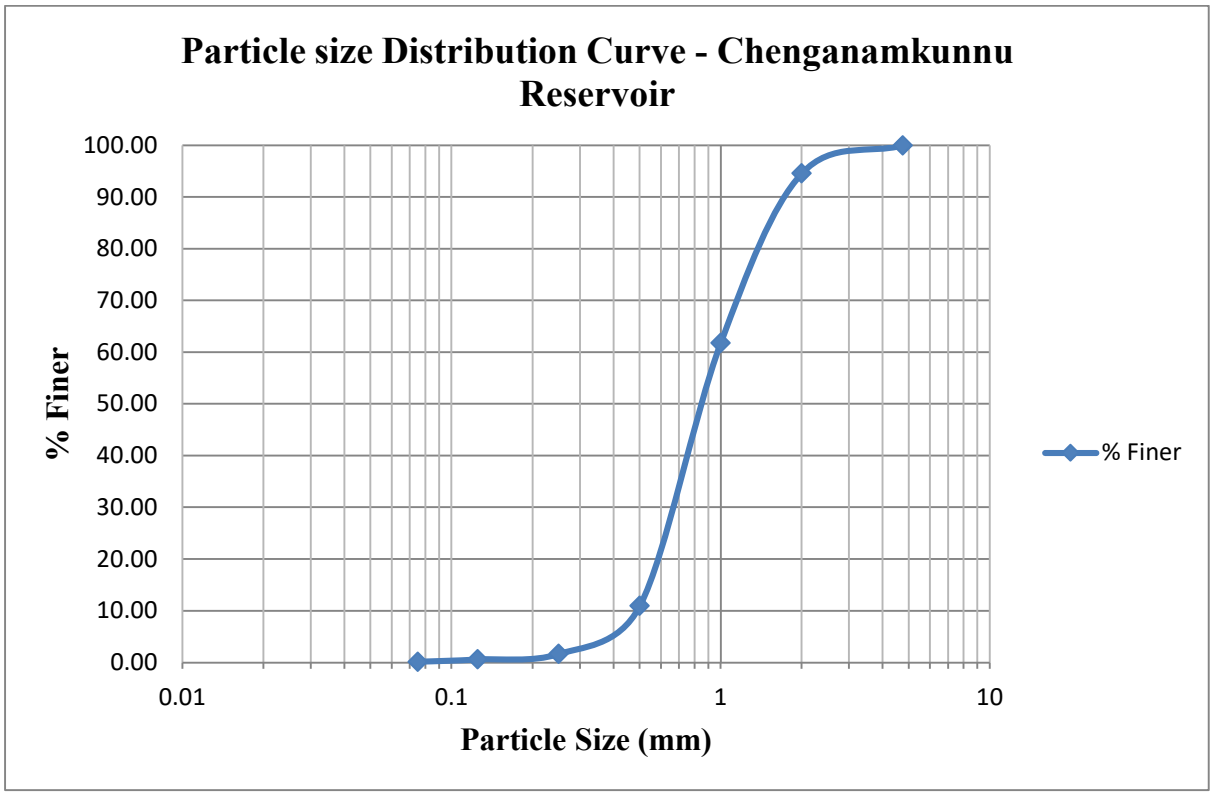
SIEVE ANALYSIS						
Sample Name			Thirunavaya - Near KWA			
Mass of pan (g)			198.48			
Mass of pan + dry sample(g)			757.1			
Mass of dry sample (g)			558.62			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained(g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.750	367.17	367.17	0	0.000	0.000	100.000
2.000	341.17	379.4	38.23	6.844	6.844	93.156
1.000	300.92	416.51	115.59	20.692	27.536	72.464
0.500	275.46	497.55	222.09	39.757	67.293	32.707
0.250	245.59	405.19	159.6	28.570	95.863	4.137
0.125	269.14	290.25	21.11	3.779	99.642	0.358
0.075	353.54	355.43	1.89	0.338	99.980	0.020
PAN	350.13	350.24	0.11	-	-	-
Total Weight of sediment sample(g)			943.17			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			17.38(3.02%)			
Weight of sediment passed (g)			558.62(96.98%)			



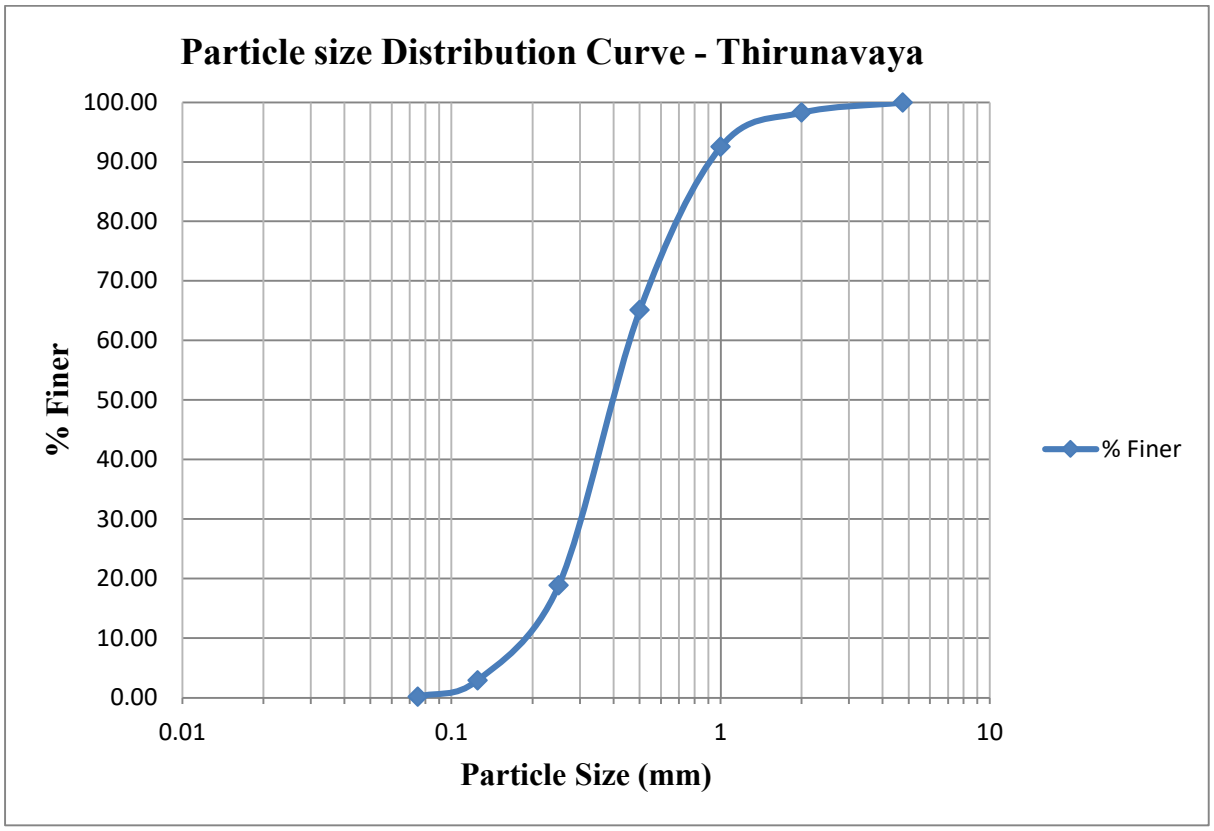
SIEVE ANALYSIS						
Sample Name			Mayyannur Check Dam			
Mass of pan (g)			194.6			
Mass of pan + dry sample (g)			669.06			
Mass of dry sample (g)			474.46			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	416.3	75.13	15.835	15.835	84.165
1	300.92	549.5	248.58	52.392	68.227	31.773
0.5	275.46	419.47	144.01	30.352	98.579	1.421
0.25	245.59	249.89	4.3	0.906	99.486	0.514
0.125	269.14	270.4	1.26	0.266	99.751	0.249
0.075	353.54	354.62	1.08	0.228	99.979	0.021
PAN	350.13	350.23	0.1	-	-	-
Total Weight of sample (g)			885.26			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			43.63(8.42%)			
Weight of sediment passed (g)			474.46(91.58%)			



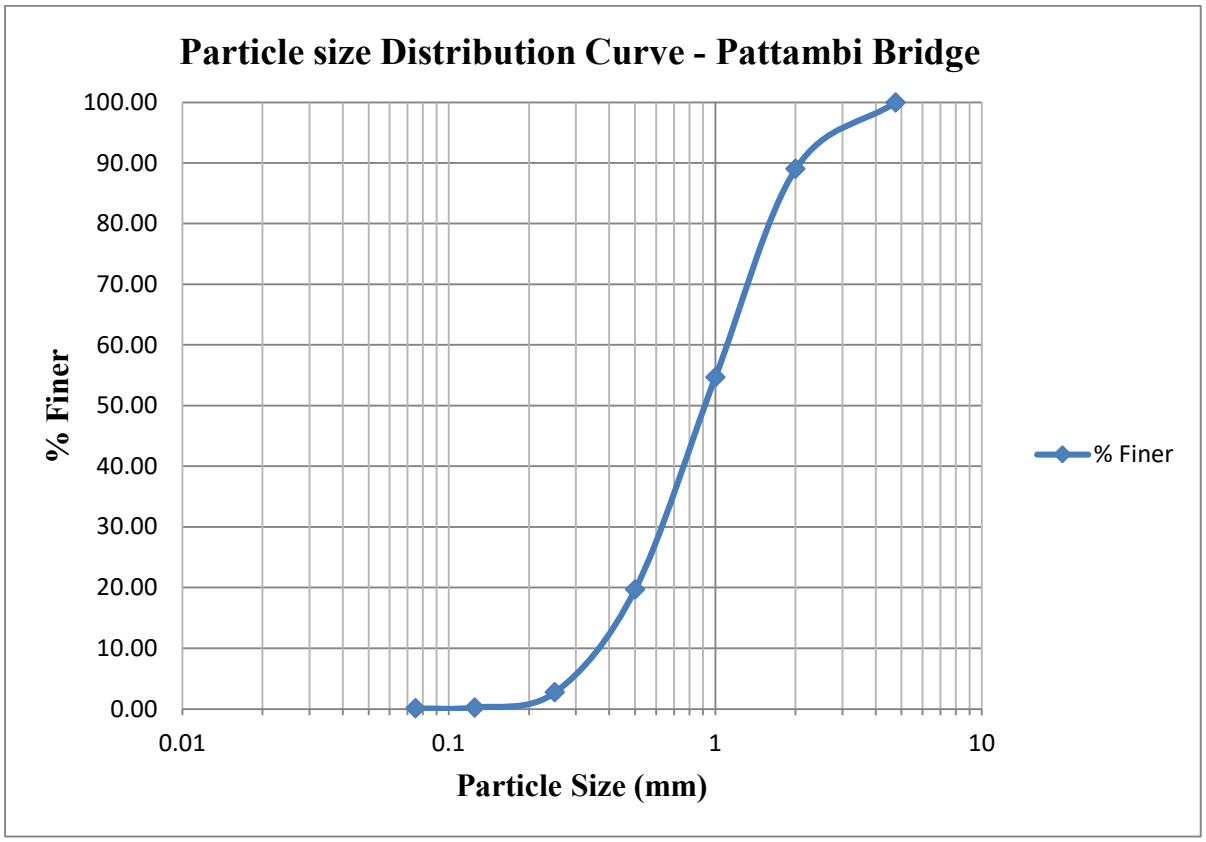
SIEVE ANALYSIS						
Sample Name			Chenganamkunnu Reservoir			
Mass of pan (g)			186.7			
Mass of pan + dry sample (g)			689.4			
Mass of dry sample (g)			502.7			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	368.4	27.23	5.417	5.417	94.583
1	300.92	465.65	164.73	32.769	38.186	61.814
0.5	275.46	531.18	255.72	50.869	89.055	10.945
0.25	245.59	292.24	46.65	9.280	98.335	1.665
0.125	269.14	274.44	5.3	1.054	99.389	0.611
0.075	353.54	355.86	2.32	0.462	99.851	0.149
PAN	350.13	350.88	0.75			
Total Weight of sample (g)			873.99			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			4.12(0.81%)			
Weight of sediment passed (g)			502.7(99.19%)			



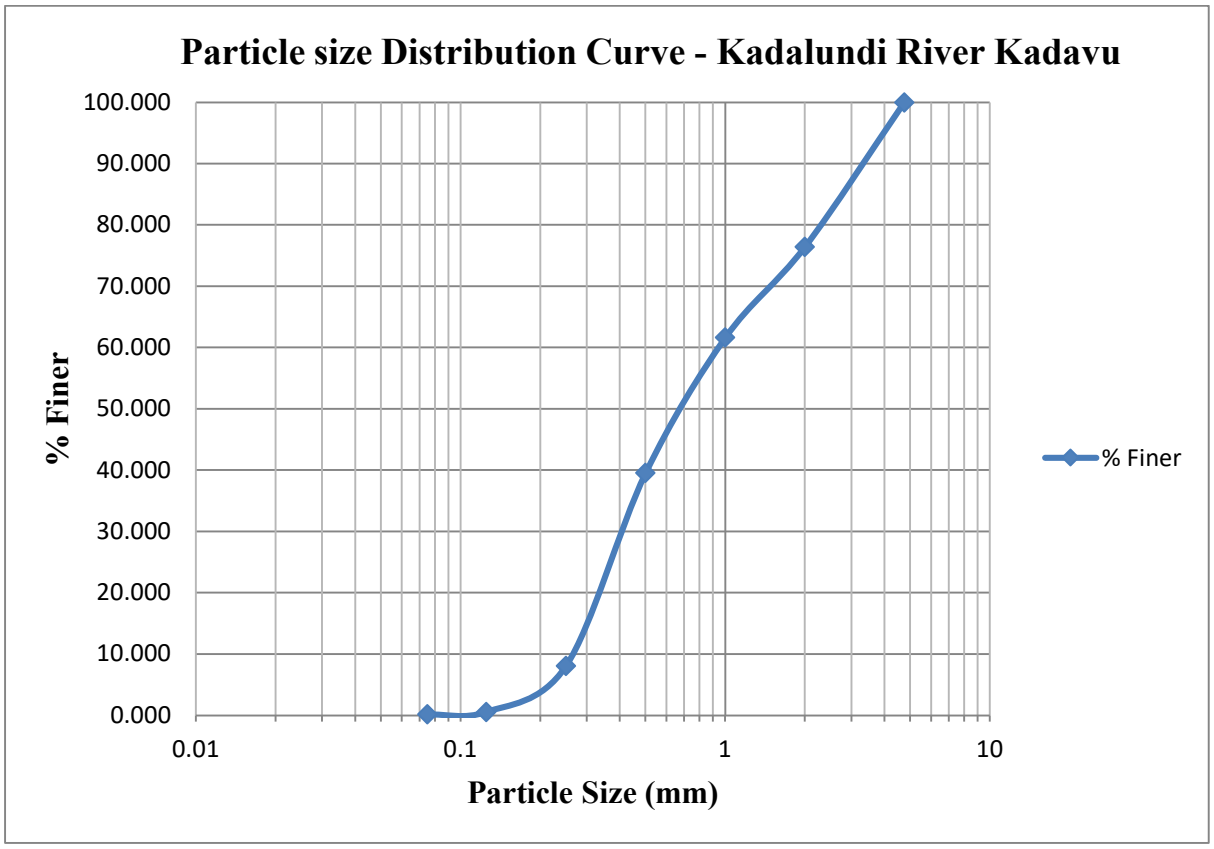
SIEVE ANALYSIS						
Sample Name			Thirunavaya			
Mass of pan (g)			183.3			
Mass of pan + dry sample (g)			663.44			
Mass of dry sample (g)			480.14			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	349.35	8.18	1.704	1.704	98.296
1	300.92	328.53	27.61	5.750	7.454	92.546
0.5	275.46	407.23	131.77	27.444	34.898	65.102
0.25	245.59	467.41	221.82	46.199	81.097	18.903
0.125	269.14	345.85	76.71	15.977	97.074	2.926
0.075	353.54	366.78	13.24	2.758	99.831	0.169
PAN	350.13	350.9	0.77			
Total Weight of sample (g)			853.52			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			6.21(1.28%)			
Weight of sediment passed (g)			480.14(98.72%)			



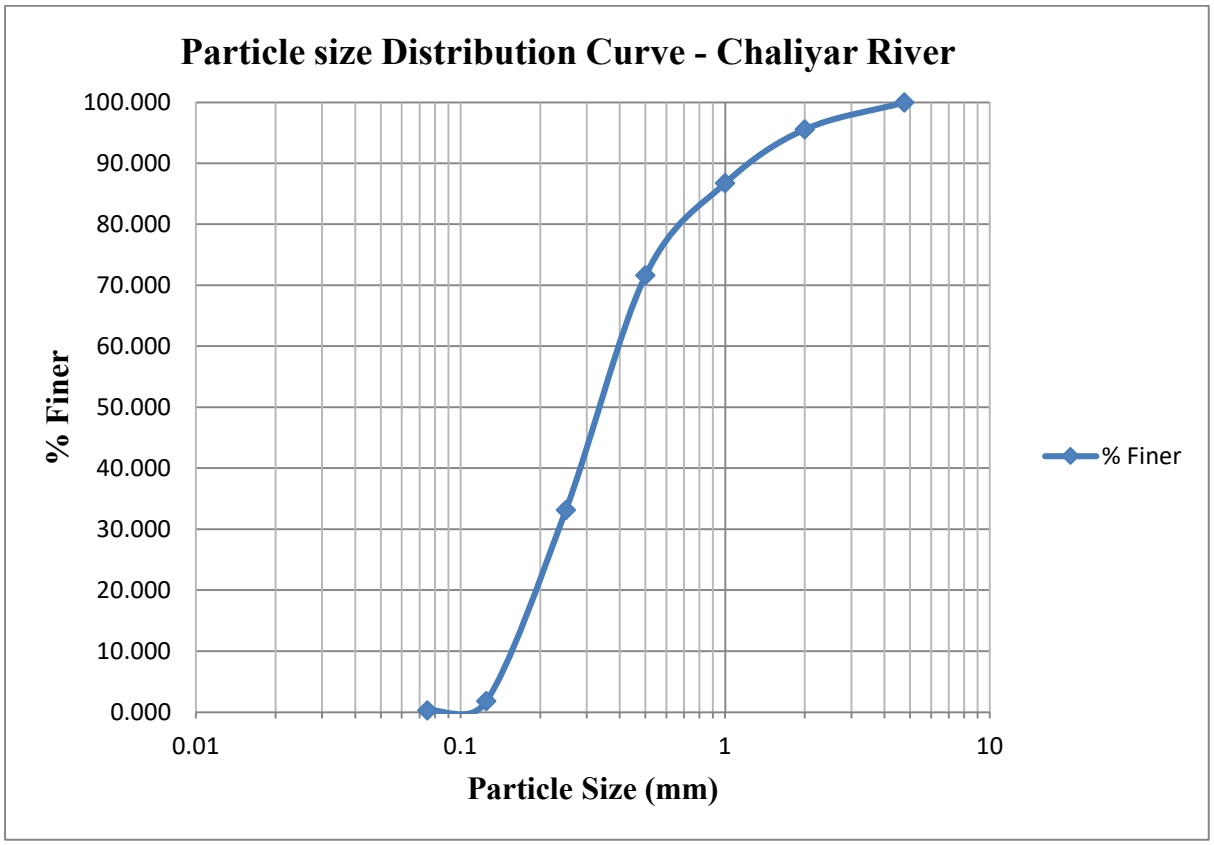
SIEVE ANALYSIS						
Sample Name			Pattambi Bridge			
Mass of pan (g)			191.96			
Mass of pan + dry sample (g)			726.61			
Mass of dry sample (g)			534.65			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	399.78	58.61	10.962	10.962	89.038
1	300.92	484.48	183.56	34.333	45.295	54.705
0.5	275.46	462.76	187.3	35.032	80.327	19.673
0.25	245.59	336.15	90.56	16.938	97.266	2.734
0.125	269.14	282.49	13.35	2.497	99.762	0.238
0.075	353.54	354.34	0.8	0.150	99.912	0.088
PAN	350.13	350.6	0.47			
Total Weight of sample (g)			913.61			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			11.79(2.16%)			
Weight of sediment passed (g)			534.65(97.84%)			



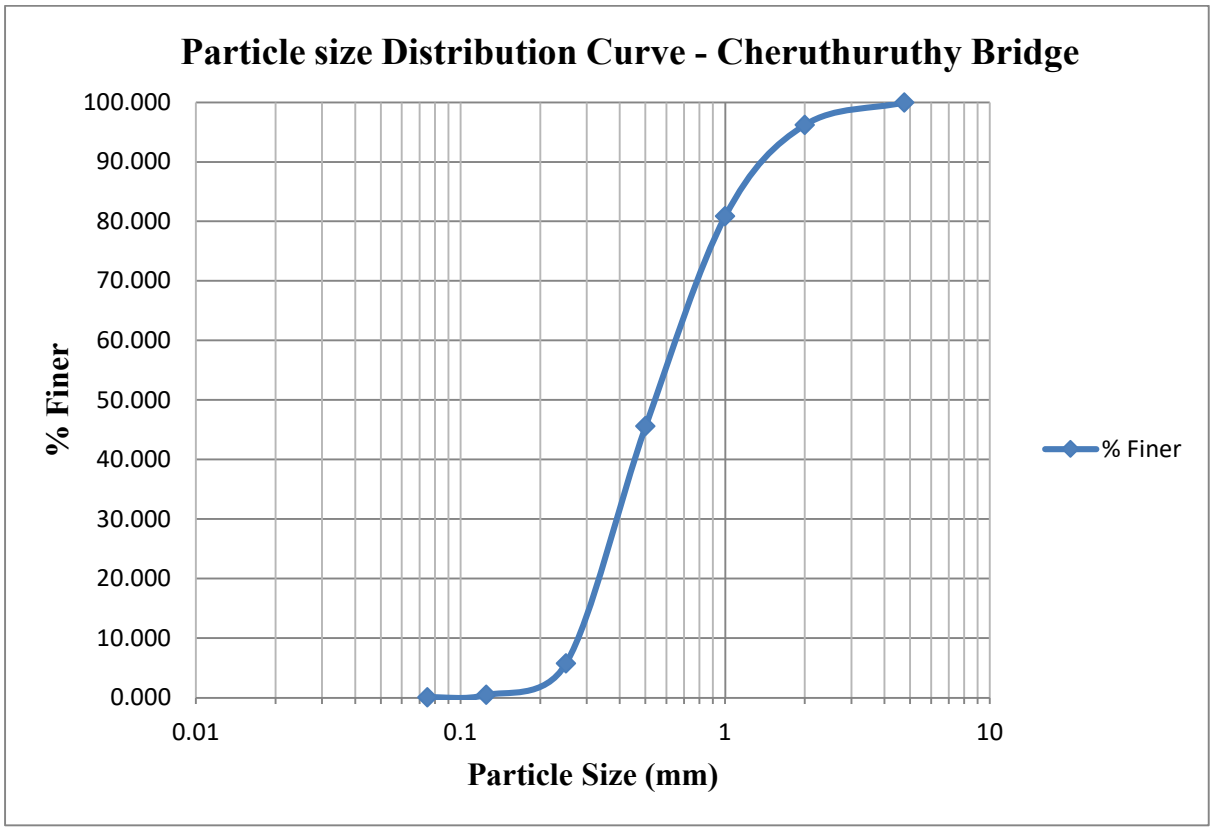
SIEVE ANALYSIS						
Sample Name			Kadalundi River Kadavu			
Mass of pan (g)			198.57			
Mass of pan + dry sample (g)			503.1			
Mass of dry sample (g)			304.53			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	412.91	71.74	23.558	23.558	76.442
1	300.92	346.07	45.15	14.826	38.384	61.616
0.5	275.46	342.74	67.28	22.093	60.477	39.523
0.25	245.59	341.49	95.9	31.491	91.968	8.032
0.125	269.14	291.96	22.82	7.494	99.461	0.539
0.075	353.54	354.74	1.2	0.394	99.856	0.144
PAN	350.13	350.57	0.44			
Total Weight of sample (g)			1028.45			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			356.75(53.95%)			
Weight of sediment passed (g)			304.53(46.05%)			



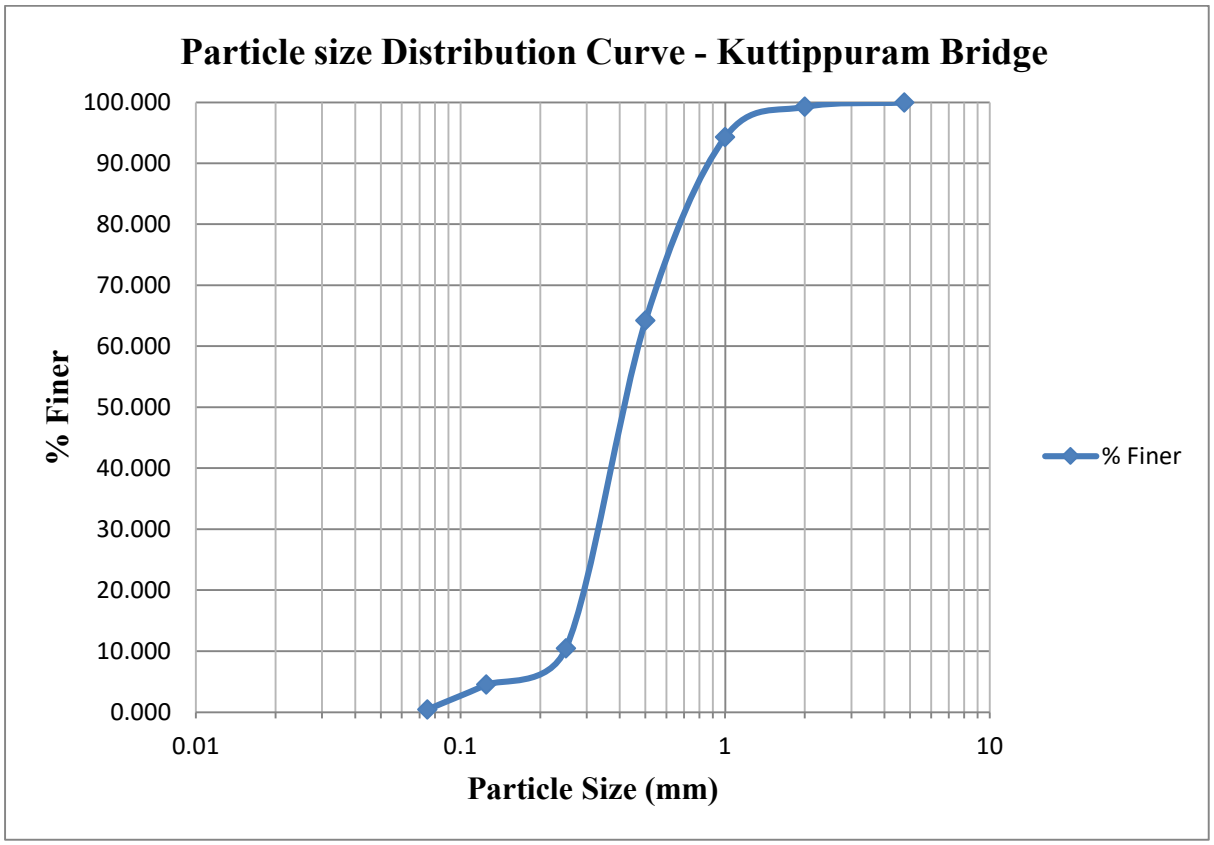
SIEVE ANALYSIS						
Sample Name			Chaliyar River			
Mass of pan (g)			194.74			
Mass of pan + dry sample (g)			713.35			
Mass of dry sample (g)			518.61			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	364.05	22.88	4.412	4.412	95.588
1	300.92	346.79	45.87	8.845	13.257	86.743
0.5	275.46	353.76	78.3	15.098	28.355	71.645
0.25	245.59	445.17	199.58	38.484	66.838	33.162
0.125	269.14	431.86	162.72	31.376	98.214	1.786
0.075	353.54	361.34	7.8	1.504	99.718	0.282
PAN	350.13	351.59	1.46			
Total Weight of sample (g)			897.87			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			12.09(2.28%)			
Weight of sediment passed (g)			518.61(97.72%)			



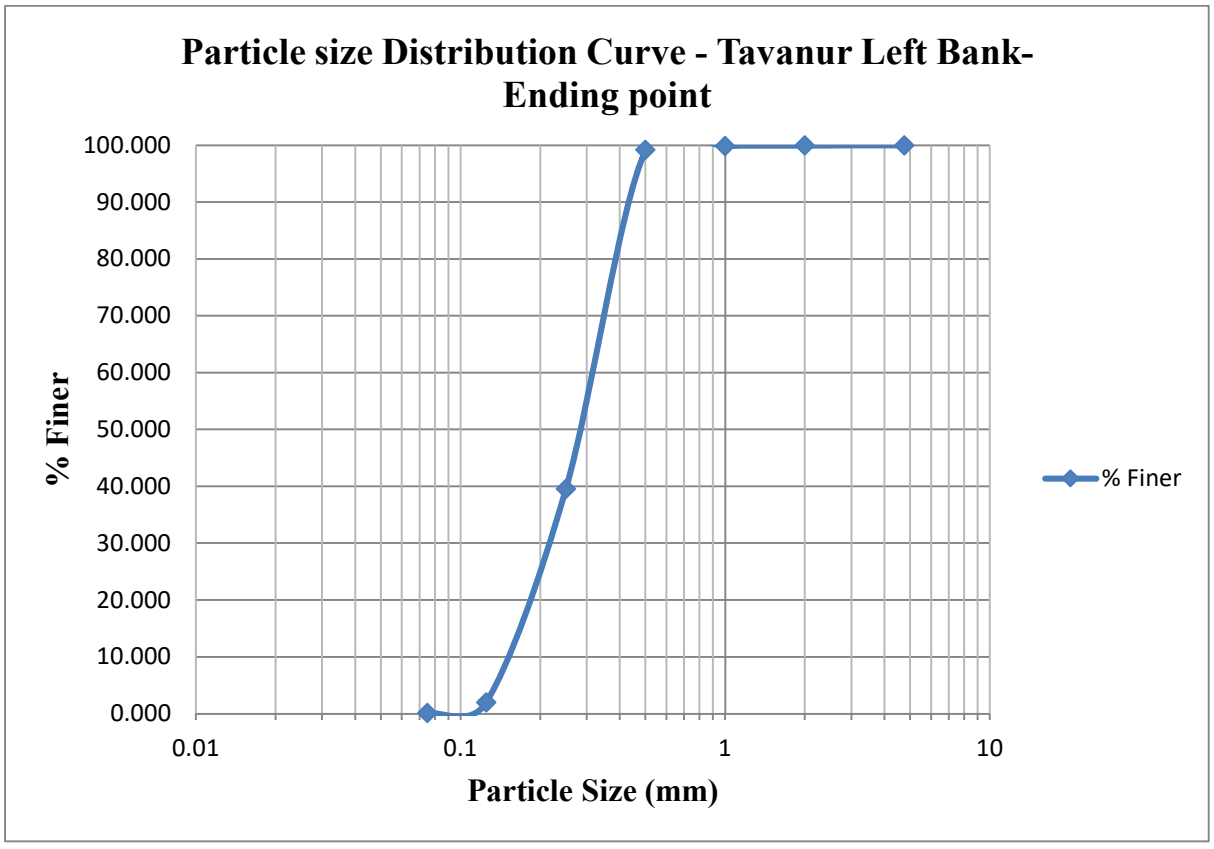
SIEVE ANALYSIS						
Sample Name			Cheruthuruthy Bridge			
Mass of pan (g)			186.78			
Mass of pan + dry sample (g)			639.35			
Mass of dry sample (g)			452.57			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	358.28	17.11	3.781	3.781	96.219
1	300.92	370.27	69.35	15.324	19.104	80.896
0.5	275.46	435.28	159.82	35.314	54.418	45.582
0.25	245.59	425.88	180.29	39.837	94.255	5.745
0.125	269.14	293.01	23.87	5.274	99.529	0.471
0.075	353.54	355.41	1.87	0.413	99.943	0.057
PAN	350.13	350.39	0.26			
Total Weight of sample (g)			825.23			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			5.49(1.20%)			
Weight of sediment passed (g)			452.57(98.80%)			



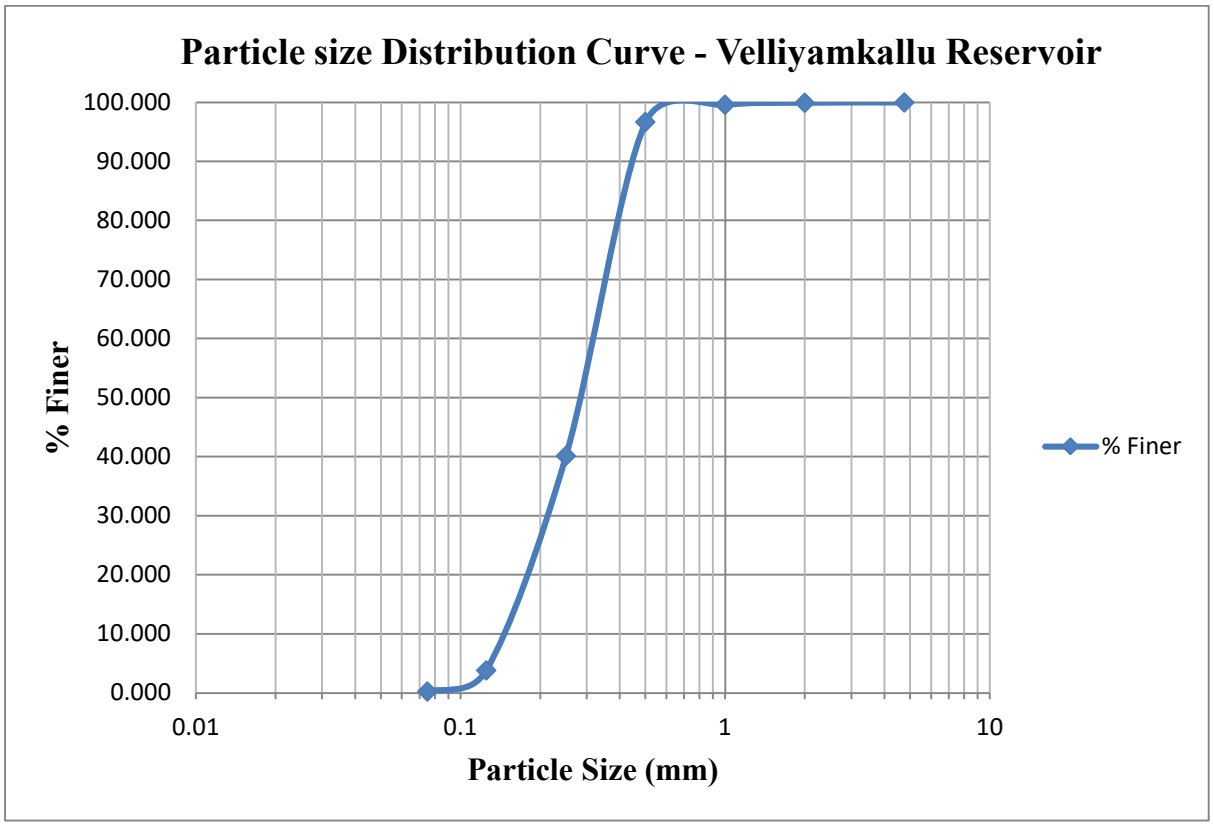
SIEVE ANALYSIS						
Sample Name			Kuttippuram Bridge			
Mass of pan (g)			185.29			
Mass of pan + dry sample (g)			771.44			
Mass of dry sample (g)			586.15			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained(g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	345.36	4.19	0.715	0.715	99.285
1	300.92	330.02	29.1	4.965	5.679	94.321
0.5	275.46	451.81	176.35	30.086	35.766	64.234
0.25	245.59	560.76	315.17	53.770	89.535	10.465
0.125	269.14	304.08	34.94	5.961	95.496	4.504
0.075	353.54	377.31	23.77	4.055	99.551	0.449
PAN	350.13	352.76	2.63			
Total Weight of sample (g)			953.47			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			0.15(0.03%)			
Weight of sediment passed (g)			586.15(99.97%)			



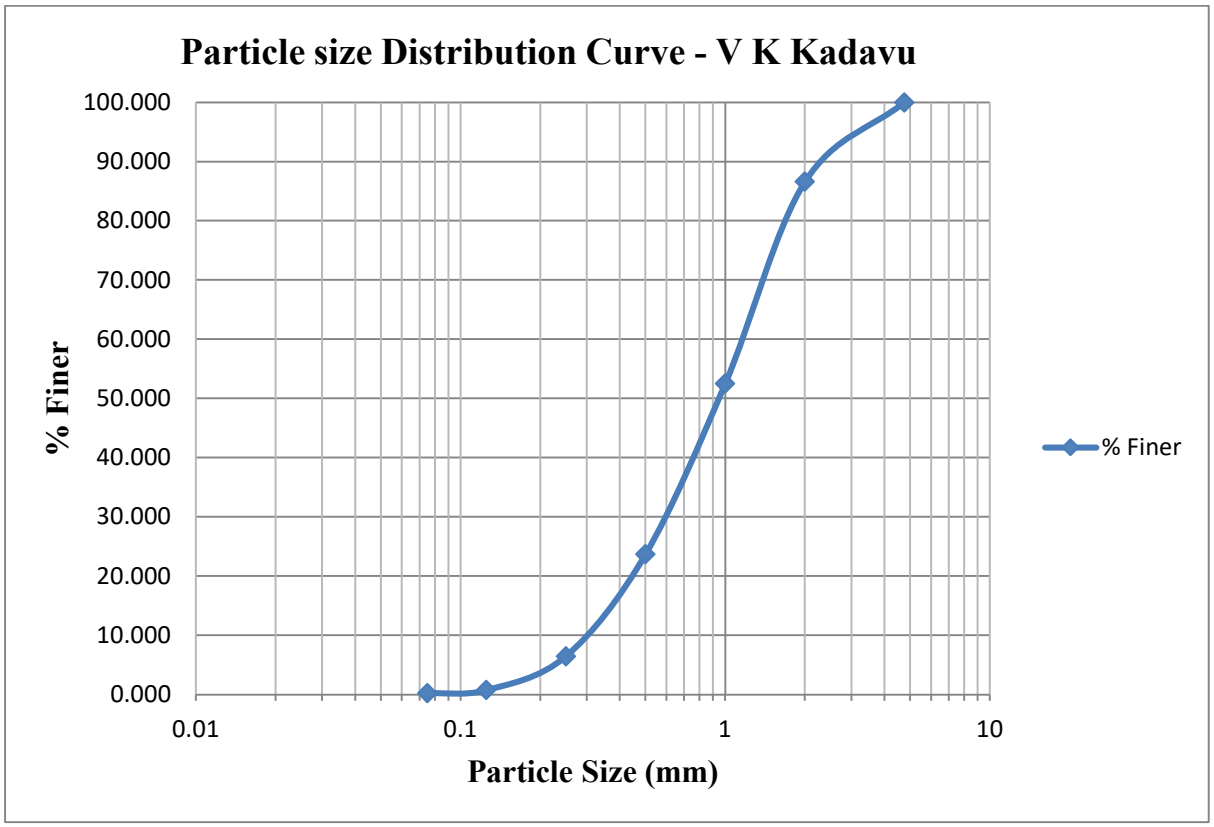
SIEVE ANALYSIS						
Sample Name			Tavanur Left Bank- Ending Point			
Mass of pan (g)			191.96			
Mass of pan + dry sample (g)			776.54			
Mass of dry sample (g)			584.58			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	341.34	0.17	0.029	0.029	99.971
1	300.92	301.48	0.56	0.096	0.125	99.875
0.5	275.46	279.54	4.08	0.698	0.823	99.177
0.25	245.59	594.16	348.57	59.627	60.450	39.550
0.125	269.14	488.71	219.57	37.560	98.011	1.989
0.075	353.54	364.6	11.06	1.892	99.902	0.098
PAN	350.13	350.7	0.57			
Total Weight of sample (g)			952.1			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			0.35(0.06%)			
Weight of sediment passed (g)			584.58(99.94%)			



SIEVE ANALYSIS						
Sample Name			Velliyamkallu Reservoir			
Mass of pan (g)			185.35			
Mass of pan + dry sample (g)			761.55			
Mass of dry sample (g)			576.2			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	341.49	0.32	0.056	0.056	99.944
1	300.92	303.01	2.09	0.363	0.418	99.582
0.5	275.46	292.39	16.93	2.938	3.356	96.644
0.25	245.59	571.38	325.79	56.541	59.898	40.102
0.125	269.14	478.22	209.08	36.286	96.184	3.816
0.075	353.54	374.27	20.73	3.598	99.781	0.219
PAN	350.13	351.39	1.26			
Total Weight of sample (g)			943.41			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			0.04(0.01%)			
Weight of sediment passed (g)			576.2(99.99%)			



SIEVE ANALYSIS						
Sample Name			V K Kadavu			
Mass of pan (g)			191.95			
Mass of pan + dry sample (g)			776.41			
Mass of dry sample (g)			584.46			
Size of sieve (mm)	Weight of sieve (g)	Weight of sieve + sediment retained (g)	Weight of sediment retained (g)	% Mass retained	% Cumulative retained	% Finer
4.75	367.17	367.17	0	0.000	0.000	100.000
2	341.17	419.39	78.22	13.383	13.383	86.617
1	300.92	500.25	199.33	34.105	47.488	52.512
0.5	275.46	443.88	168.42	28.816	76.305	23.695
0.25	245.59	346.35	100.76	17.240	93.544	6.456
0.125	269.14	302.48	33.34	5.704	99.249	0.751
0.075	353.54	356.72	3.18	0.544	99.793	0.207
PAN	350.13	351.34	1.21			
Total Weight of sample (g)			974.28			
Weight of 4.75mm sieve(g)			367.17			
Weight of sediment retained (g)			22.65(3.73%)			
Weight of sediment passed (g)			584.46(96.27%)			



CONCLUSIONS:

- The characteristics of the sediments on the bank was having almost similar nature. So the twelve sampling points was decided based on visual interpretation and those were the locations which was showing visible changes in its characteristics.
- Major portion of the sand samples consists of fine sand of size ranging between 4.75mm and 75 microns. Only one sample from Kadalundi River Kadavu had comparatively higher percentage (53.95%) of coarse sand.
- The particle size distributions of the finer portion of twelve sand samples are represented using the gradation curves.

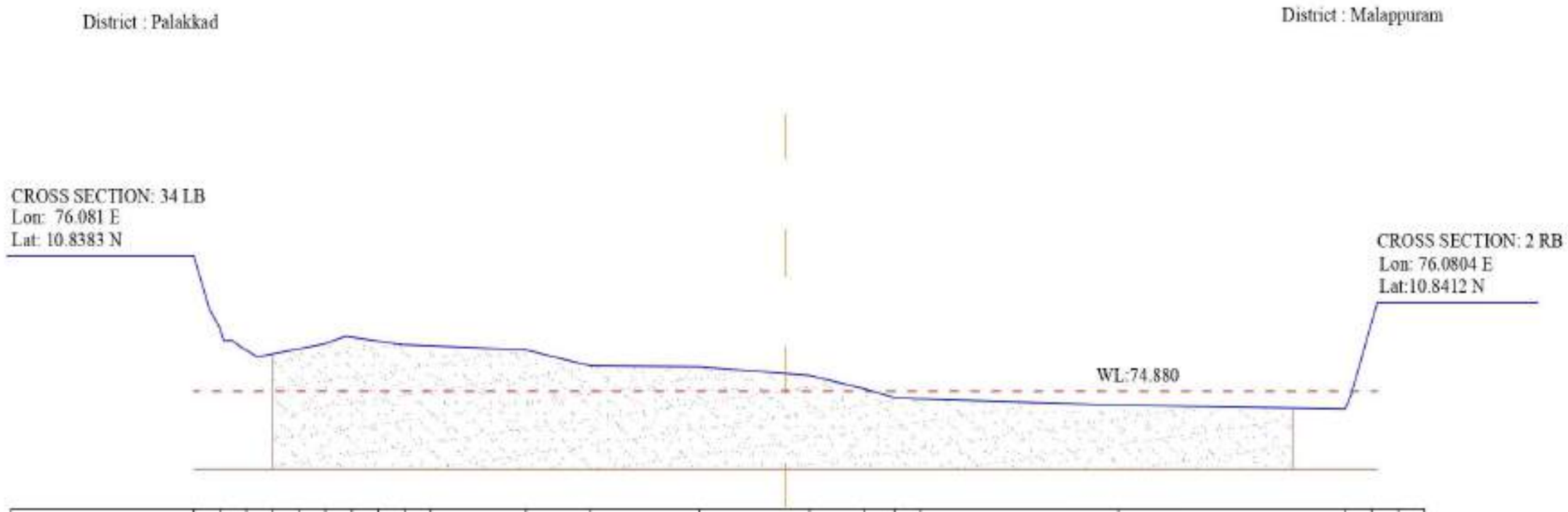
ANNEXURE-II

Cross-sections of sand mining sites

BHARATHAPUZHA RIVER

Cross Section 2

Annexure-II



Elevation	78.336	76.980	76.483	76.162	76.180	75.998	75.757	76.078	76.280	76.066	75.936	75.529	75.501	75.285	74.941	74.716	74.684	74.524	74.423	74.796	77.139
Distance	0.000	4.421	7.511	8.498	10.777	13.576	18.112	36.791	43.289	59.265	94.579	112.971	144.027	175.392	190.881	199.552	205.340	263.281	327.952	329.650	337.034
REMARK	CS34	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	M	M	CS2

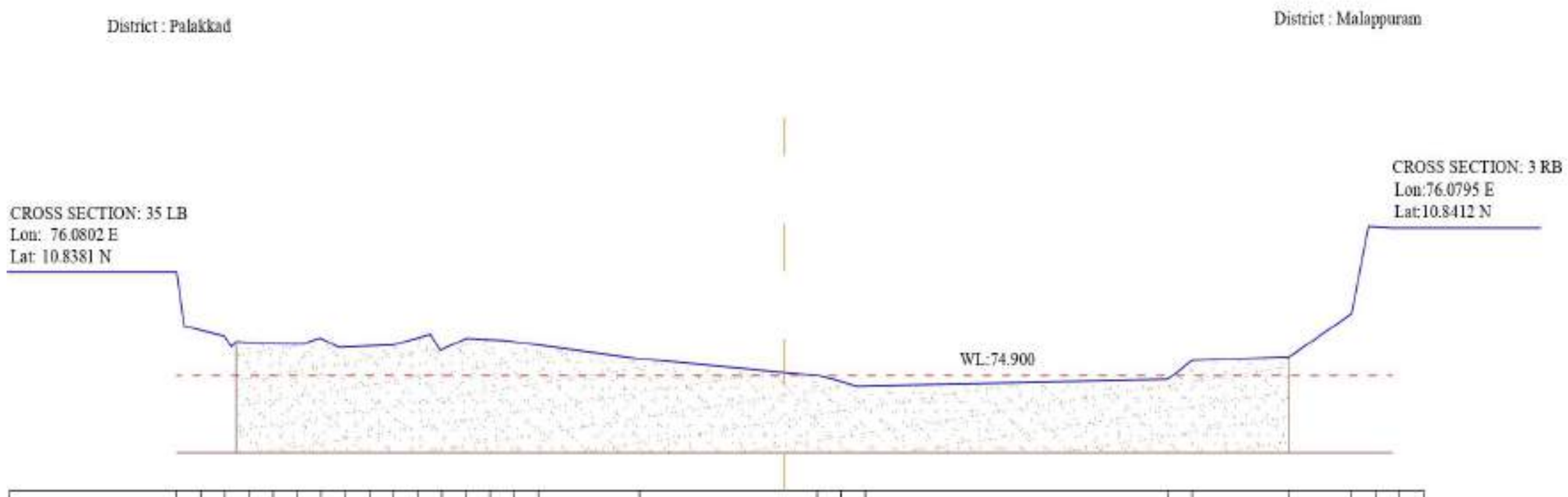
REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	TBM C1 MANKENRI RAILWAY BRIDGE, RB
Latitude	10°50'29.73'' N
Longitude	76°4'47.472'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
6.6	251.7	50	330.00	12585.00

BHARATHAPUZHA RIVER

Cross Section 3



Elevation	77.606	76.197	75.936	75.653	75.790	75.742	75.728	75.803	75.882	75.645	75.652	75.707	75.979	75.563	75.876	75.816	75.343	74.911	74.796	74.630	74.808	75.303	75.395	76.512	78.800	78.765
Distance	0.000	2.225	14.824	16.963	18.496	25.935	39.506	41.551	44.633	50.578	53.280	67.483	78.945	81.950	90.195	102.259	144.135	199.332	204.896	211.635	308.436	316.037	346.310	365.714	370.991	378.445
REMARK	CS35	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	M	M	CS3

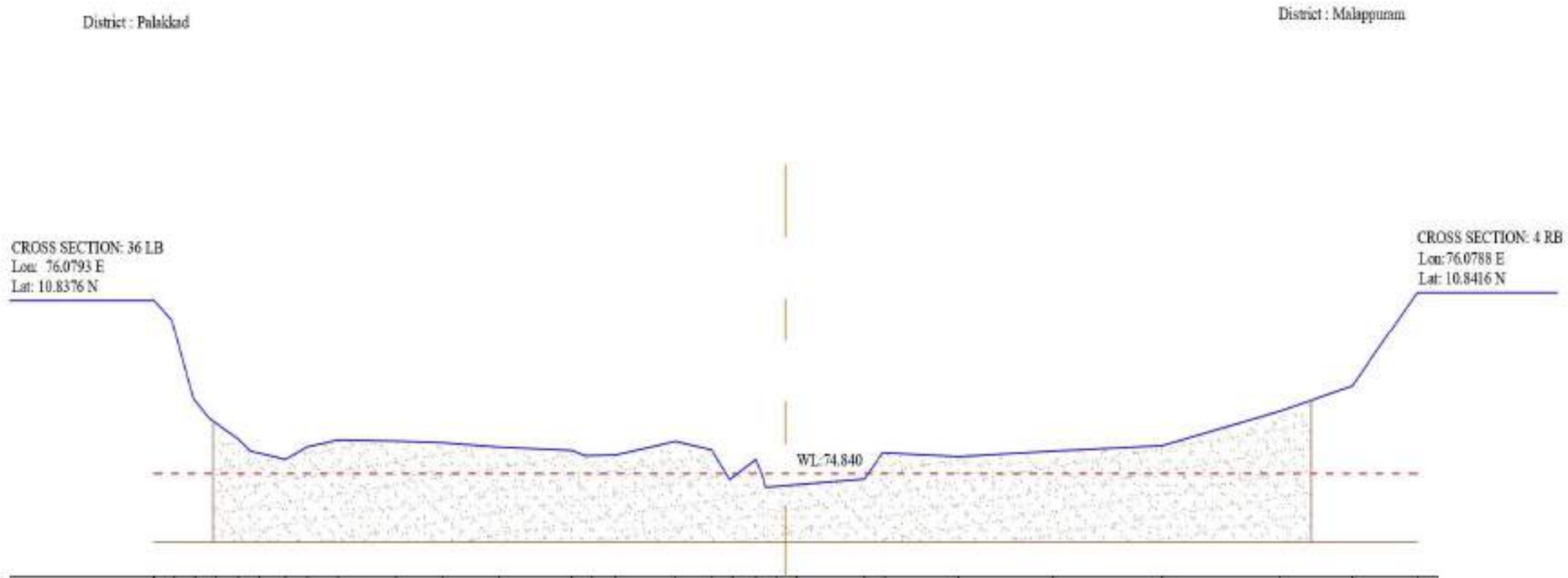
REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	TBM C1 MANKENRI RAILWAY BRIDGE, RB
Latitude	10°50'29.73'' N
Longitude	76°4'47.472'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
14.8	295	100	1480.00	29500.00

BHARATHAPUZHA RIVER

Cross Section 4



Elevation	79.857	79.297	77.010	76.438	75.836	75.486	75.251	75.616	75.812	75.780	75.733	75.606	75.511	75.356	75.376	75.773	75.521	74.666	75.248	74.805	74.444	74.679	75.443	75.328	75.491	75.646	76.643	77.370	80.091			
Distance	0.000	6.505	14.304	20.057	30.714	35.079	47.928	55.779	67.121	88.128	105.224	125.356	151.912	156.928	167.987	189.744	202.950	209.448	218.847	221.141	222.350	258.374	265.016	292.500	327.072	366.687	409.616	435.834	459.399			
REMARK	CS36	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	CS4			

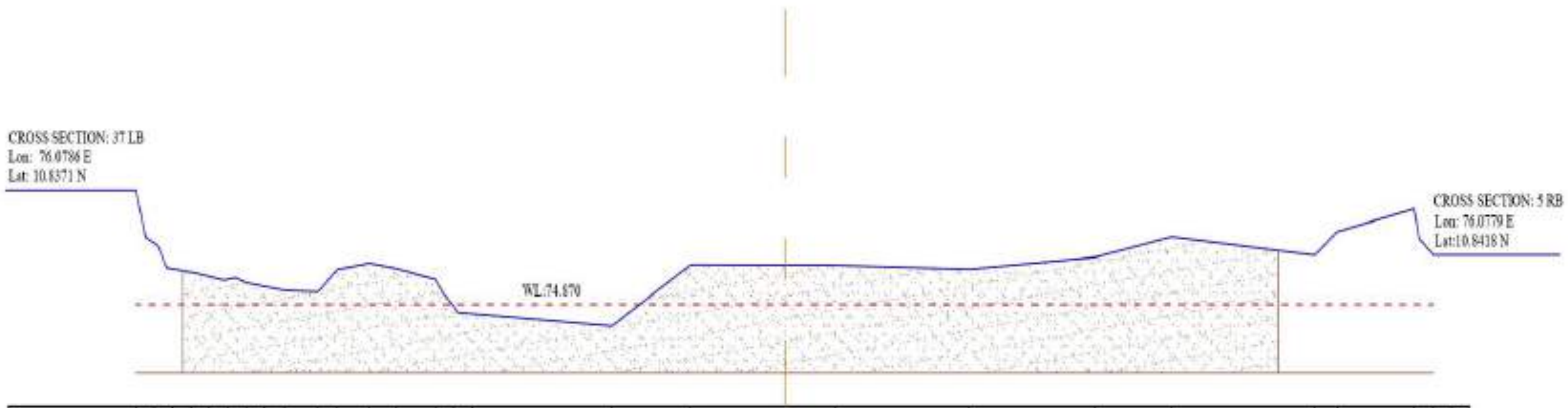
REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	TBM C1 MANKENRI RAILWAY BRIDGE, RB
Latitude	10°50'29.73'' N
Longitude	76°4'47.472'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
143.1	374.8	100	14130.00	37480.00

BHARATHAPUZHA RIVER

Cross Section 5



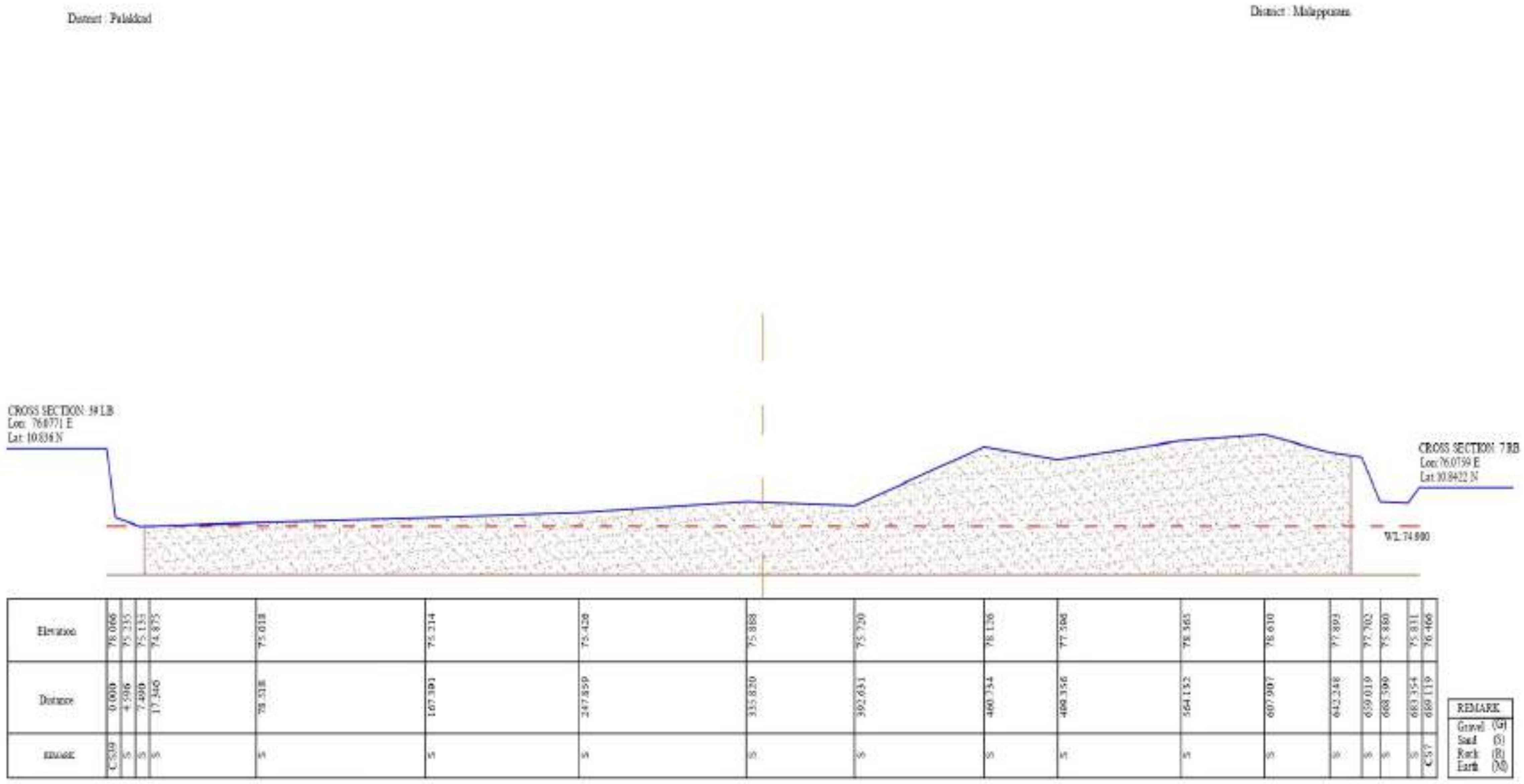
Distance	Elevation	REMARK
0.000	78.224	CS37
4.129	76.831	S
8.954	76.601	S
12.734	75.949	S
23.569	75.808	S
35.908	75.585	S
40.551	75.660	S
45.161	75.510	S
60.472	75.285	S
74.371	75.245	S
82.098	75.892	S
95.316	76.081	S
105.910	75.932	S
122.126	75.607	S
125.741	74.158	S
131.573	74.631	S
194.167	74.235	S
226.308	76.041	S
285.095	76.027	S
339.920	75.903	S
391.334	76.296	S
422.489	76.851	S
480.803	76.313	S
489.986	77.003	S
521.433	77.677	S
523.357	76.798	S
529.239	76.319	CS5

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
		Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Note	TBM C1 MANKENRI RAILWAY BRIDGE, RB	275.5	402.3	100	27550.00	40230.00
Latitude	10°50'29.73'' N					
Longitude	76°4'47.472'' E					

BHARATHAPUZHA RIVER

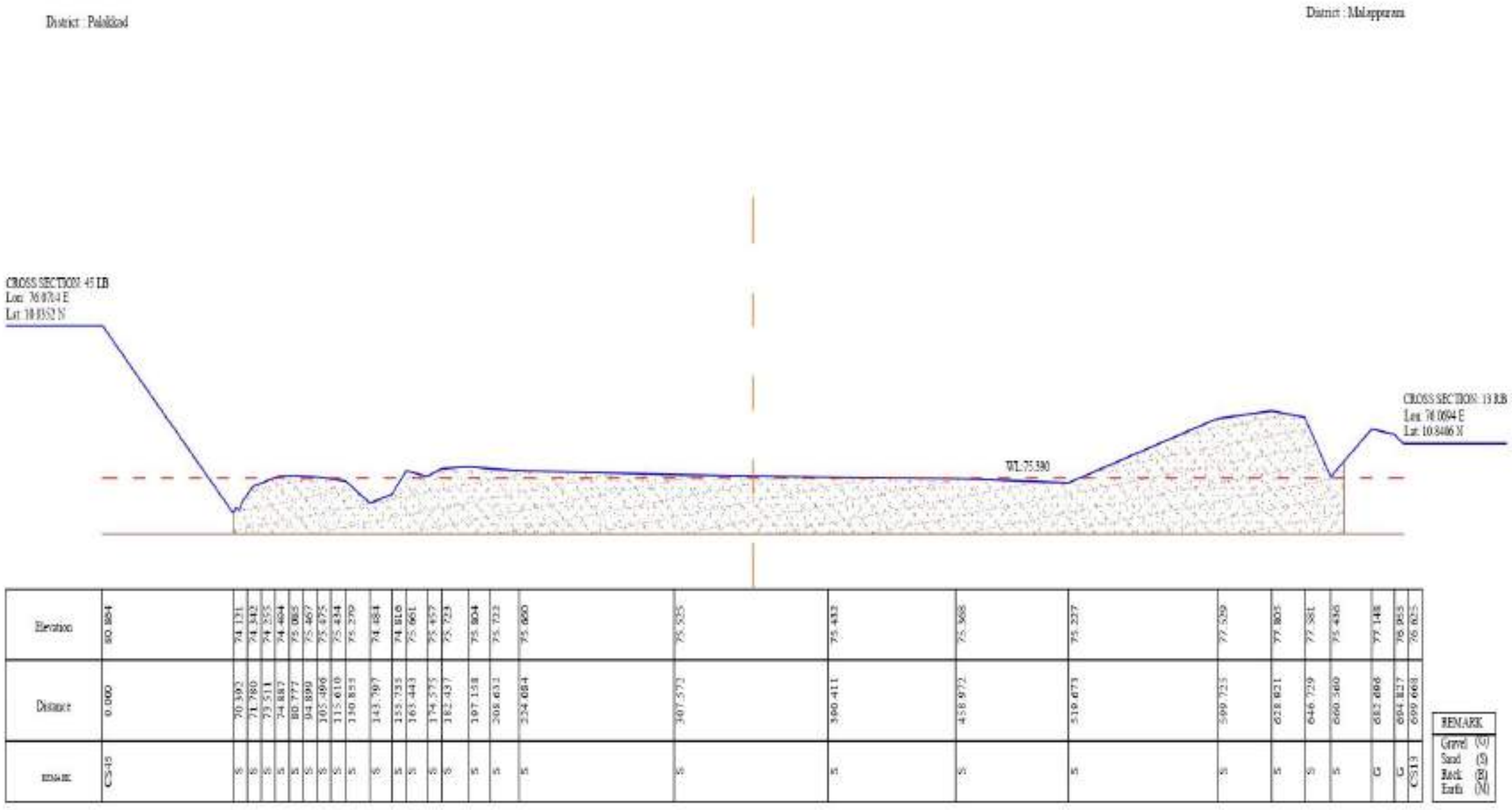
Cross Section 7



Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM C1** MANKENRI RAILWAY BRIDGE, RB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°50'29.73'' N					
Longitude	76°4'47.472'' E	799.1	617.5	100	79910.00	61750.00

BHARATHAPUZHA RIVER

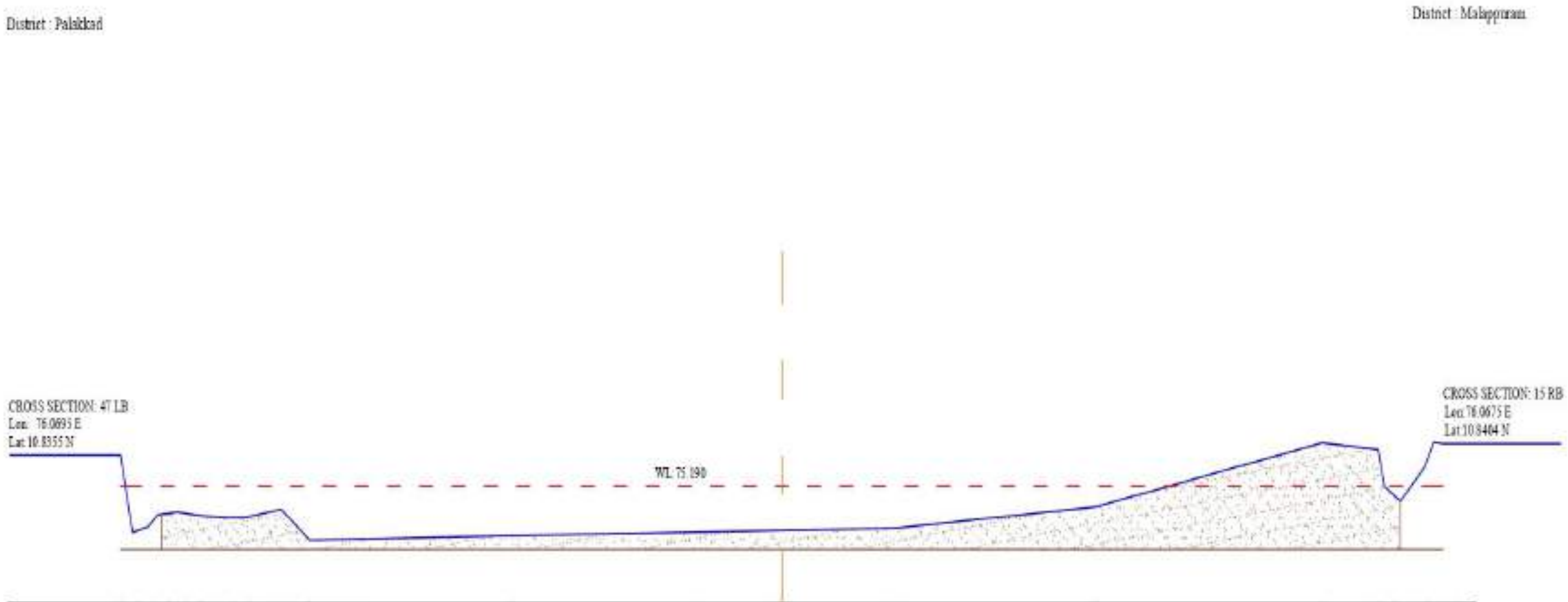
Cross Section 13



Identification of TBM		Area of Cross Section (m²)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM C1** MANKENRI RAILWAY BRIDGE, RB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°50'29.73'' N	204.8	629.3	100	20480.00	62930.00
Longitude	76°4'47.472'' E					

BHARATHAPUZHA RIVER

Cross Section 15



Elevation	76.157	74.544	73.730	73.898	74.285	74.364	74.239	74.191	74.197	74.450	73.485
Distance	0.000	4.041	5.554	12.695	17.247	26.132	38.482	50.462	57.862	74.397	87.640
REMARK	CS47	S	S	S	S	S	S	S	S	S	S

Elevation	73.627	73.739	73.863	74.527	76.535	76.321	75.187	74.706	75.774	76.555	76.507
Distance	181.929	269.797	359.149	452.179	557.362	583.439	586.154	593.081	604.851	609.099	613.434
REMARK	S	S	S	S	S	S	S	S	S	M	CS15

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

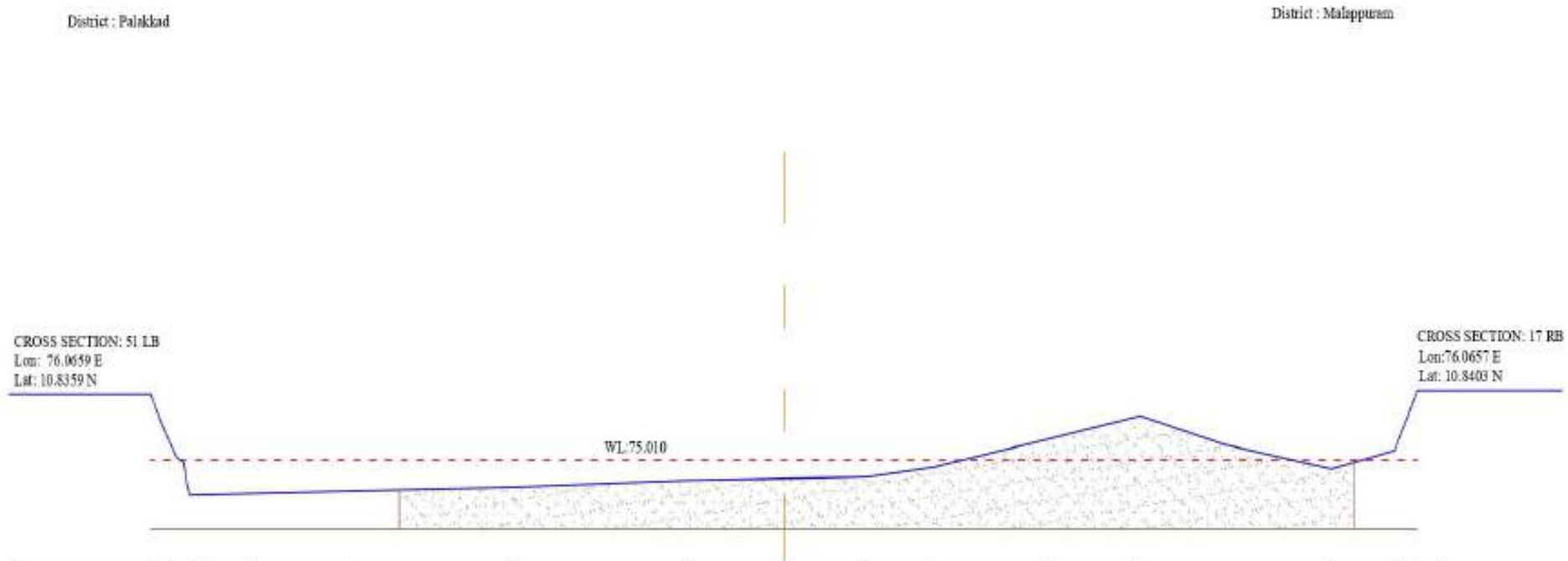
Identification of TBM		Area of Cross Section (m²)		Zone of Influence (m)	Sand Volume (m³)	
Note	**TBM C1** MANKENRI RAILWAY BRIDGE, RB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°50'29.73'' N	81.1	396.5	100	8110.00	39650.00
Longitude	76°4'47.472'' E					

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

BHARATHAPUZHA RIVER

Cross Section 17



Elevation	76.932	76.134	75.091	74.953	74.308	74.006	74.123	74.226	74.432	74.527	74.803	75.589	76.301	75.463	74.758	75.289	77.036			
Distance	0.000	3.828	9.730	12.484	13.797	14.740	79.211	135.689	204.349	271.678	296.589	338.419	375.319	407.255	447.812	471.682	480.409			
REMARK	CS51	M	M	M	M	M	M	S	S	S	DB	S	S	S	S	S	CS17			

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	TBM C1 MANKENRI RAILWAY BRIDGE, RB
Latitude	10°50'29.73'' N
Longitude	76°4'47.472'' E

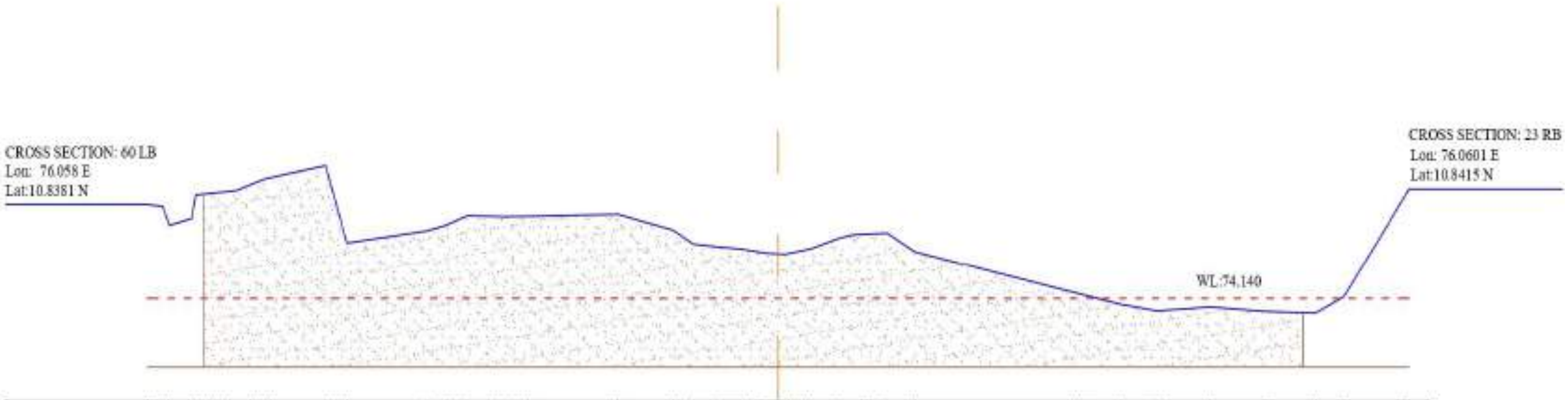
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
77.1	404.1	100	7710.00	40410.00

BHARATHAPUZHA RIVER

Cross Section 23

District : Palakkad

District : Malappuram



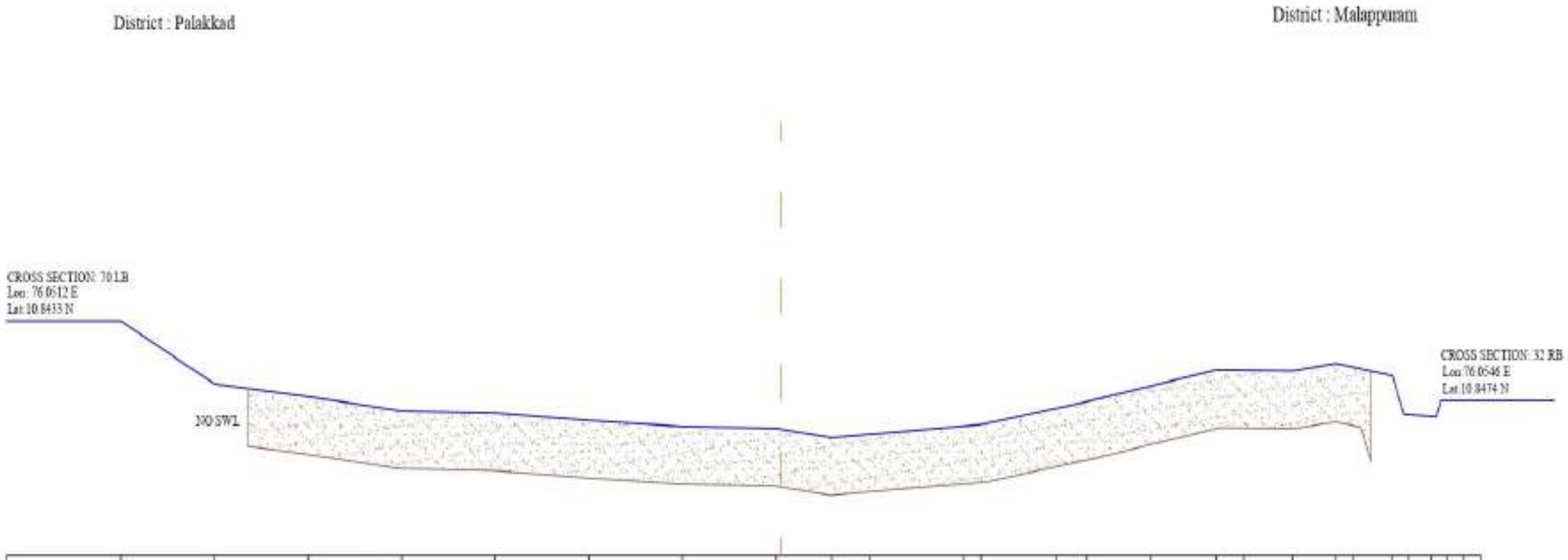
Elevation	Distance	REMARK
76.887	0.000	CS60
76.835	5.506	S
76.278	8.023	S
76.485	16.254	S
77.165	17.640	S
77.292	32.412	S
77.627	42.878	S
78.018	65.124	S
75.765	72.971	S
76.120	102.033	S
76.278	109.088	S
76.433	113.346	S
76.565	117.310	S
76.539	130.716	S
76.542	137.475	S
76.603	172.099	S
76.147	192.241	S
75.737	199.554	S
75.655	208.352	S
75.597	216.712	S
75.467	226.977	S
75.443	233.282	S
75.605	242.894	S
75.914	253.304	S
76.011	258.158	S
76.054	270.495	S
75.509	280.709	S
74.276	340.934	S
73.962	356.266	S
73.772	369.248	S
73.890	388.761	S
73.760	408.678	S
73.711	427.209	S
74.191	437.702	M
77.336	461.457	CS23

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM B3** SREE AYYAPPANKAVU BHAGAVATHI TEMPLE, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°50'13.153'' N					
Longitude	76°3'33.874'' E	128.2	361.7	100	12820.00	36170.00

BHARATHAPUZHA RIVER

Cross Section 32



Elevation	79.866	77.683	77.246	76.743	76.674	76.423	76.305	76.141	75.825	75.938	76.216	76.270	76.839	77.066	77.609	78.173	78.161	78.140	78.393	78.383	77.973	76.631	76.561	76.547	77 Lon					
Distance	0.000	42.600	85.200	127.800	170.400	213.000	255.600	298.200	323.471	340.800	383.400	391.637	426.000	439.708	468.600	498.623	511.200	533.488	553.199	553.800	578.830	584.114	596.400	598.766	600.853					
REMARK	CS70	S	S	S	S	S	S	S	S	S	S	DB	S	S	S	S	S	S	S	S	S	S	S	S	CS32					

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	**TBM B4** ANAKKARA PUMP HOUSE, LB
Latitude	10°50'32.599'' N
Longitude	76°3'17.254'' E

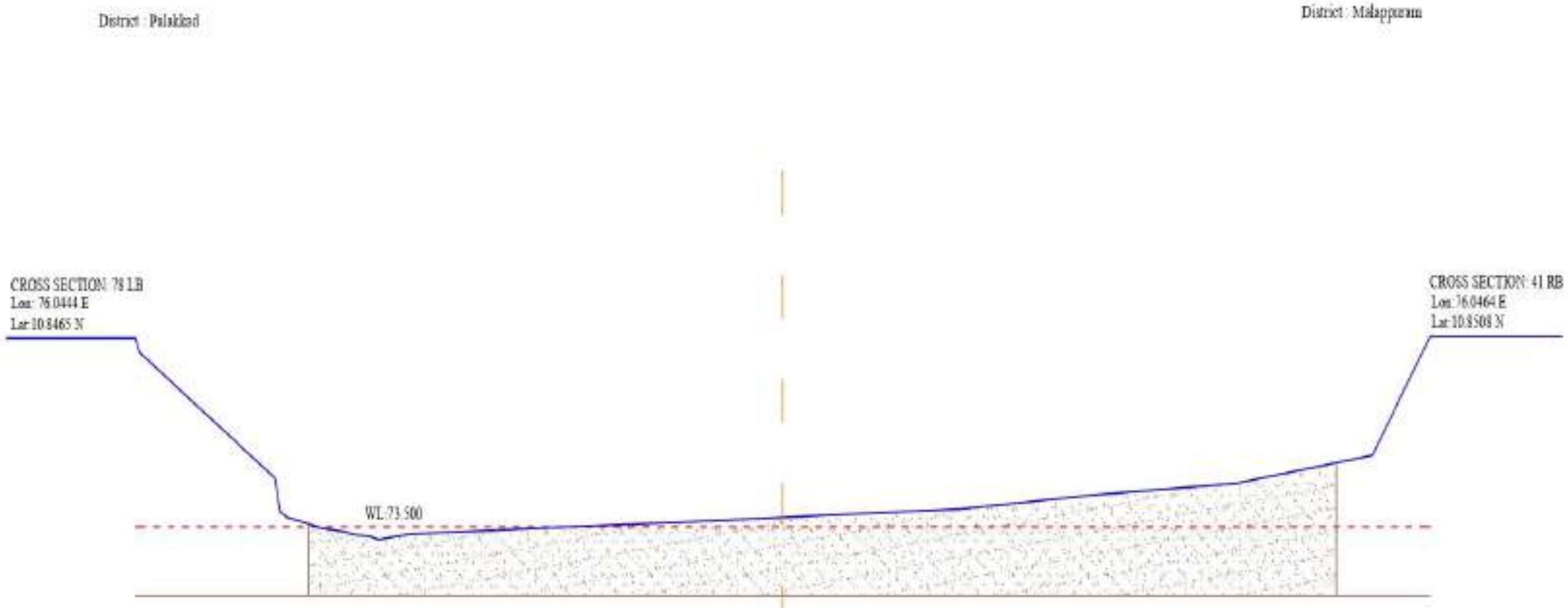
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
544.7	0	100	54470.00	0.00

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

BHARATHAPUZHA RIVER

Cross Section 41



Elevation	78.947	78.536	74.965	74.907	73.938	73.771	73.461	73.366	73.269	73.232	73.137	73.300	73.474	73.634	73.825	74.015	74.432	74.743	75.565	78.988
Distance	0.000	1.709	57.300	58.198	60.228	63.280	78.029	86.620	91.623	97.586	101.472	114.600	171.900	229.200	286.500	343.800	401.100	458.400	515.700	539.720
REMARK	C578	M	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	C541

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

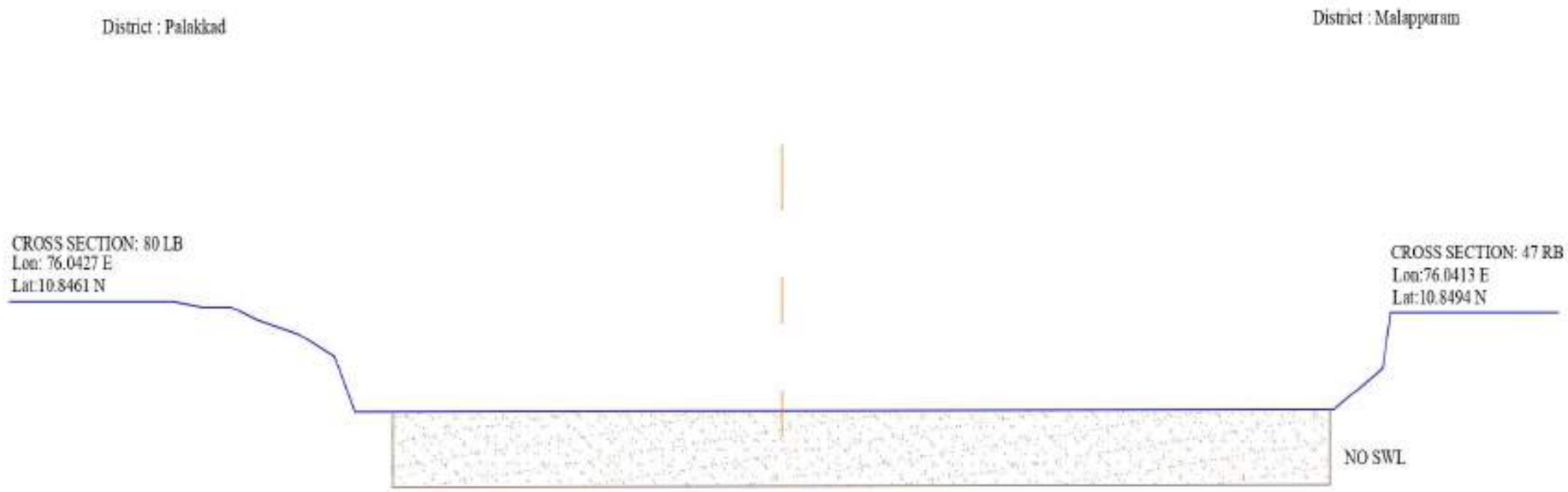
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM B4** ANAKKARA PUMP HOUSE, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°50'32.599'' N	198.1	461.6	100	19810.00	46160.00
Longitude	76°3'17.254'' E					

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

BHARATHAPUZHA RIVER

Cross Section 47



Elevation	78.947	78.796	78.792	78.456	78.083	77.491	77.189	76.030	76.040	76.051	76.062	76.072	76.083	76.094	77.160	78.642
Distance	0.000	9.461	18.829	27.119	40.544	52.046	53.400	58.590	106.800	160.200	213.600	267.000	320.400	373.800	389.474	392.121
REMARK	CS80	S	S	S	S	S	S	S	S	S	S	S	S	S	M	CS47

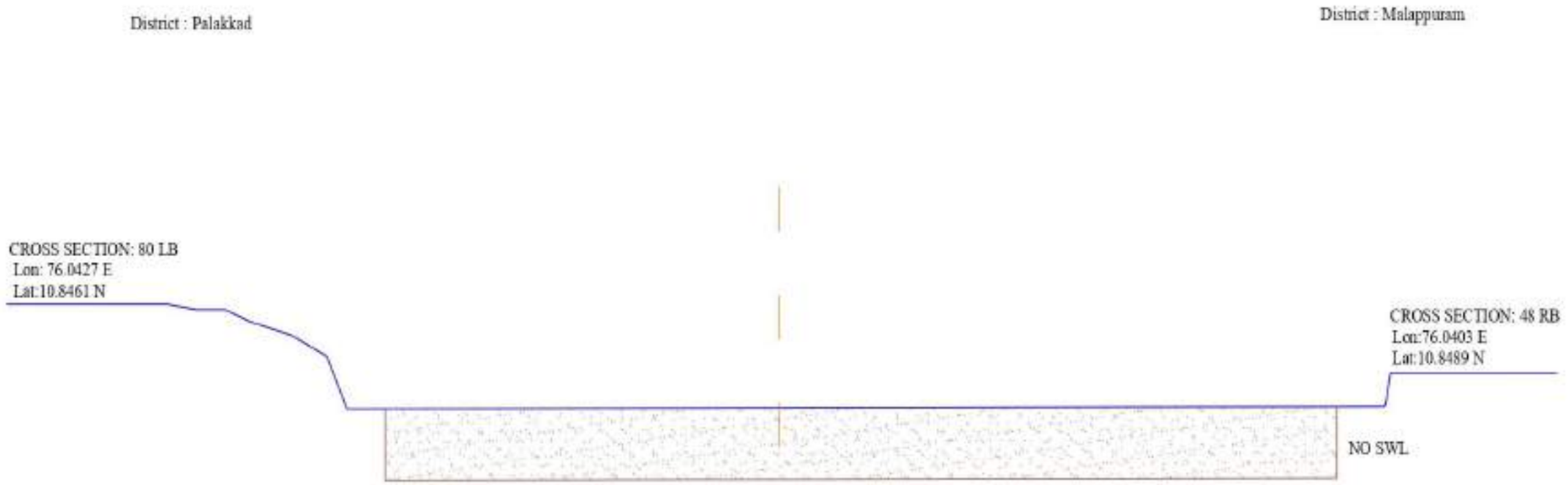
REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	TBM C7 THETTALITHODU RAILWAY BRIDGE, RB
Latitude	10°51'2.778'' N
Longitude	76°2'36.768'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
352.9	0	100	35290.00	0.00

BHARATHAPUZHA RIVER

Cross Section 48



Elevation	78.947	78.796	78.792	78.456	78.083	77.491	77.189	76.030	76.040	76.051	76.062	76.072	76.083	76.094	76.099	76.146	77.027
Distance	0.000	9.461	18.829	27.119	40.544	52.046	53.400	58.590	106.800	160.200	213.600	267.000	320.400	373.800	397.795	398.610	400.158
REMARK	CS80	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	CS48

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	TBM C7 THETTALITHODU RAILWAY BRIDGE, RB
Latitude	10°51'2.778'' N
Longitude	76°2'36.768'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
365	0	100	36500.00	0.00

LR/11909/2023-LR(K1)

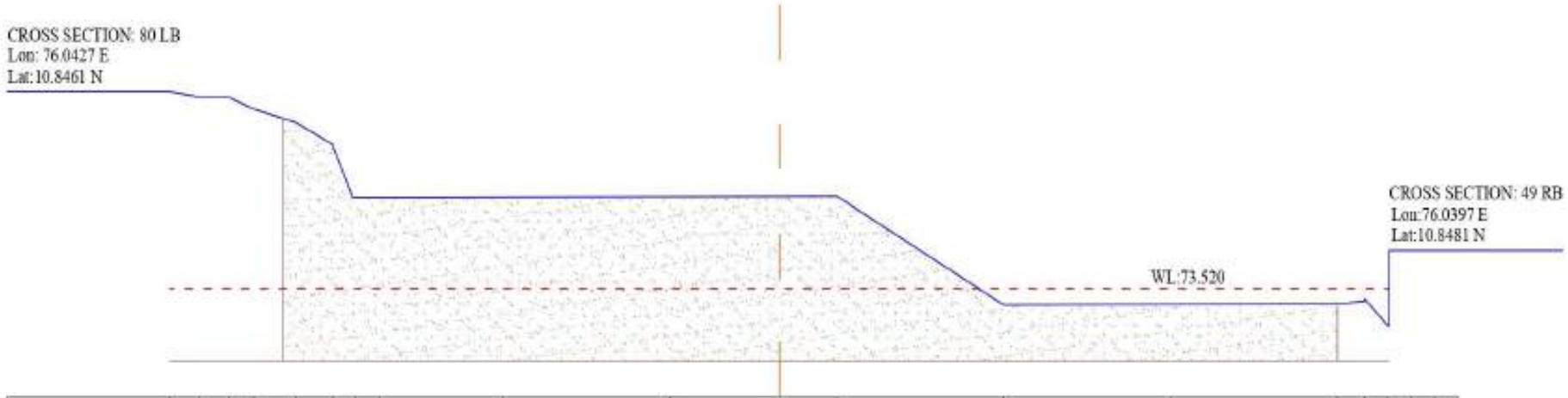
518256/2024/Tapal CLR

BHARATHAPUZHA RIVER

Cross Section 49

District : Palakkad

District : Malappuram



Elevation	78.947	78.796	78.792	78.456	78.083	77.491	77.189	76.030	76.040	76.051	76.062	73.072	73.083	73.094	73.170	73.232	72.468	74.563		
Distance	0.000	9.461	18.829	27.119	40.544	52.046	53.400	58.590	106.800	160.200	213.600	267.000	320.400	373.800	382.471	382.625	390.355	390.448		
REMARK	CS80	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	CS49		

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	**TBM C7** THETTALITHODU RAILWAY BRIDGE, RB
Latitude	10°51'2.778'' N
Longitude	76°2'36.768'' E

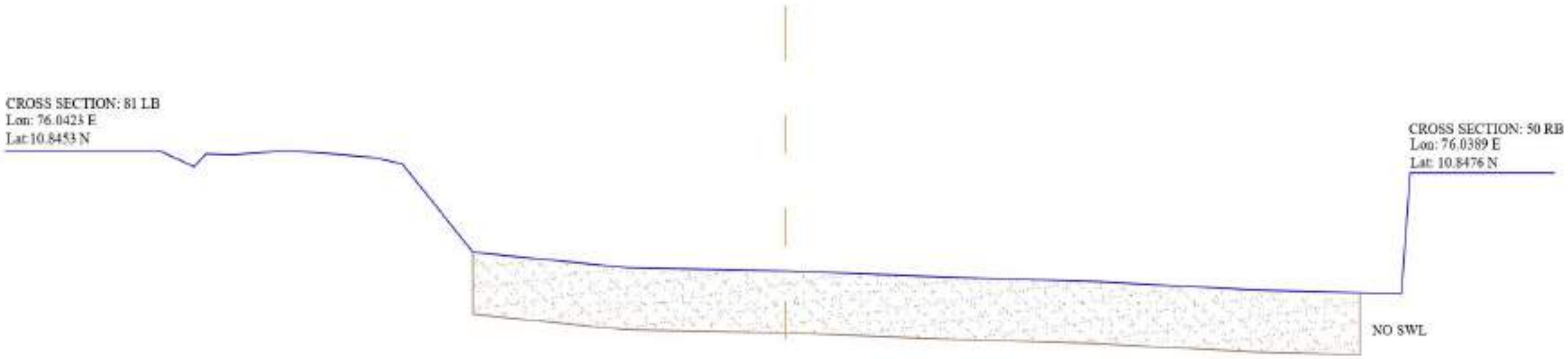
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
104.3	308.6	100	10430.00	30860.00

BHARATHAPUZHA RIVER

Cross Section 50

District : Palakkad

District : Malappuram

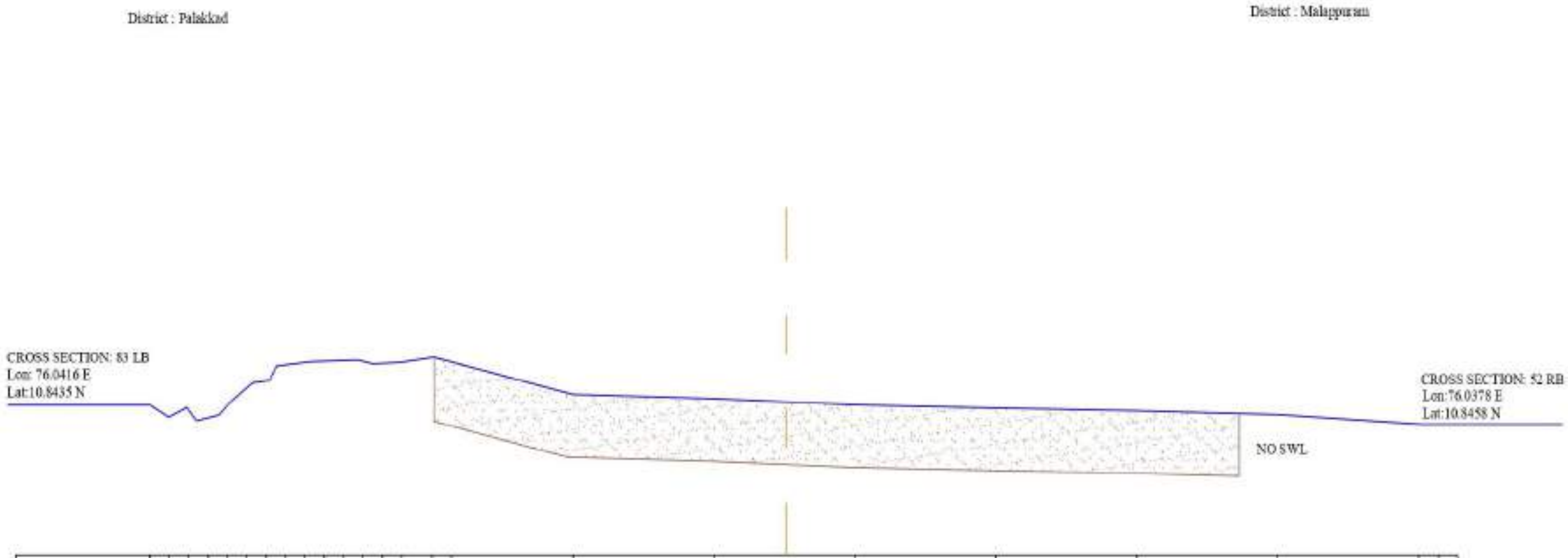


Elevation	78.499	77.993	78.409	78.383	78.511	78.449	78.420	78.294	78.082	75.231	74.726	74.623	74.435	74.276	74.015	73.893	77.789
Distance	0.000	12.146	16.346	26.384	45.267	56.100	61.191	76.589	86.876	112.200	168.300	224.400	280.500	336.600	392.700	445.478	448.577
REMARK	CS81	S	S	S	S	S	S	S	S	S	S	S	S	S	S	M	CS50

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM C7** THETTALITHODU RAILWAY BRIDGE, RB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°51'2.778'' N					
Longitude	76°2'36.768'' E	412.6	0	100	41260.00	0.00

BHARATHAPUZHA RIVER
Cross Section 52



Elevation	77.449	77.063	77.364	76.944	77.128	77.521	78.158	78.231	78.688	78.749	78.831	78.881	78.764	78.813	78.964	78.974
Distance	0.000	7.247	14.270	17.972	26.620	30.876	39.742	46.231	48.942	54.600	62.294	80.480	86.345	97.155	109.200	109.992
REMARK	CS83	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

Elevation	77.784	77.653	77.453	77.356	77.267	77.145	76.839	76.832
Distance	163.800	218.400	273.000	327.600	382.200	436.800	491.400	492.665
REMARK	S	S	S	S	S	M	M	CS52

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

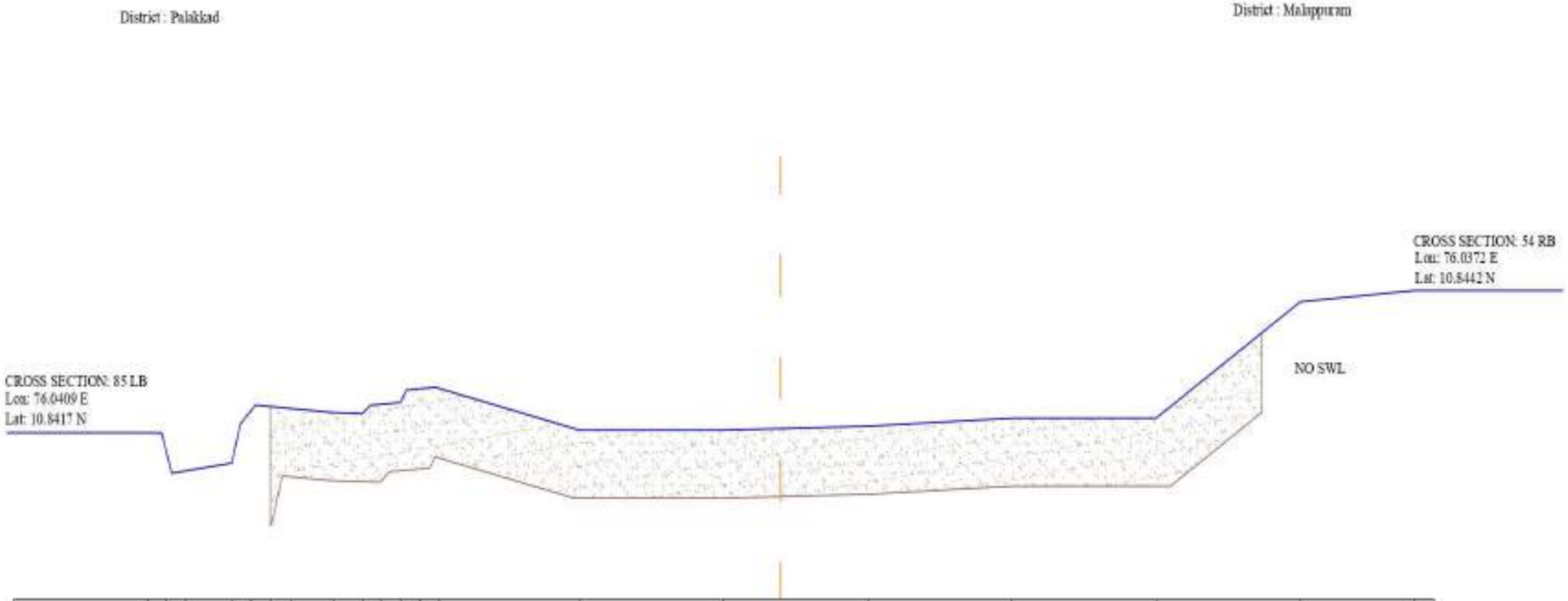
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
		Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Note	**TBM C7** THETTALITHODU RAILWAY BRIDGE, RB					
Latitude	10°51'2.778'' N					
Longitude	76°2'36.768'' E	351	0	100	35100.00	0.00

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

BHARATHAPUZHA RIVER

Cross Section 54



	CS85			CS84				CS83				CS82				CS81				CS80				CS79				CS54
Elevation	77.329	77.325	76.138	76.432	77.585	78.141	78.039	77.918	77.891	78.138	78.217	78.581	78.665	77.384	77.403	77.521	77.640	77.759	79.858	81.510
Distance	0.000	5.727	9.605	33.092	36.479	42.295	56.300	72.789	84.101	87.198	98.949	101.285	112.600	168.900	225.200	281.500	337.800	394.100	450.400	495.058
REMARK	S	S	S	S	S	S		S	S	S	S	S	S	S	S	S	S	S	M	CS54

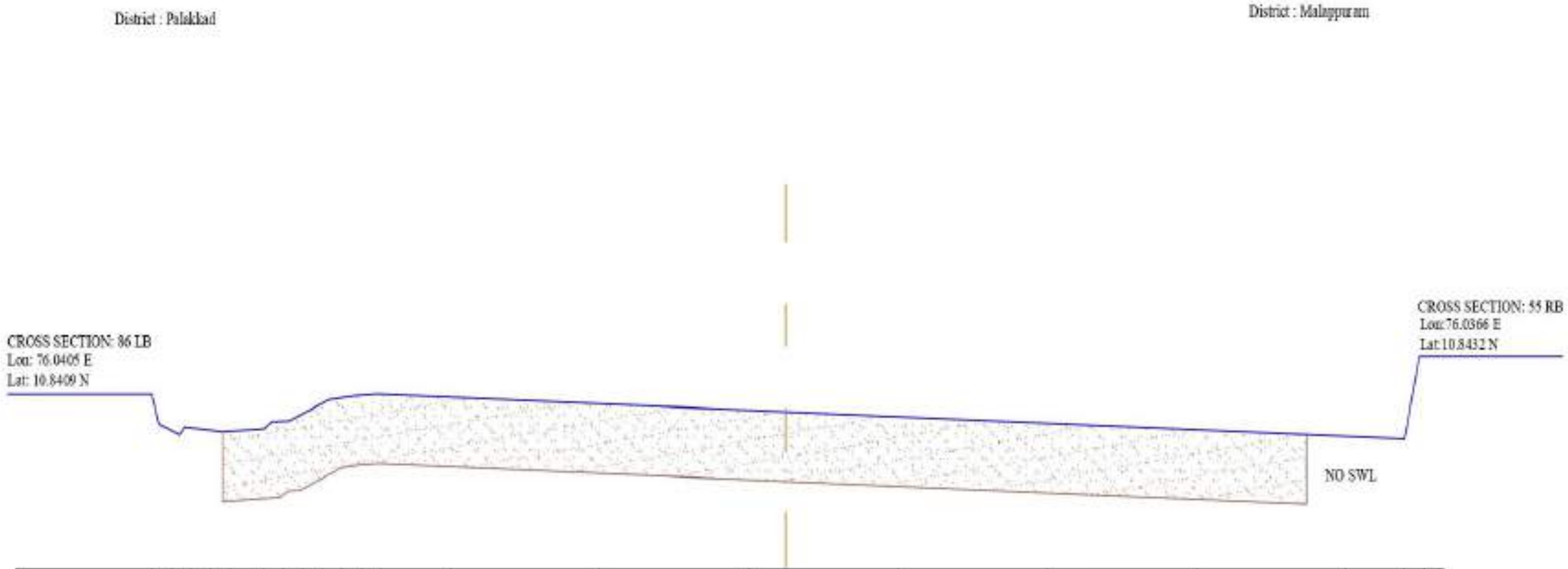
REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	**TBM C8** NEAR GHSS KUTTIPURAM KADAVU, RB
Latitude	10°50'43.554'' N
Longitude	76°2'14.274'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
388.9	0	100	38890.00	0.00

BHARATHAPUZHA RIVER

Cross Section 55



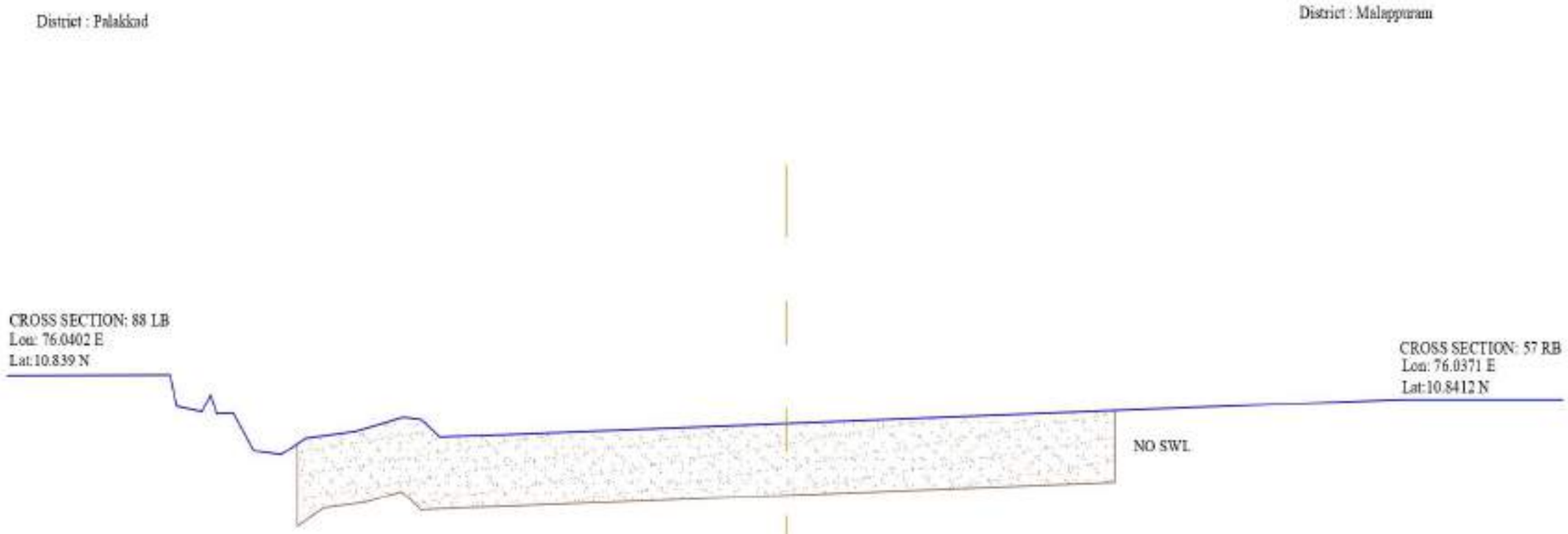
Elevation	77.456	76.599	76.283	76.508	76.368	76.455	76.663	76.680	76.868	77.302	77.417	77.462	77.371	77.183	76.995	76.807	76.619	76.432	76.244	76.170	78.536
Distance	0.000	2.582	10.747	12.546	27.076	42.821	46.080	52.571	57.200	67.920	78.081	86.542	114.400	171.600	228.800	286.000	343.200	400.400	457.600	480.112	485.803
REMARK	CS86	S	S	S	S	S	S	S		S	S	S	S	S	S	S	S	S	M	M	CS55

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM		Area of Cross Section (m²)		Zone of Influence (m)	Sand Volume (m³)	
Note	**TBM C8** NEAR GHSS KUTTIPURAM KADAVU, RB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°50'43.554'' N	399.6	0	100	39960.00	0.00
Longitude	76°2'14.274'' E					

BHARATHAPUZHA RIVER

Cross Section 57



Elevation	78.599	77.724	77.573	78.054	77.516	77.539	76.481	76.373	76.841	76.950	77.028	77.417	77.352	76.874	76.904	76.928	76.933	77.113	77.293	77.473	77.653	77.833	77.919
Distance	0.000	2.281	10.865	13.917	15.929	21.728	28.856	38.251	46.585	56.700	63.872	80.269	86.492	92.774	100.578	Lon.913	113.400	170.100	226.800	283.500	340.200	396.900	423.933
REMARK	CS88	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	M	M	CS57

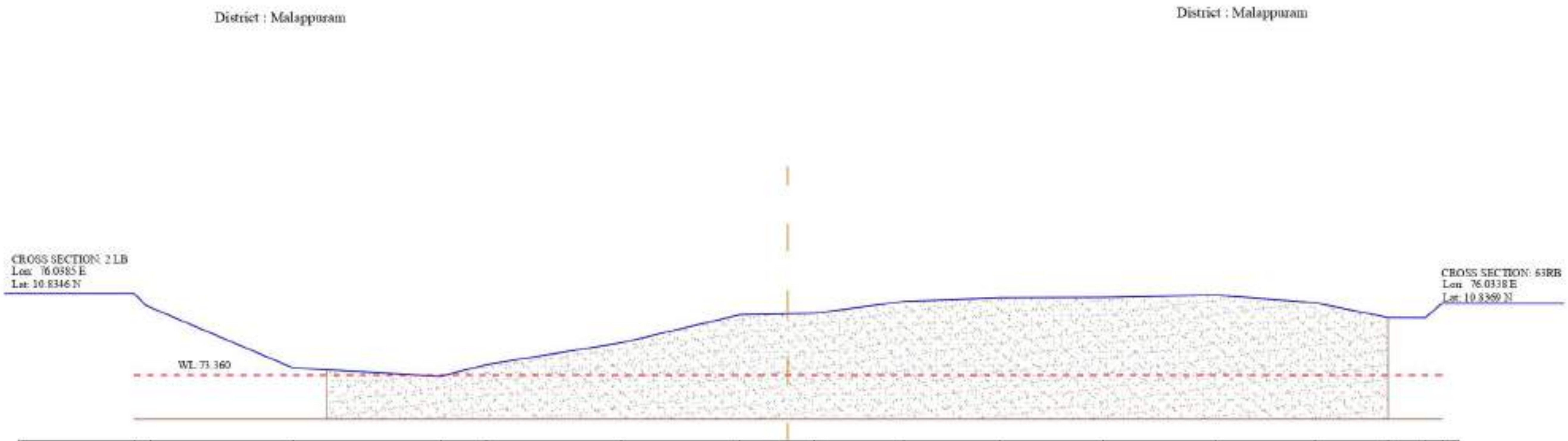
REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	TBM C8 NEAR GHSS KUTTIPURAM KADAVU, RB
Latitude	10°50'43.554'' N
Longitude	76°2'14.274'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
226.5	0	100	22650.00	0.00

BHARATHAPUZHA RIVER

Cross Section 2



Elevation	77.038	76.491	73.674	73.300	73.821	74.816	76.080	76.140	76.675	76.844	76.861	76.966	76.625	75.952	75.947	76.381
Distance	0.000	5.533	138.764	138.764	159.256	220.397	273.790	307.577	348.140	391.337	437.967	488.932	533.716	566.723	583.701	591.083
REMARK	CS2	S	S	S	S	S	S	S	S	S	S	S	S	S	S	CS63

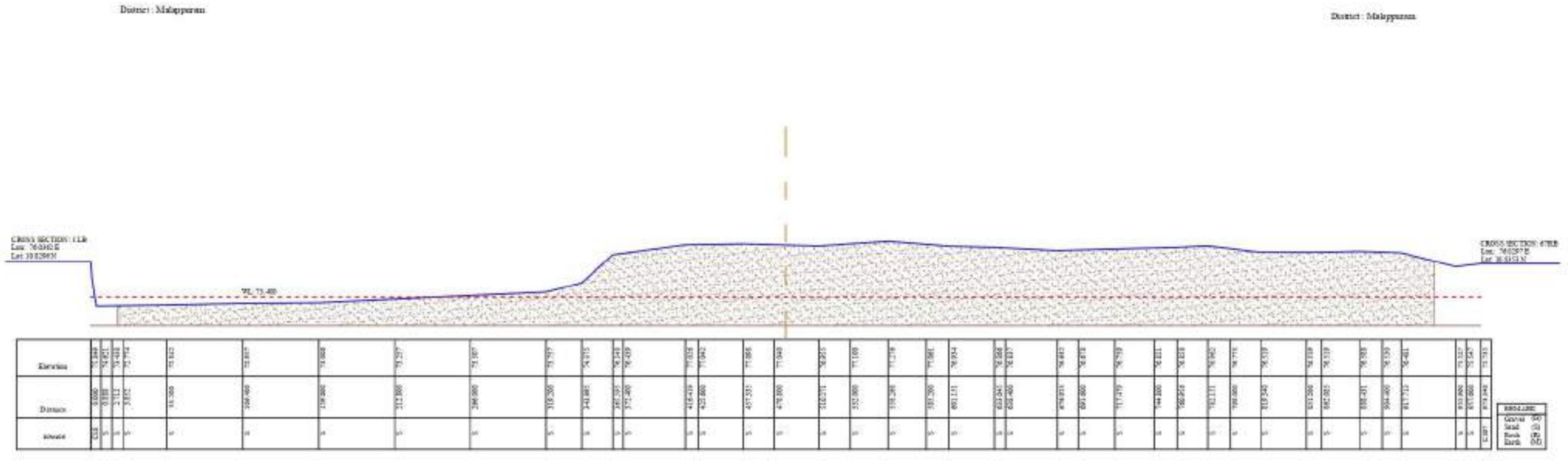
REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	**TBM C8** NEAR GHSS KUTTIPURAM KADAVU, RB
Latitude	10°50'43.554'' N
Longitude	76°2'14.274'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
234	417	50	11690.00	20835.00

BHARATHAPUZHA RIVER

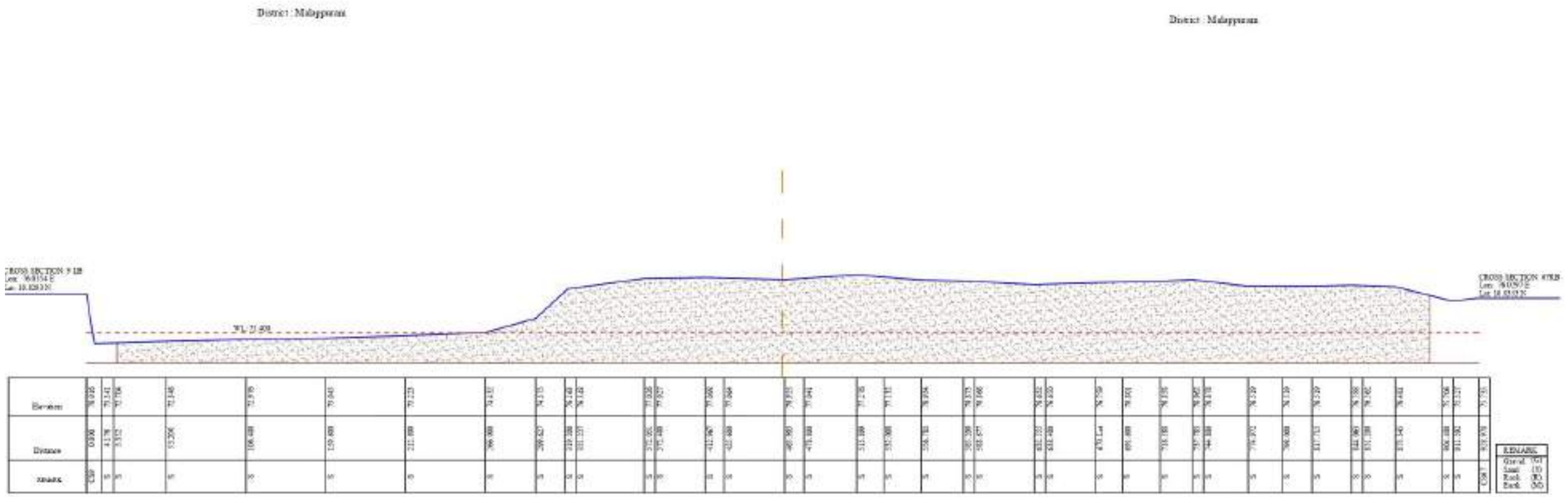
Cross Section 8



Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM C2** PARAPPANTHODU PUMP HOUSE, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°49'46.296'' N	497	850	100	49660.00	85030.00
Longitude	76°2'11.445'' E					

BHARATHAPUZHA RIVER

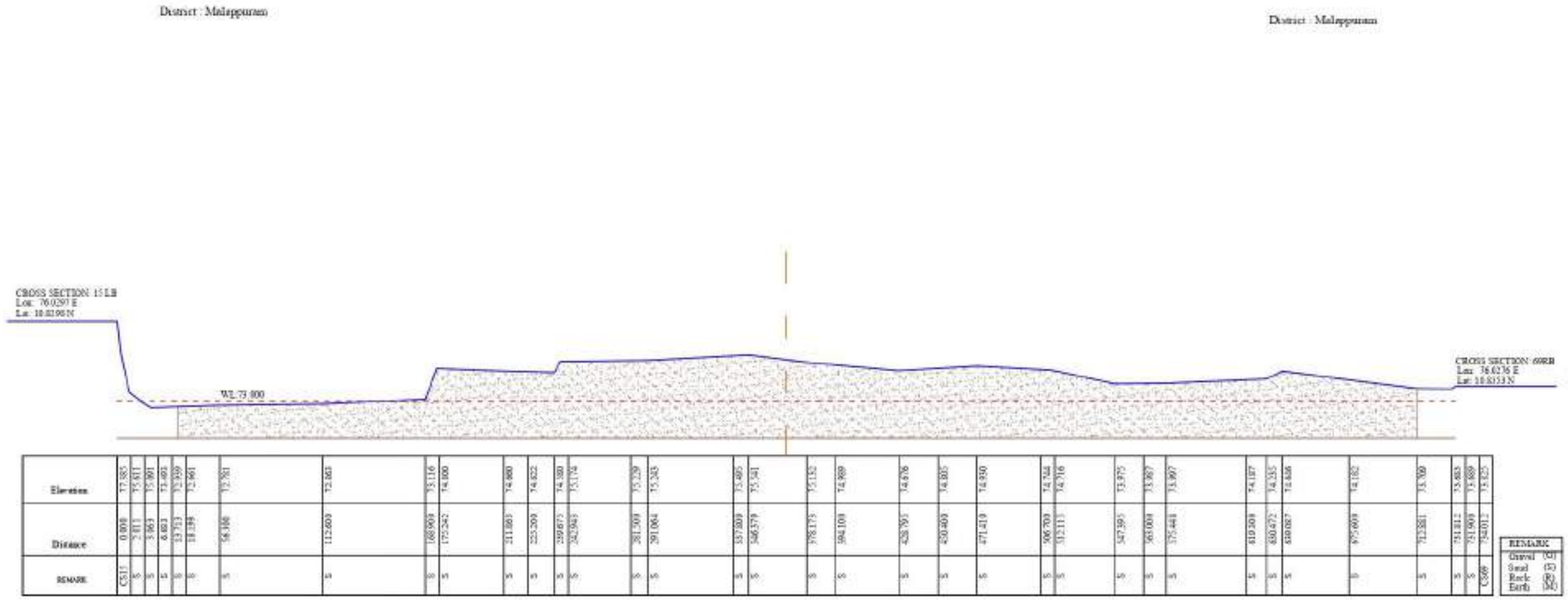
Cross Section 9



Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	TBM C2 PARAPPANTHODU PUMP HOUSE, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°49'46.296'' N	563	804	100	56310.00	80360.00
Longitude	76°2'11.445'' E					

BHARATHAPUZHA RIVER

Cross Section 15

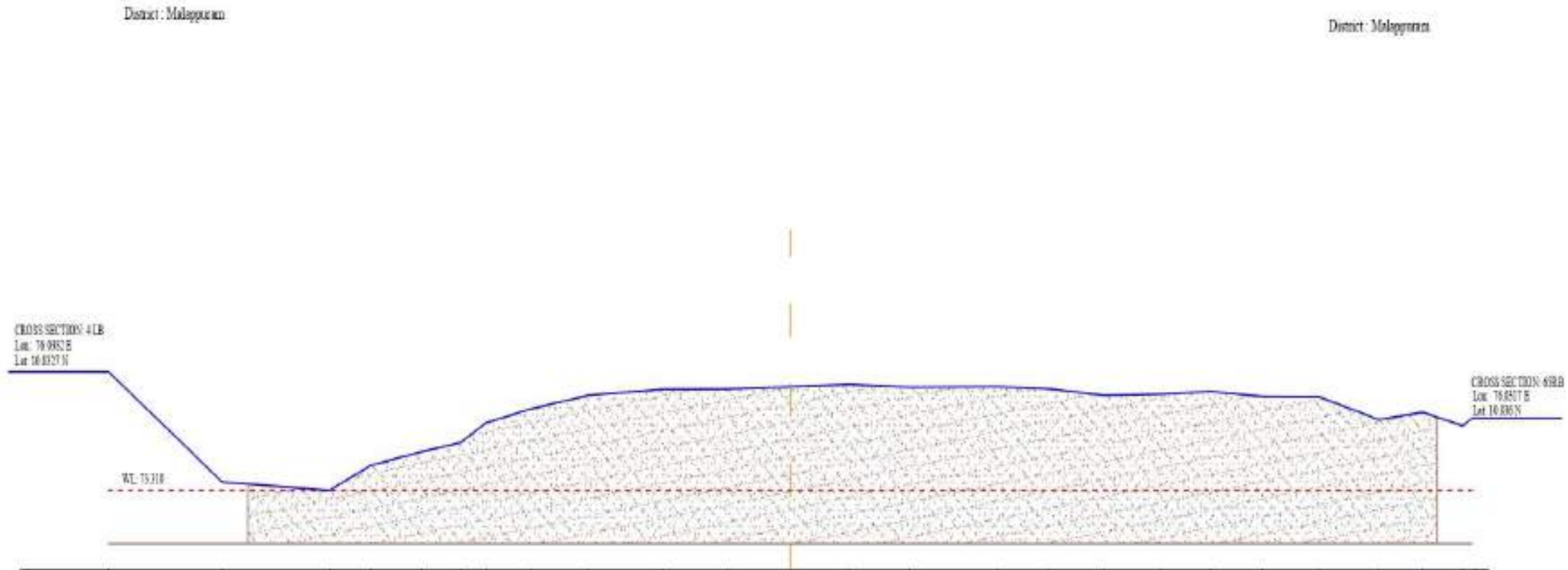


Identification of TBM	
Note	**TBM C9** KAVUMOPURAM KADAVU, RB
Latitude	10°50'7.974'' N
Longitude	76°1'38.58'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
409	650	100	40890.00	64960.00

BHARATHAPUZHA RIVER

Cross Section 65



Identification of TBM	
Note	**TBM C8** NEAR GHSS KUTTIPURAM KADAVU, RB
Latitude	10°50'43.554'' N
Longitude	76°2'14.274'' E

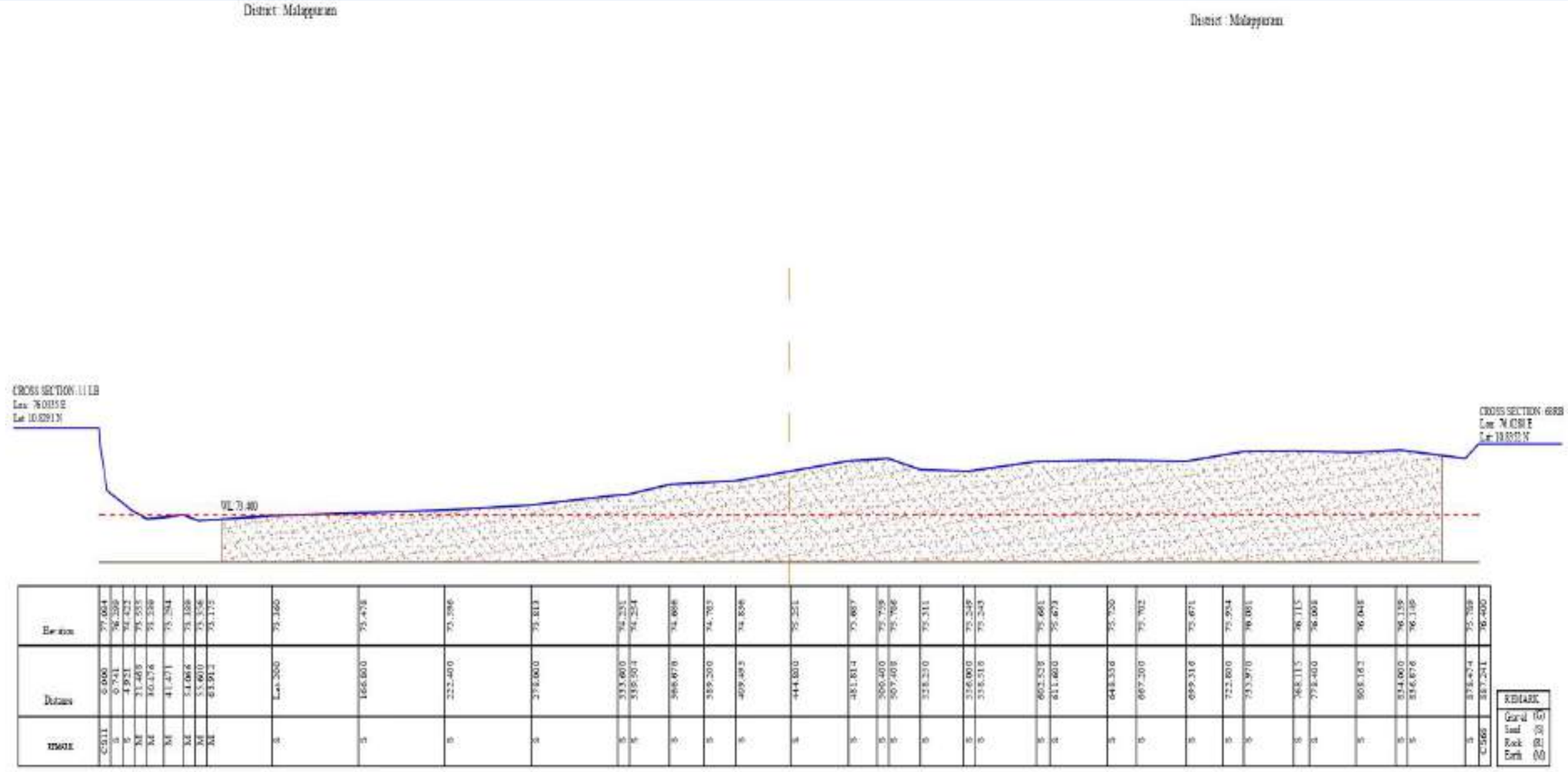
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
1382.6	764.8	100	138260.00	76480.00

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

BHARATHAPUZHA RIVER

Cross Section 68



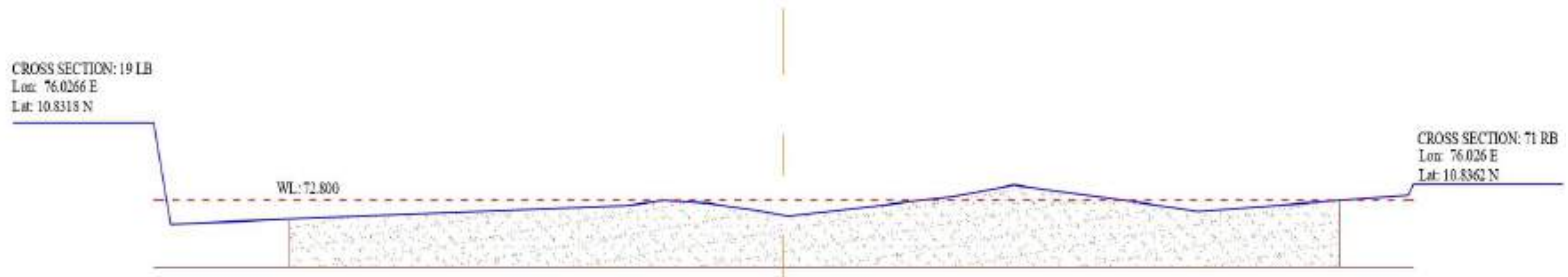
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM C2** PARAPPANTHODU PUMP HOUSE, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°49'46.296'' N					
Longitude	76°2'11.445'' E	984.8	839.7	100	98480.00	83970.00

BHARATHAPUZHA RIVER

Cross Section 71

District : Malappuram

District : Malappuram



Elevation	75.100	74.138	72.751	72.091	72.236	72.402	72.568	72.648	72.792	72.732	72.714	72.502
Distance	0.000	2.137	5.213	6.642	53.700	107.400	161.100	187.064	201.534	214.800	218.903	237.863
REMARK	CS19	S	S	S	S	S	S	S	S	S	S	S

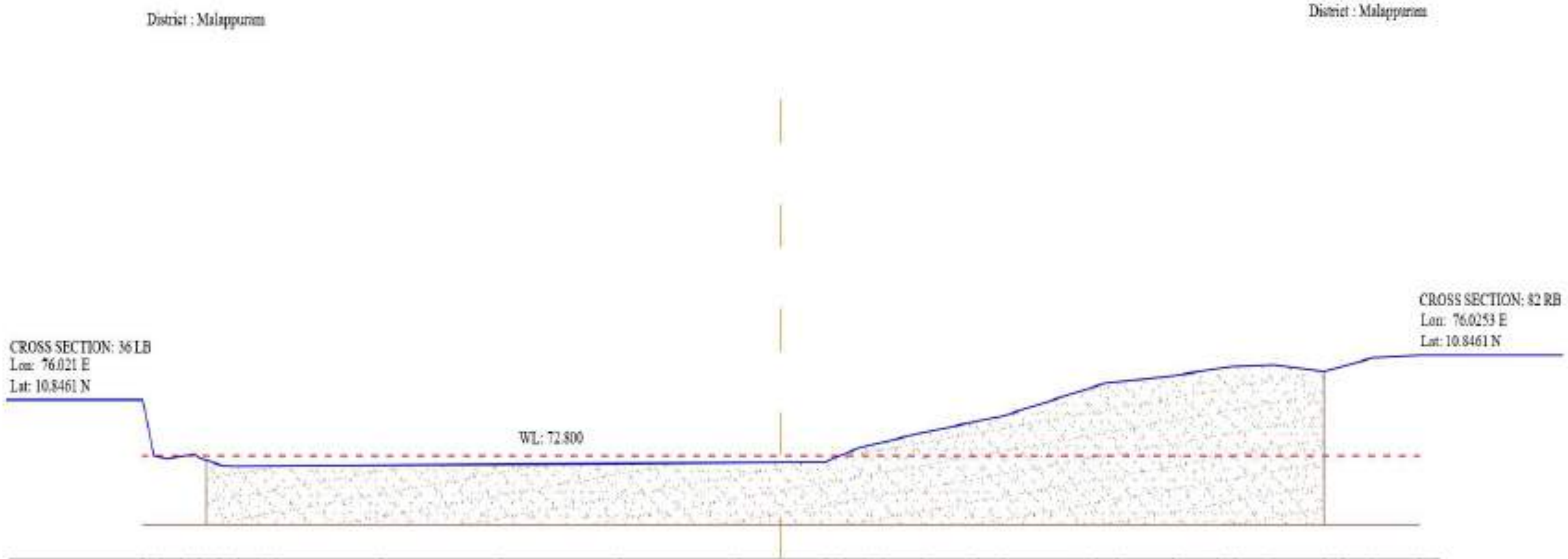
Elevation	72.325	72.484	72.899	73.004	73.249	72.872	72.572	72.466	72.566	72.881	72.952	73.270
Distance	250.720	268.500	314.931	322.200	339.777	375.900	403.870	412.511	429.600	483.300	495.429	497.451
REMARK	S	S	S	S	S	S	S	S	S	M	M	CS71

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM		Area of Cross Section (m²)		Zone of Influence (m)	Sand Volume (m³)	
Note	**TBM C3** VARATHURKAYAL NEW PUMP HOUSE, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°49'53.243'' N					
Longitude	76°1'36.731'' E	17.3	411.2	100	1730.00	41120.00

BHARATHAPUZHA RIVER

Cross Section 82



Elevation	Distance	REMARK
74.410	0.000	CS36
72.789	4.541	M
72.707	9.810	S
72.847	20.240	S
72.728	22.277	S
72.509	31.187	S
72.496	36.759	S
72.501	46.700	S
72.523	93.400	S
72.546	140.100	S
72.568	186.800	S
72.501	233.500	S
72.607	267.384	S
72.734	270.679	S
73.011	280.200	S
73.028	280.796	S
73.451	304.928	S
73.790	326.900	S
73.941	336.724	S
74.814	373.600	S
74.877	376.255	S
75.101	403.054	S
75.303	420.300	S
75.372	426.216	S
75.416	442.541	S
75.219	462.226	S
75.319	467.000	S
75.611	481.024	S
75.696	499.542	CS82

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	**TBM C3** VARATHURKAYAL NEW PUMP HOUSE, LB
Latitude	10°49'53.243'' N
Longitude	76°1'36.731'' E

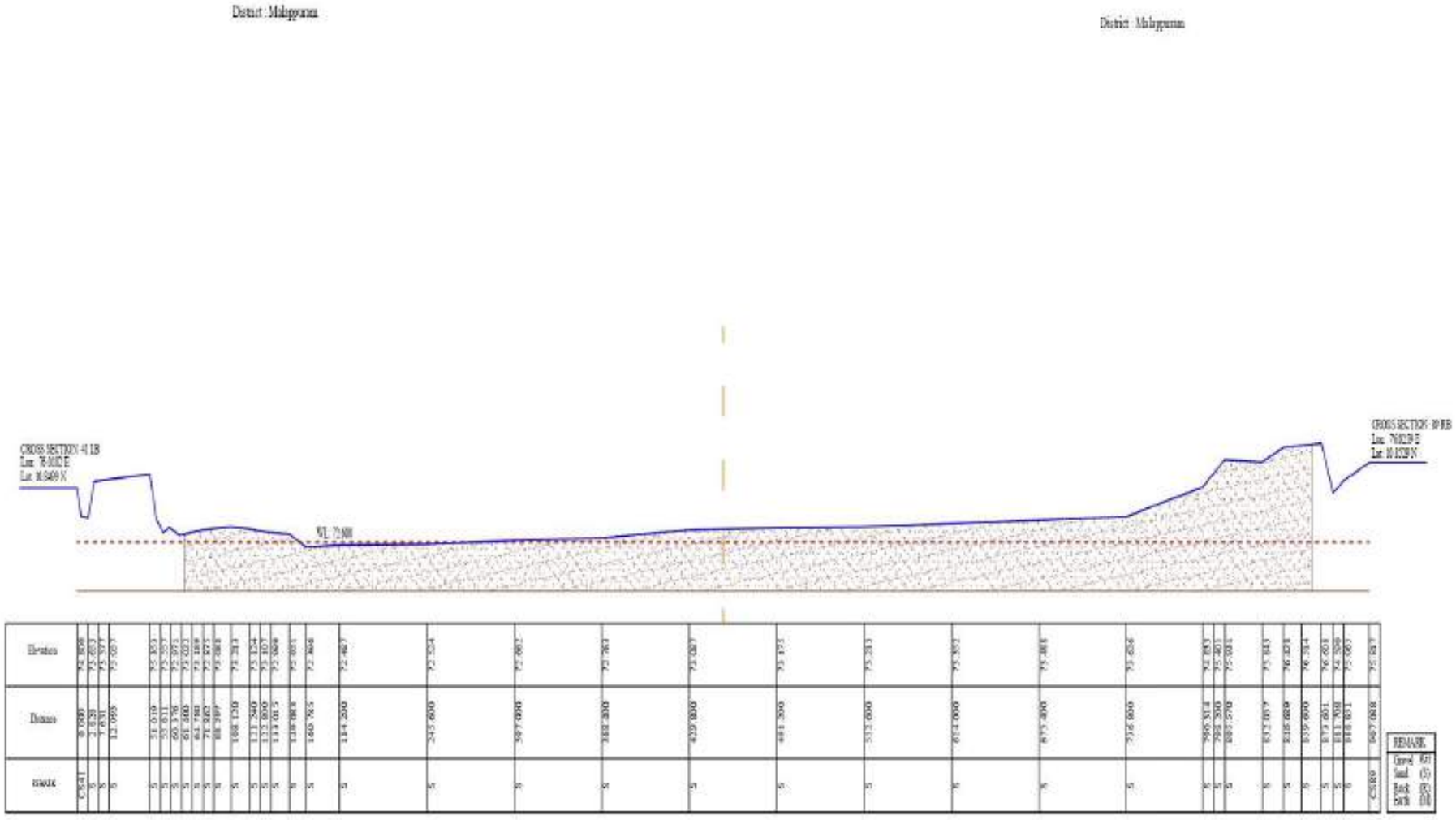
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
310.5	420.9	100	31050.00	42090.00

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

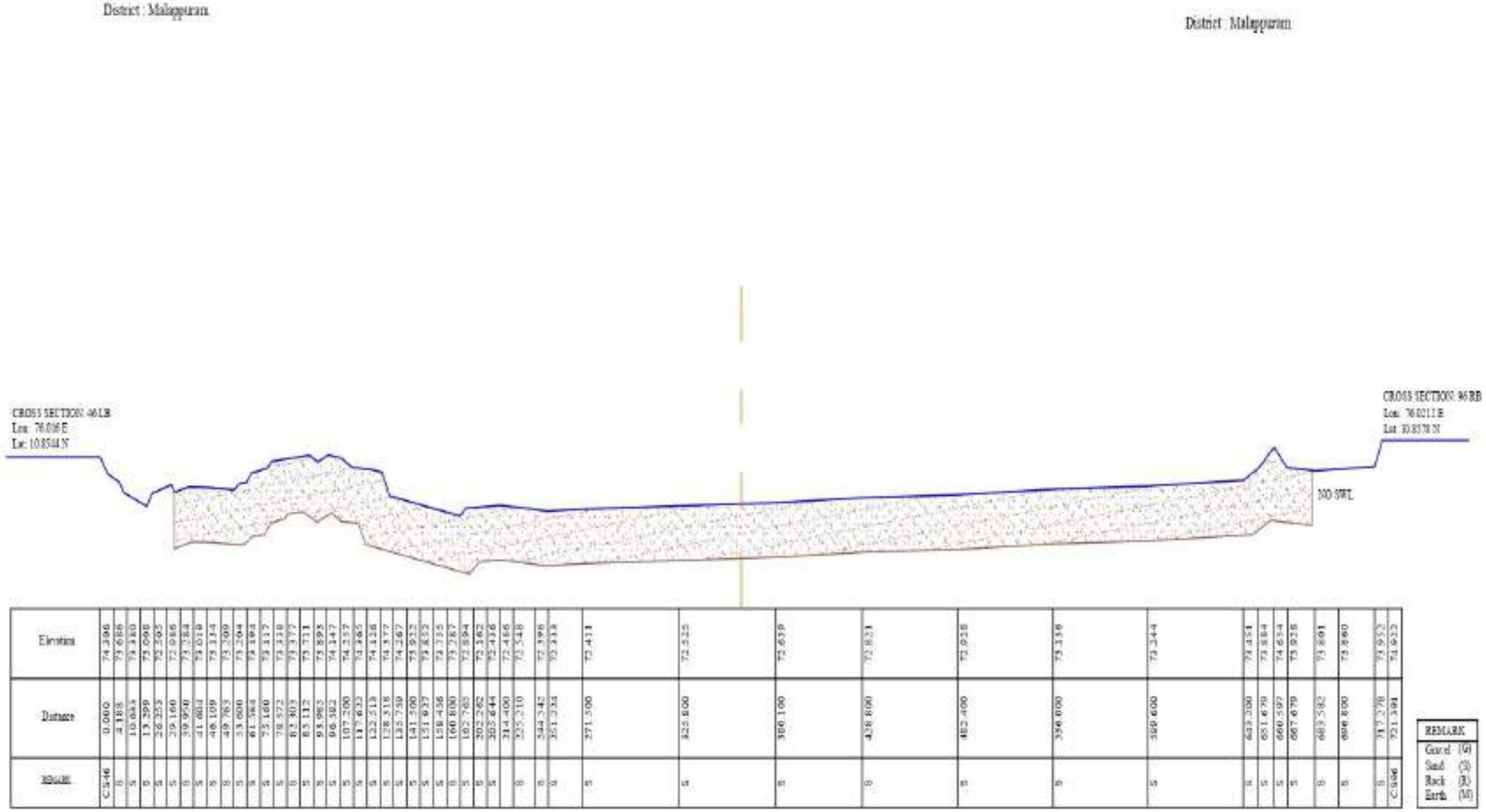
BHARATHAPUZHA RIVER

Cross Section 89



Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM C6** MATHILUSHERI PUMP HOUSE, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°50'51.714'' N	554.5	826.3	100	55450.00	82630.00
Longitude	76°1'11.432'' E					

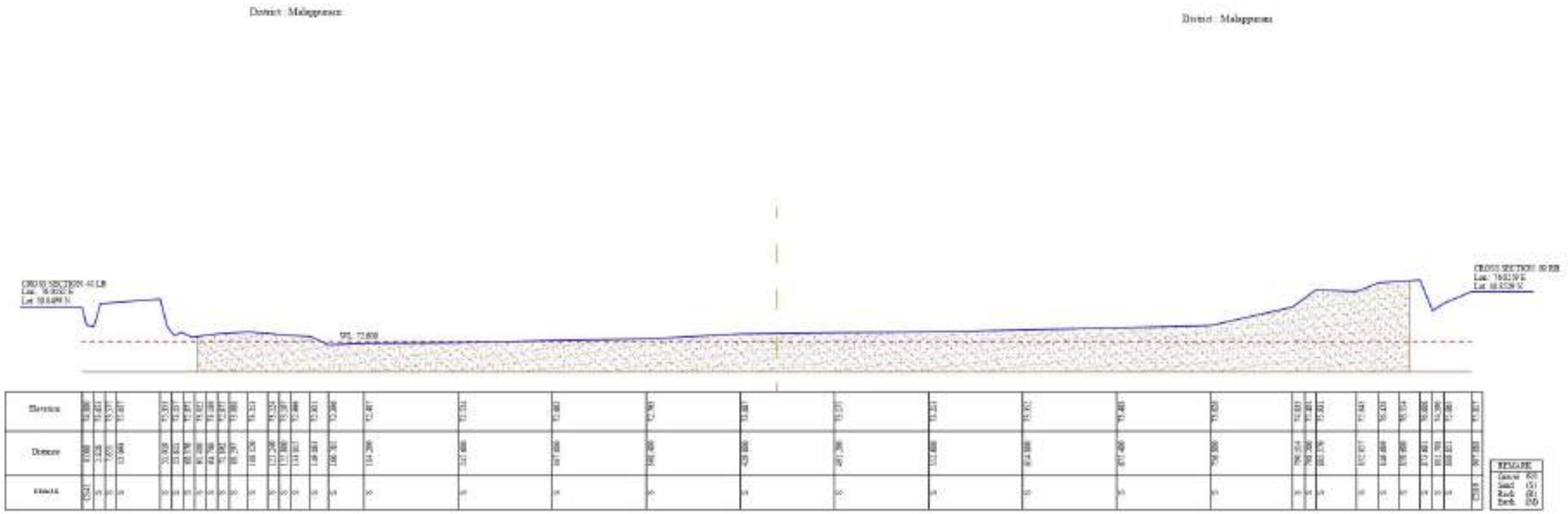
BHARATHAPUZHA RIVER
Cross Section 96



Identification of TBM		Area of Cross Section (m²)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM C6** MATHILUSHERI PUMP HOUSE, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°50'51.714'' N	650.1	0	100	65010.00	0.00
Longitude	76°1'11.432'' E					

BHARATHAPUZHA RIVER

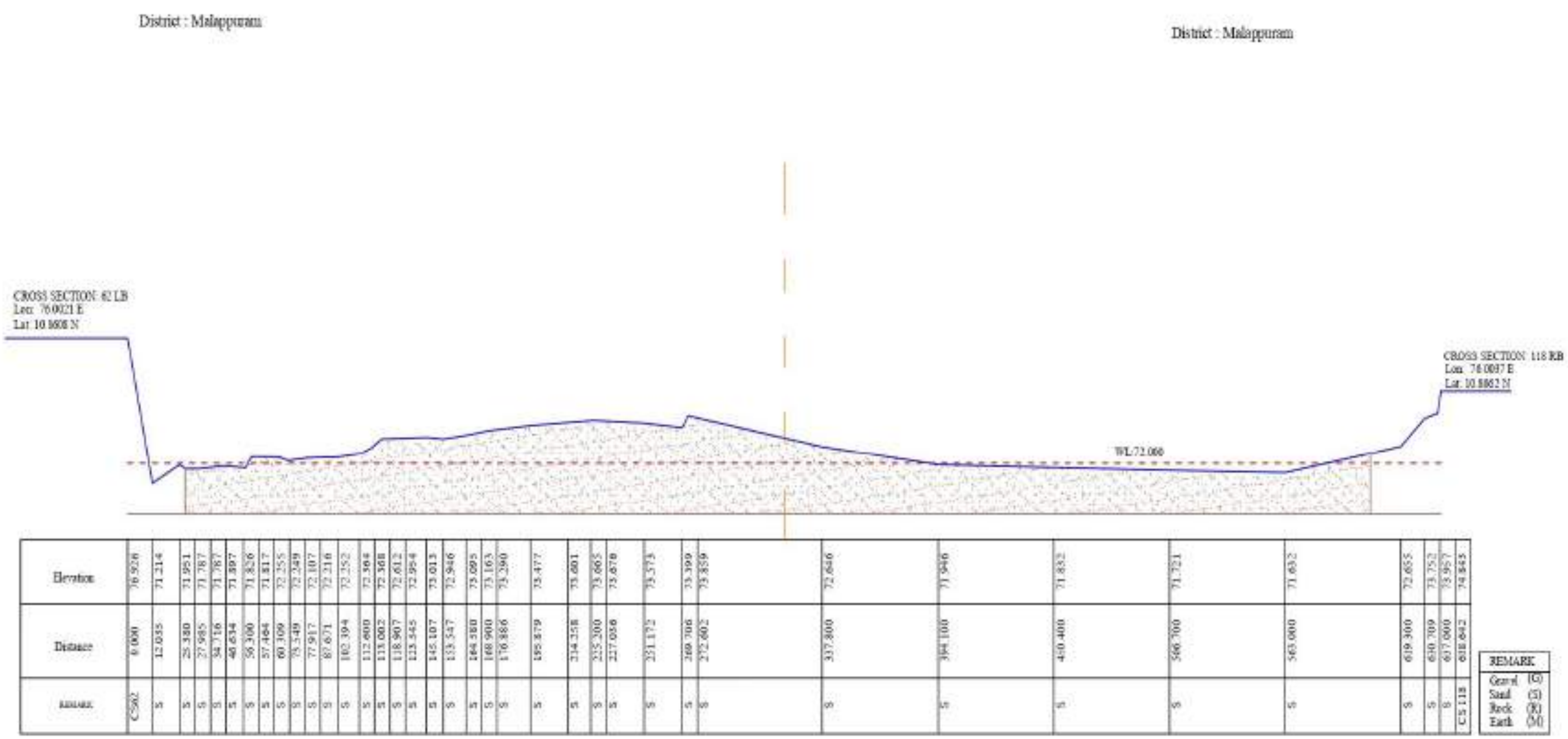
Cross Section 41



Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM C6** MATHILUSHERI PUMP HOUSE, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°50'51.714'' N					
Longitude	76°1'11.432'' E	75.5	745	100.00	7550.00	74500.00

BHARATHAPUZHA RIVER

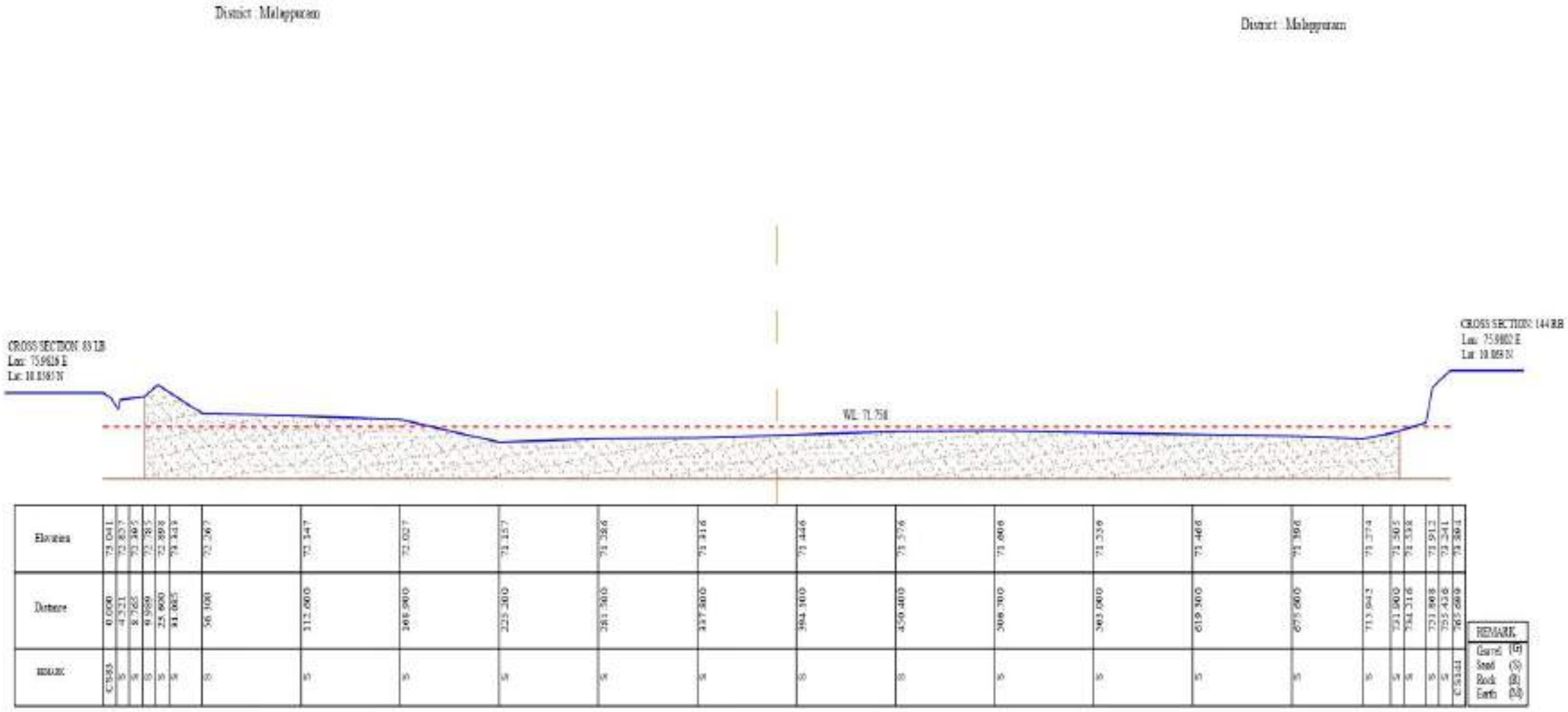
Cross Section 62



Identification of TBM		Area of Cross Section (m²)		Zone of Influence (m)	Sand Volume (m³)	
		Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Note	**TBM C10** CHEMBIKKAL PUMP HOUSE, RB	288	578	100.00	28800.00	57760.00
Latitude	10°51'54.726'' N					
Longitude	76°0'39.864'' E					

BHARATHAPUZHA RIVER

Cross Section 83

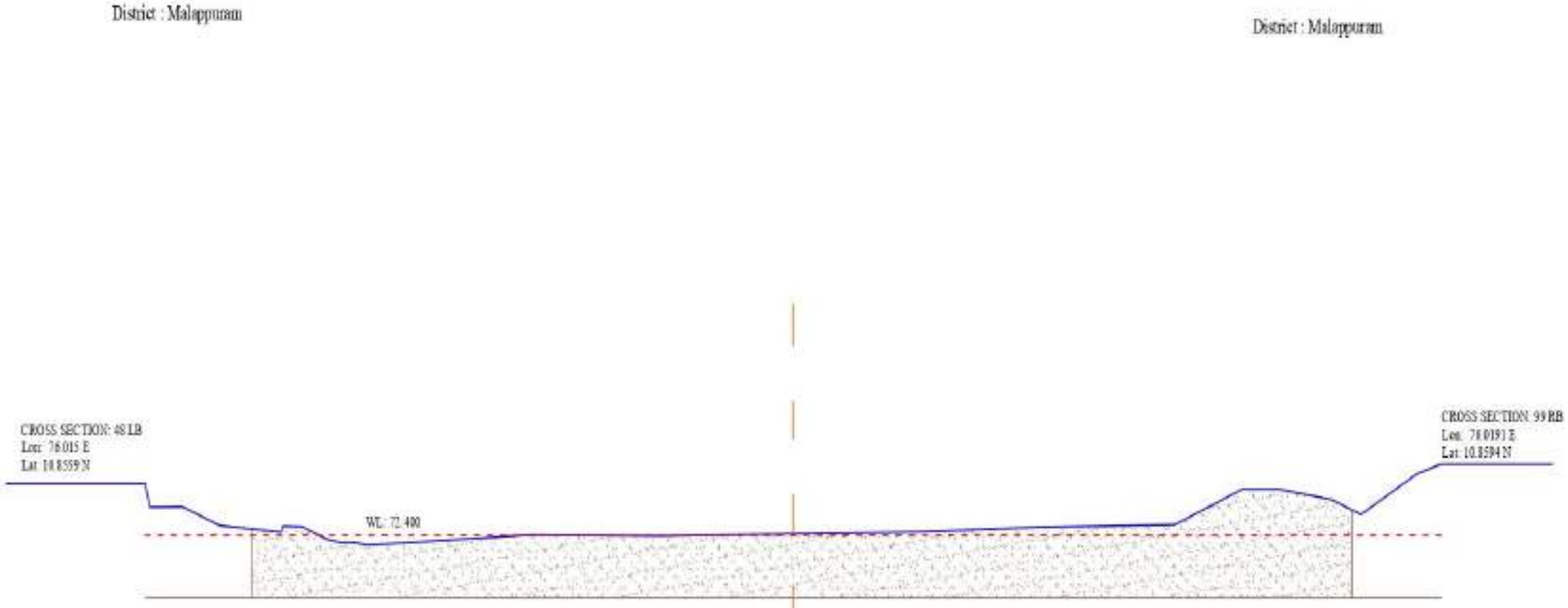


Identification of TBM	
Note	**TBM C13** THAVANUR SREE BHRAMA TEMPLE, LB
Latitude	10°51'23.105'' N
Longitude	75°58'56.537'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
83.8	635	100	8380.00	63450.00

BHARATHAPUZHA RIVER

Cross Section 99



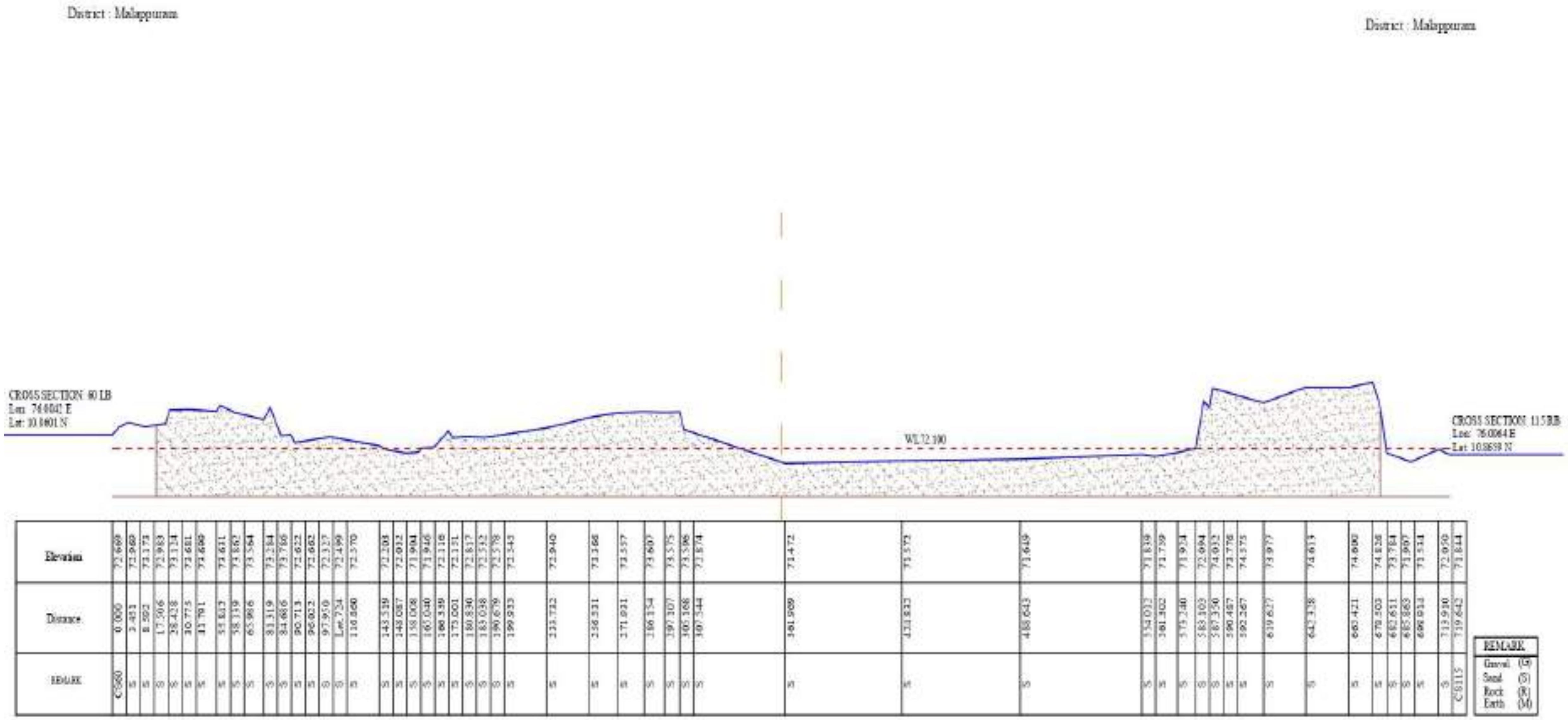
Elevation	74.062	73.508	73.322	72.728	72.533	72.508	72.702	72.684	72.277	72.157	72.168	72.079	72.153	72.217	72.382	72.447	72.511	72.676	72.741	73.878	73.880	73.728	73.548	73.073	73.625	74.590	74.578	74.689
Distance	0.000	1.965	17.005	53.586	58.600	61.838	62.628	71.508	82.418	89.181	95.444	100.874	117.300	175.800	234.400	293.000	351.600	410.200	468.800	499.271	516.573	527.400	540.249	555.464	564.330	579.245	586.000	590.008
REMARK	CS48	S	S	S		S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	C599

REMARK	
Gravel	(G)
Sand	(S)
Rock	(R)
Earth	(M)

Identification of TBM	
Note	**TBM C6** MATHILUSHERI PUMP HOUSE, LB
Latitude	10°50'51.714'' N
Longitude	76°1'11.432'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
127.2	508.6	100	1272.00	50860.00

BHARATHAPUZHA RIVER
Cross Section 115



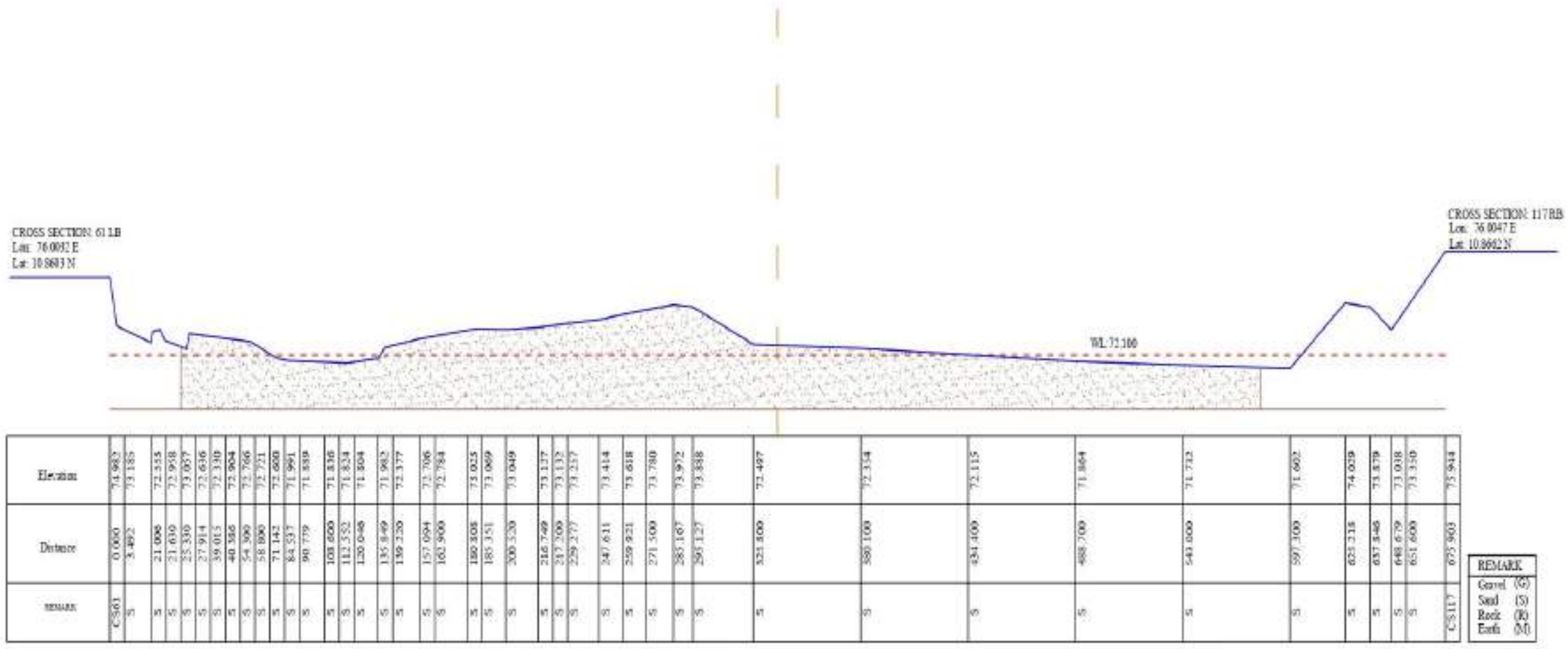
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
		Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Note	**TBM C10** CHEMBIKKAL PUMP HOUSE, RB					
Latitude	10°51'54.726'' N					
Longitude	76°0'39.864'' E	223.9	547.2	100	22390.00	54720.00

BHARATHAPUZHA RIVER

Cross Section 117

District : Malappuram

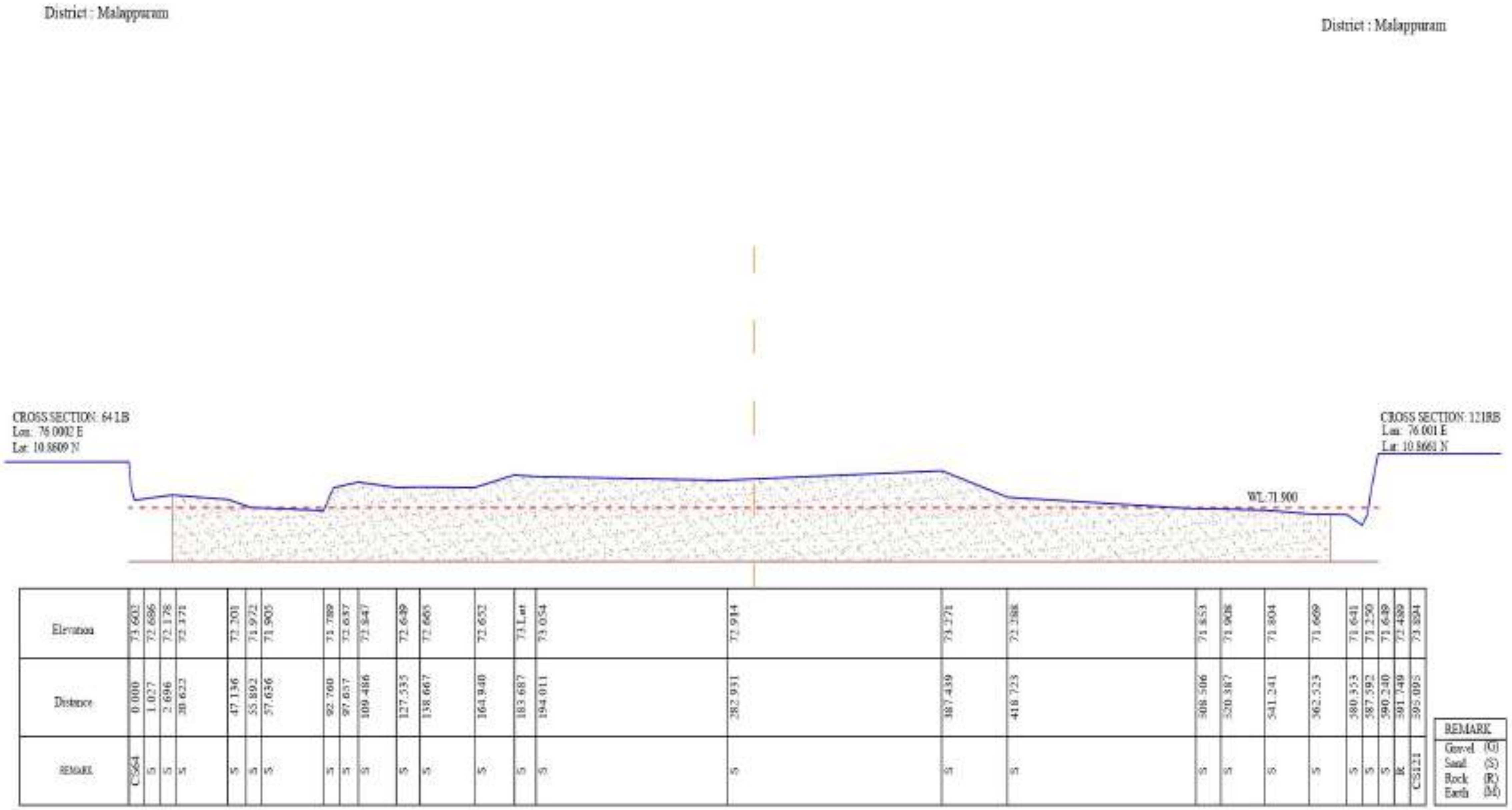
District : Malappuram



Identification of TBM		Area of Cross Section (m²)		Zone of Influence (m)	Sand Volume (m³)	
Note	**TBM C10** CHEMBIKKAL PUMP HOUSE, RB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°51'54.726'' N					
Longitude	76°0'39.864'' E	20.3	449.9	100	2030.00	44990.00

BHARATHAPUZHA RIVER

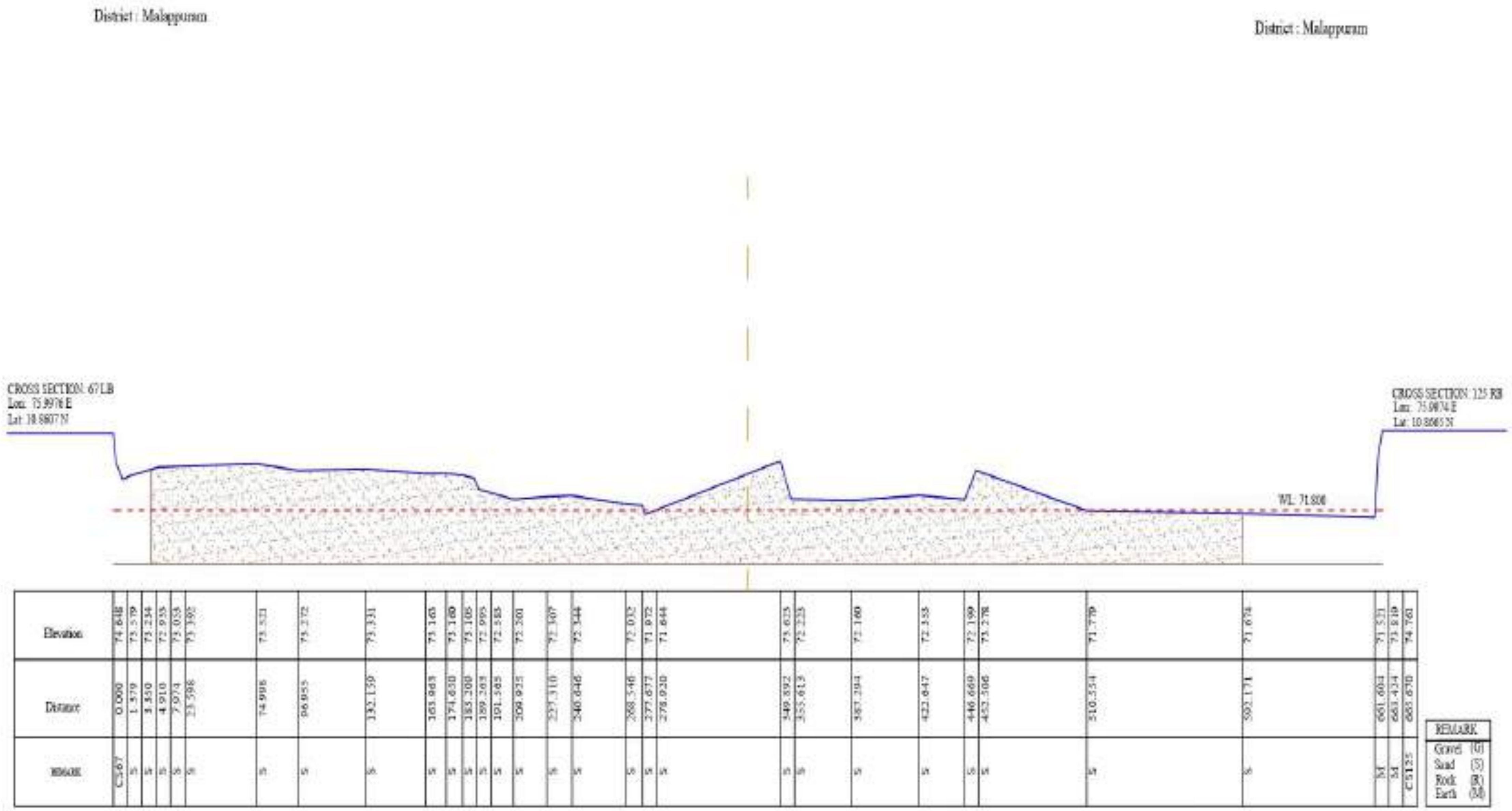
Cross Section 121



Identification of TBM		Area of Cross Section (m²)		Zone of Influence (m)	Sand Volume (m³)	
Note	**TBM C10** CHEMBIKKAL PUMP HOUSE, RB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°51'54.726'' N	152.4	541.8	100	15240.00	54180.00
Longitude	76°0'39.864'' E					

BHARATHAPUZHA RIVER

Cross Section 125



Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM C10** CHEMBIKKAL PUMP HOUSE, RB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	10°51'54.726'' N					
Longitude	76°0'39.864'' E	121.2	512.6	100	12120.00	51260.00

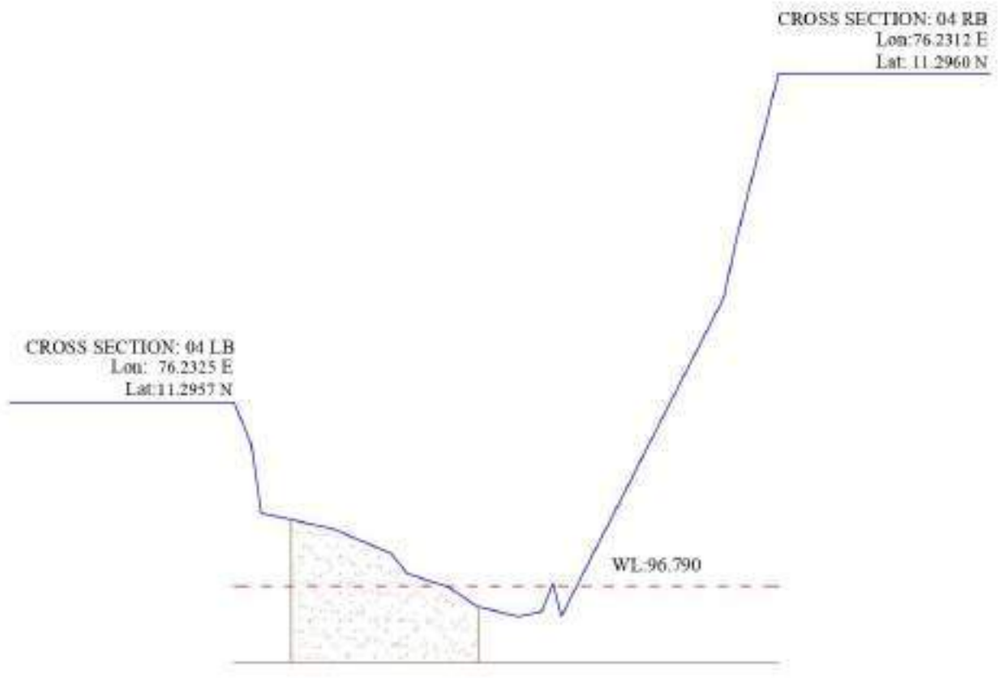
LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 4

District : Malappuram



District : Malappuram

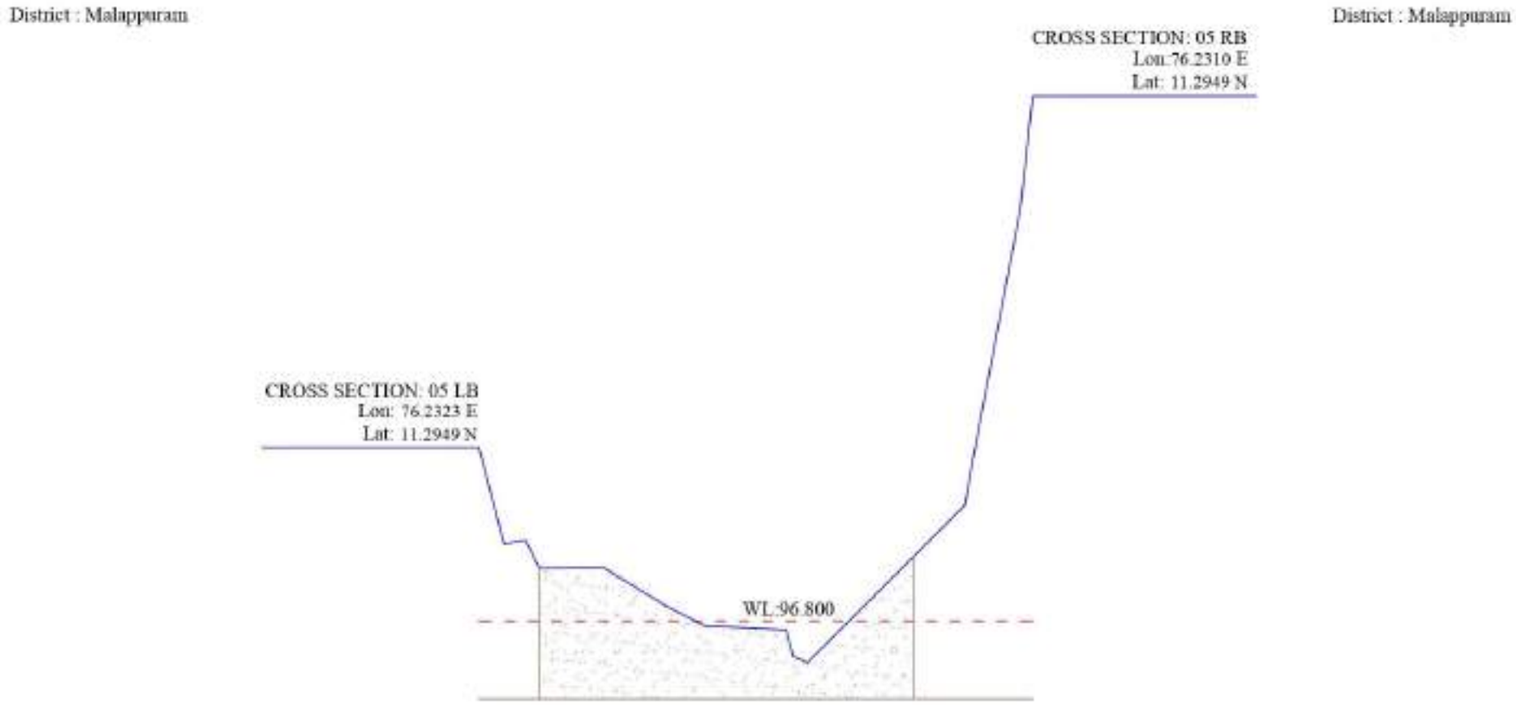
REMARK		Elevation	Distance	REMARK
(G)	Gravel	101.631	143.278	CS4
(S)	Sand	100.524	138.785	S
(R)	Rock	98.717	136.103	S
(M)	Earth	98.312	117.515	S
		97.661	102.033	S
		97.120	97.614	S
		96.769	86.949	S
		96.252	79.084	S
		95.995	68.357	S
		96.133	62.335	R
		96.853	59.329	R
		96.005	57.108	R
		104.397	14.380	M
		105.816	11.318	M
		110.289	0.000	CS4

Identification of TBM	
Note	**TBM N1** NEAR REVERA ESTATE, RB
Latitude	11°17'48.948'' N
Longitude	76°13'54.101'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
40.4	96.1	100	4040.00	9610.00

CHALIYAR RIVER

Cross Section 5



REMARK		Distance	Elevation
(G)	Gravel	141.833	101.234
(S)	Sand	135.361	98.769
(R)	Rock	129.916	98.866
(M)	Earth	126.315	98.142
		109.831	98.152
		93.423	97.152
		83.957	96.673
		63.116	96.569
		61.316	95.884
		57.689	95.731
		17.395	99.752
		15.509	100.823
		3.162	107.340
		0.000	116.232

REMARK
CS5
S
S
S
S
S
S
S
S
S
S
M
CS5

Identification of TBM	
Note	**TBM N1** NEAR REVERA ESTATE, RB
Latitude	11°17'48.948'' N
Longitude	76°13'54.101'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
50.9	177.3	100	5090.00	17730.00

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

CHALIYAR RIVER

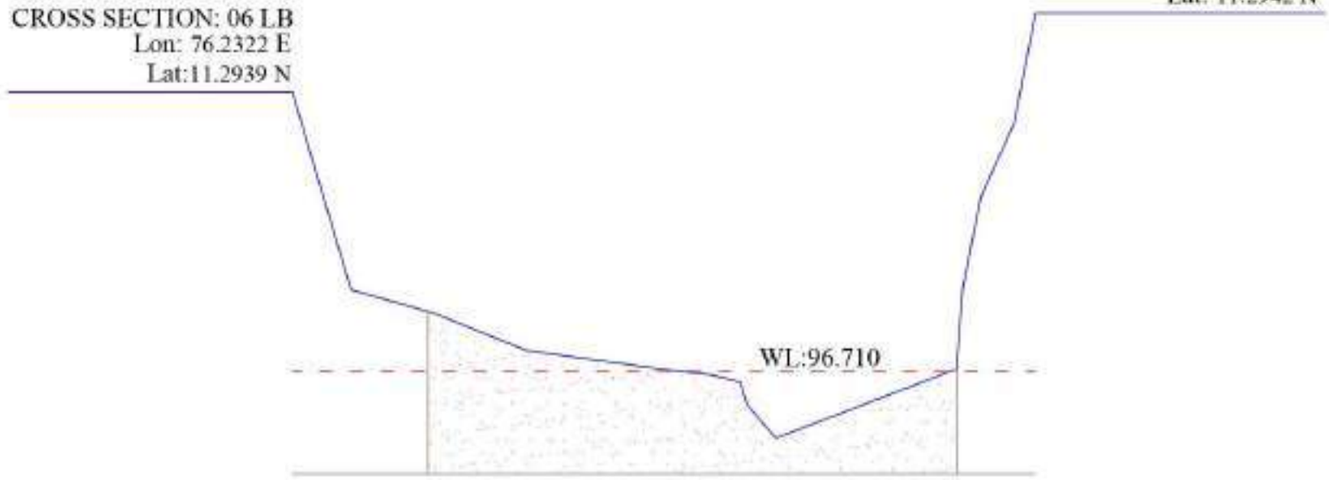
Cross Section 6

District : Malappuram

CROSS SECTION: 06 LB
Lon: 76.2322 E
Lat:11.2939 N

District : Malappuram

CROSS SECTION: 06 RB
Lon: 76.2308 E
Lat: 11.2942 N



Elevation	102.159	99.980	98.298	97.854	97.116	96.768	96.638	96.499	96.060	95.407	96.757	98.336	100.112	101.549	103.697
Distance	145.131	138.676	133.640	117.663	99.442	73.771	63.160	57.630	56.381	50.706	15.438	14.177	10.669	4.169	0.000
REMARK	CS6	S	S	S	S	S	S	S	S	S	S	S	S	S	CS6

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	TBM N1 NEAR REVERA ESTATE, RB
Latitude	11°17'48.948'' N
Longitude	76°13'54.101'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
21.3	177.1	100	2130.00	17710.00

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

CHALIYAR RIVER

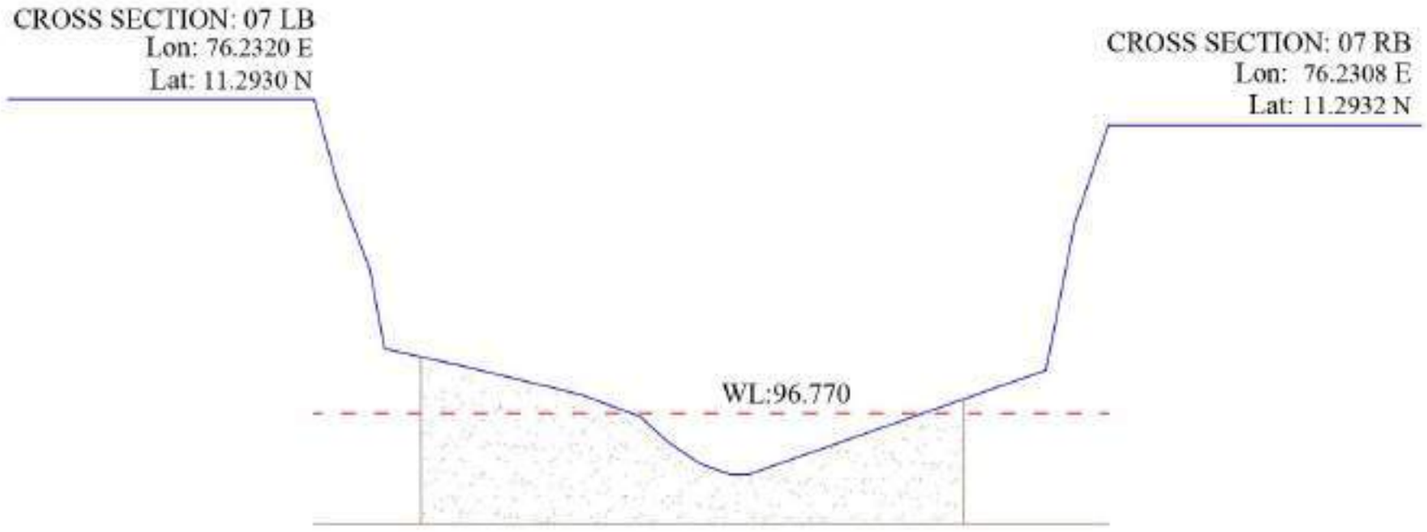
Cross Section 7

District : Malappuram

District : Malappuram

CROSS SECTION: 07 LB
Lon: 76.2320 E
Lat: 11.2930 N

CROSS SECTION: 07 RB
Lon: 76.2308 E
Lat: 11.2932 N



Elevation	102.484	100.873	99.394	97.944	97.584	97.102	96.704	96.239	95.852	95.663	95.665	97.556	100.269	102.008
Distance	144.583	140.084	134.446	131.722	115.560	95.653	85.131	80.054	74.281	68.820	65.365	11.387	6.052	0.000
REMARK	CS7	S	S	S	S	S	S	S	S	S	S	M	S	CS7

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM N1** NEAR REVERA ESTATE, RB
Latitude	11°17'48.948'' N
Longitude	76°13'54.101'' E

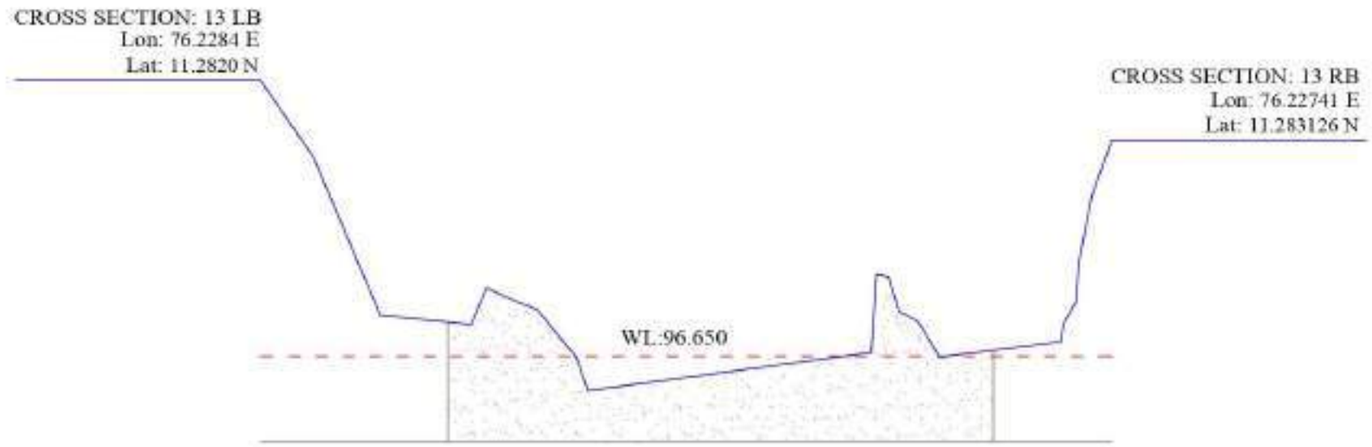
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
21.6	164.8	100	2160.00	16480.00

CHALIYAR RIVER

Cross Section 13

District : Malappuram

District : Malappuram



REMARK		Elevation	Distance	REMARK
		103.078	189.353	CS13
		101.288	177.515	M
		97.600	162.642	S
		97.390	142.406	S
		98.235	139.015	S
		97.894	131.803	S
		97.736	127.751	S
		97.043	122.329	S
		96.636	119.074	S
		95.851	116.482	S
		96.734	53.502	S
		98.554	52.304	S
		98.510	49.629	S
		97.691	47.295	S
		97.456	43.003	S
		96.630	38.293	S
		96.984	11.292	S
		97.388	10.727	S
		97.909	7.976	S
		98.775	7.382	S
		100.371	4.442	S
		101.670	0.000	CS13
(G)	Gravel			
(S)	Sand			
(R)	Rock			
(M)	Earth			

Identification of TBM	
Note	**TBM N2** KALATHIN KADAVU, LB
Latitude	11°16'55.13''N
Longitude	76°13'42.885''E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
43.1	218.8	100	4310.00	21880.00

LR/11909/2023-LR(K1)

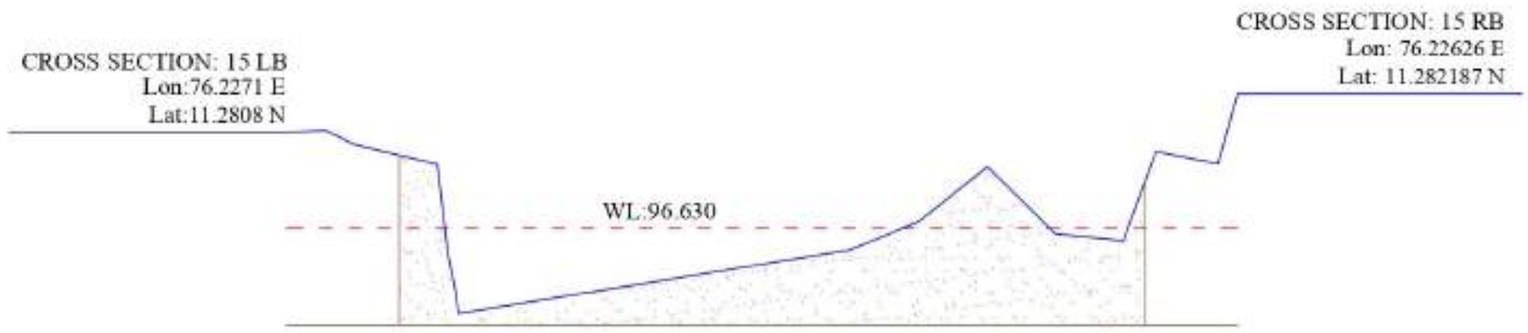
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 15

District : Malappuram

District : Malappuram



REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Elevation	Distance	REMARK
98.621	196.209	CS15
98.652	188.090	S
98.370	182.489	S
97.956	165.111	S
96.079	162.908	S
95.313	161.364	S
94.874	160.745	S
96.162	81.333	S
96.172	80.256	S
96.775	65.739	S
97.902	51.577	S
96.519	37.598	S
96.376	23.546	S
98.219	16.822	S
97.962	4.003	S
99.408	0.000	CS15

Identification of TBM	
Note	TBM N2 KALATHIN KADAVU, LB
Latitude	11°16'55.13''N
Longitude	76°13'42.885''E

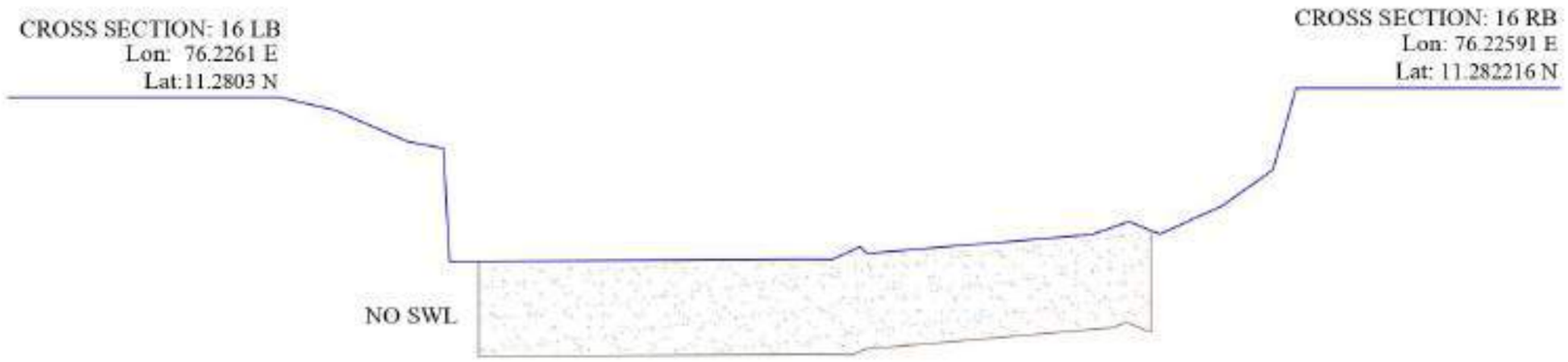
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
32.4	211.5	100	3240.00	21150.00

CHALIYAR RIVER

Cross Section 16

District : Malappuram

District : Malappuram



Elevation	99.838	99.568	98.908	98.768	96.374	96.424	96.420	96.687	96.543	96.951	97.219	96.963	97.547	98.313	100.026
Distance	214.400	202.725	187.350	179.788	178.467	103.690	97.764	91.948	90.517	43.071	35.253	28.755	15.677	4.856	0.000
REMARK	CS16	S	S	S	S	S	S	S	S	S	S	S	S	S	CS16

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	TBM N2 KALATHIN KADAVU, LB
Latitude	11°16'55.13''N
Longitude	76°13'42.885''E

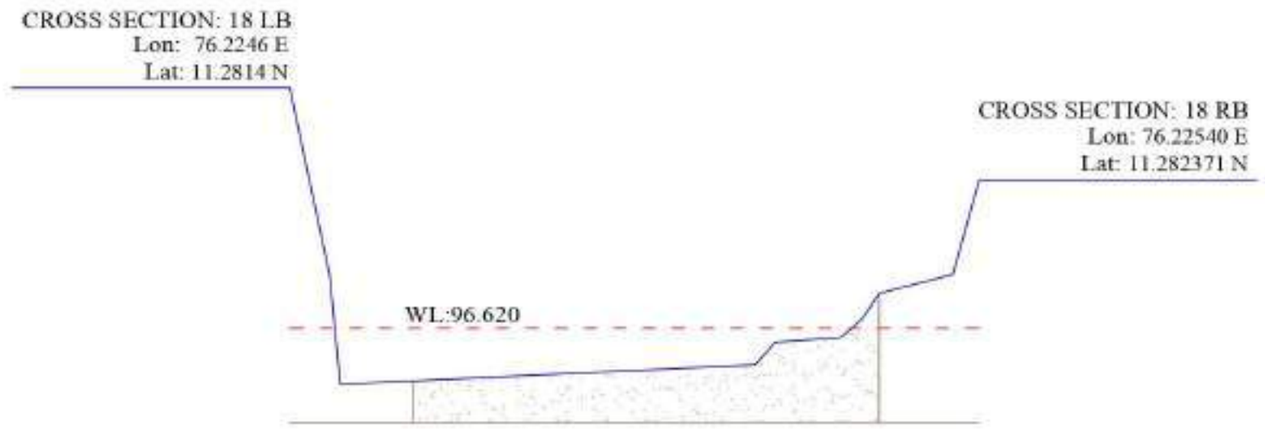
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
285.9	0.0	100	28590.00	0.00

CHALIYAR RIVER

Cross Section 18

District : Malappuram

District : Malappuram



Elevation	101.739	100.386	97.761	95.431		95.845	96.328	96.425	96.819	97.365	97.772	99.773
Distance	140.984	138.242	132.871	130.743		45.815	41.712	28.364	23.900	20.450	5.325	0.000
REMARK	CS18	S	S	S		S	S	S	S	S	G	CS18

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM N2** KALATHIN KADAVU, LB
Latitude	11°16'55.13''N
Longitude	76°13'42.885''E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
1.8	118.8	100	180.00	11880.00

LR/11909/2023-LR(K1)

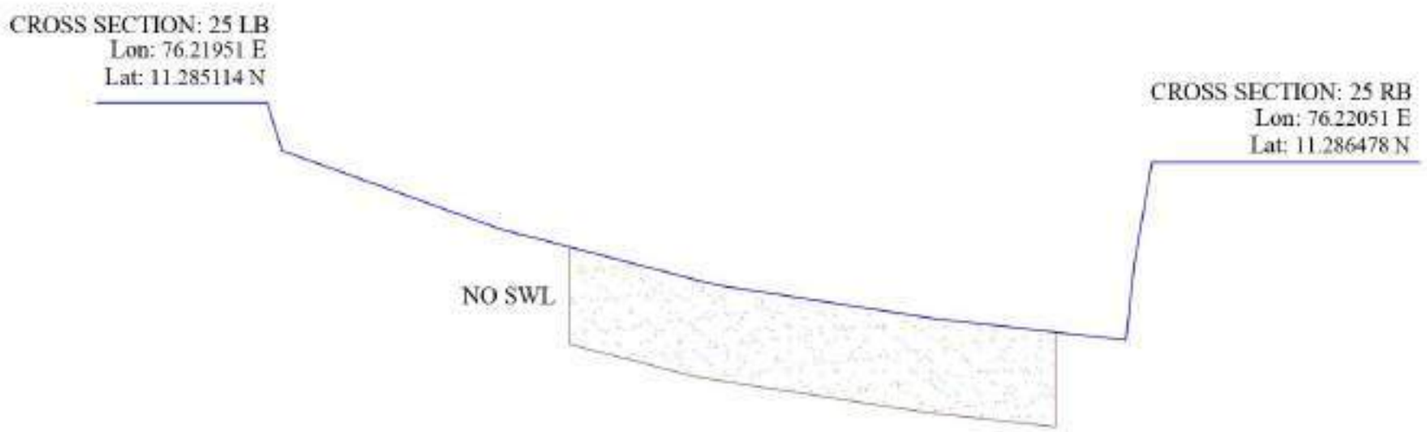
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 25

District : Malappuram

District : Malappuram



Elevation	100.096	97.930	96.317	96.775	97.488	98.684	100.352	101.363
Distance	0.000	3.808	5.535	46.300	92.600	138.900	185.200	188.284
REMARK	CS25	S	S	S	S	S	S	CS25

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM N2** KALATHIN KADAVU, LB
Latitude	11°16'55.13''N
Longitude	76°13'42.885''E

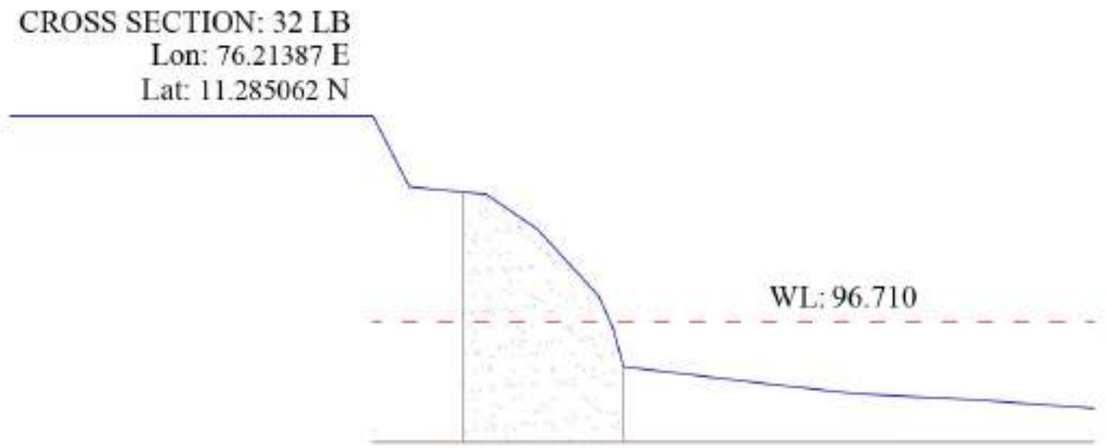
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
210.1	0.0	100	21010.00	0.00

CHALIYAR RIVER

Cross Section 32

District : Malappuram

District : Malappuram



Elevation	100.141	98.963	98.835	98.251	97.142	96.622	95.964	95.667	95.514	95.415	95.269
Distance	0.000	6.079	18.930	27.491	37.632	39.948	41.785	66.902	80.668	100.248	120.208
REMARK	CS32	S	S	S	S	S	G	G	M	M	M

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	TBM N2 KALATHIN KADAVU, LB
Latitude	11°16'55.13''N
Longitude	76°13'42.885''E

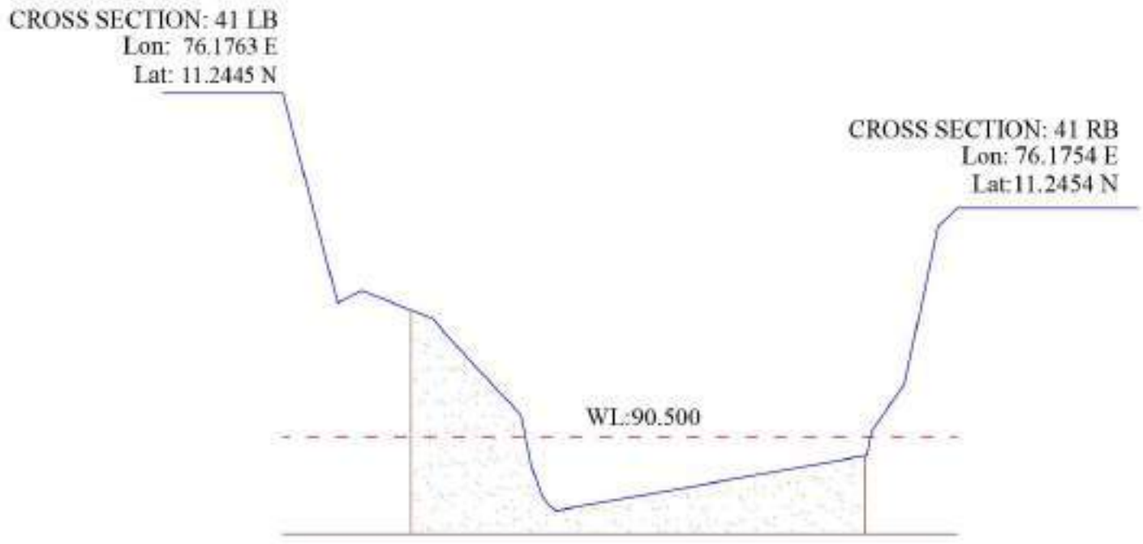
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
34.5	52.7	100	3450.00	5270.00

CHALIYAR RIVER

Cross Section 41

District : Malappuram

District : Malappuram



Elevation	97.537	93.239	93.495	92.922	92.229	92.228	90.938	89.884	89.292	89.103	88.982	90.116	90.578	91.585	94.806	95.188
Distance	138.333	127.049	122.126	107.646	101.509	101.481	89.441	87.247	85.164	83.799	82.193	18.524	17.701	10.805	3.857	0.000
REMARK	CS41	S	S	S	S	S	S	S	S	S	S	S	S	S	S	CS41

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	TBM M1 IPPOTTIKAL KADAVU, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	11°14'54.649'' N	37.0	119.5	100	3700.00	11950.00
Longitude	76°10'45.812'' E					

LR/11909/2023-LR(K1)

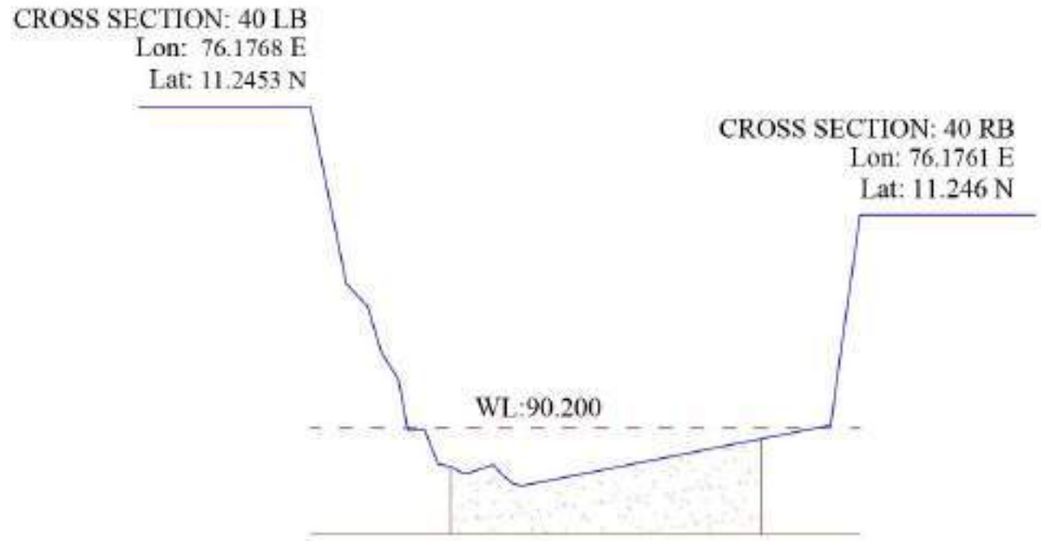
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 40

District : Malappuram

District : Malappuram



Elevation	Distance	REMARK
96.216	103.206	CS40
92.939	96.600	S
92.905	96.532	S
92.479	92.508	S
91.611	89.906	S
91.116	86.762	S
90.148	84.956	S
90.166	81.770	RK
89.522	79.295	RK
89.475	76.930	RK
89.351	74.640	S
89.351	73.619	S
89.508	68.877	S
89.333	67.344	S
89.152	65.201	S
89.114	63.468	S
89.411	48.300	S
90.250	5.515	S
91.740	3.512	S
94.196	0.000	CS40

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM M1** IPPOTTIKAL KADAVU, LB
Latitude	11°14'54.649'' N
Longitude	76°10'45.812'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
0.0	76.4	100	0.00	7640.00

LR/11909/2023-LR(K1)

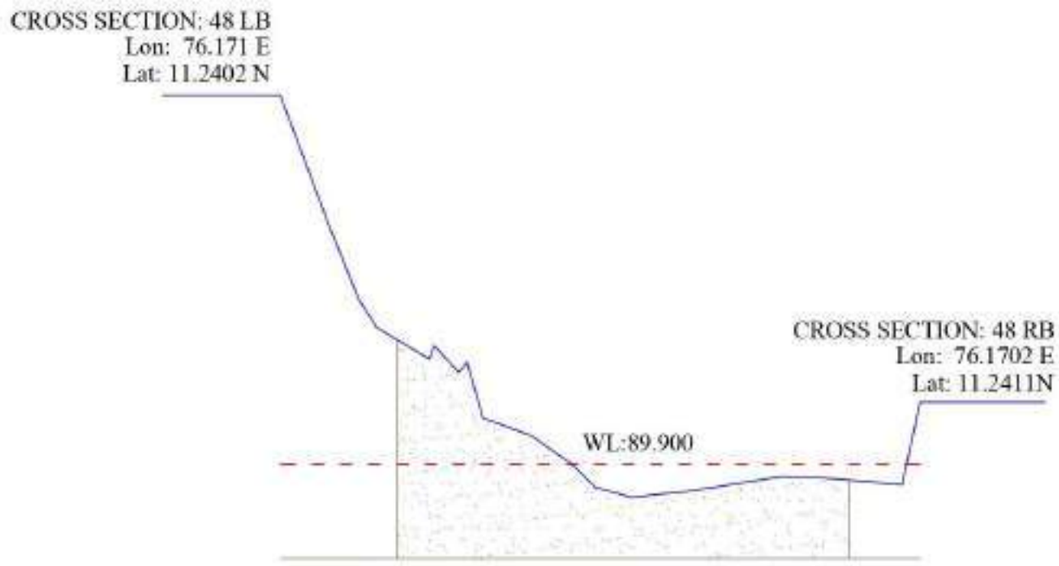
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 48

District : Malappuram

District : Malappuram



Elevation	Distance	REMARK
97.727	135.879	CS48
95.078	125.955	S
93.407	119.267	S
92.797	115.361	S
92.132	104.246	S
92.417	103.208	S
91.854	98.023	S
92.056	96.194	S
90.879	92.807	S
90.509	82.601	S
89.911	74.103	S
89.405	68.940	S
89.190	61.058	S
89.248	57.016	S
89.314	49.979	S
89.428	42.609	S
89.634	29.340	S
89.620	22.922	S
89.568	15.656	S
89.461	3.803	S
91.220	0.000	CS48

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM M1** IPPOTTIKAL KADAVU, LB
Latitude	11°14'54.649'' N
Longitude	76°10'45.812'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
50.1	165.8	100	5010.00	16580.00

CHALIYAR RIVER

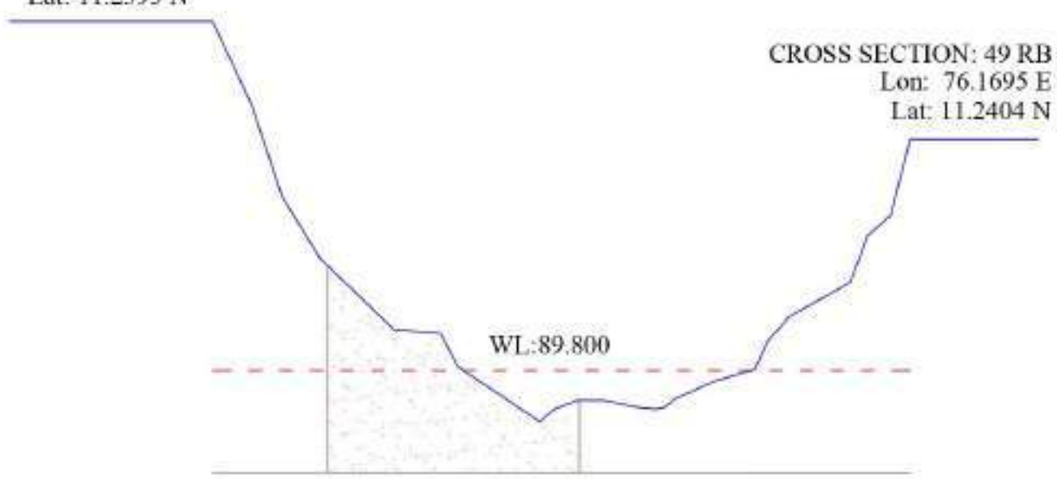
Cross Section 49

District : Malappuram

District : Malappuram

CROSS SECTION: 49 LB
Lon: 76.1701 E
Lat: 11.2395 N

CROSS SECTION: 49 RB
Lon: 76.1695 E
Lat: 11.2404 N



Elevation	Distance	REMARK
96.631	136.680	CS49
94.996	129.054	S
93.205	123.072	S
92.000	115.681	S
90.602	101.231	S
90.525	92.053	S
89.869	88.591	S
88.794	72.553	S
89.026	69.979	S
89.212	65.164	S
89.209	59.798	S
89.072	53.329	S
89.043	49.867	G
89.077	47.975	G
89.230	46.271	G
89.581	38.624	G
89.815	30.469	G
90.382	27.835	G
90.848	23.706	G
91.519	11.798	G
92.434	8.325	S
92.834	3.818	S
94.324	0.000	CS49

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	TBM M1 IPPOTTIKAL KADAVU, LB
Latitude	11°14'54.649'' N
Longitude	76°10'45.812'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
26.6	85.0	100	2660.00	8500.00

LR/11909/2023-LR(K1)

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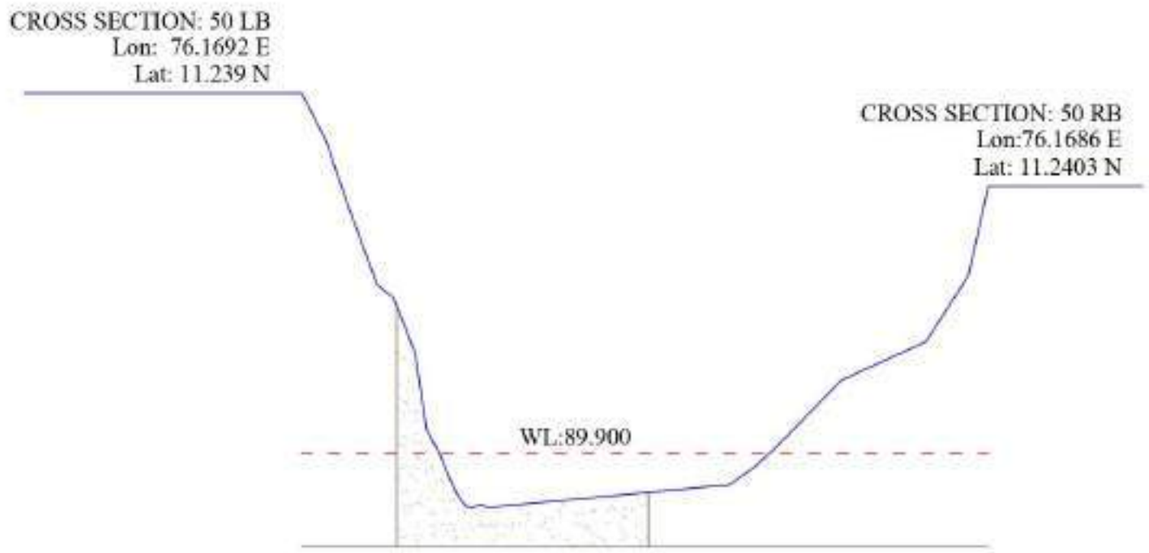
CHALIYAR RIVER

Cross Section 50

District : Malappuram

District : Malappuram



Elevation	97.548	96.542	95.243	93.474	93.192	92.018	90.406	89.921	89.417	88.982	88.764	88.735	88.803	88.744	89.202	89.217	89.599	90.017	91.447	92.263	93.665	95.570
Distance	145.827	140.658	136.294	129.811	126.290	121.675	119.324	116.691	114.602	112.631	110.817	109.678	107.700	106.224	57.150	55.116	49.643	45.126	31.198	13.250	4.225	0.000
REMARK	CS50	S	S	S	S	S	S	S	S	S	S	S	S	S	G	G	G	G	G	G	G	CS50

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM M1** IPPOTTIKAL KADAVU, LB
Latitude	11°14'54.649'' N
Longitude	76°10'45.812'' E

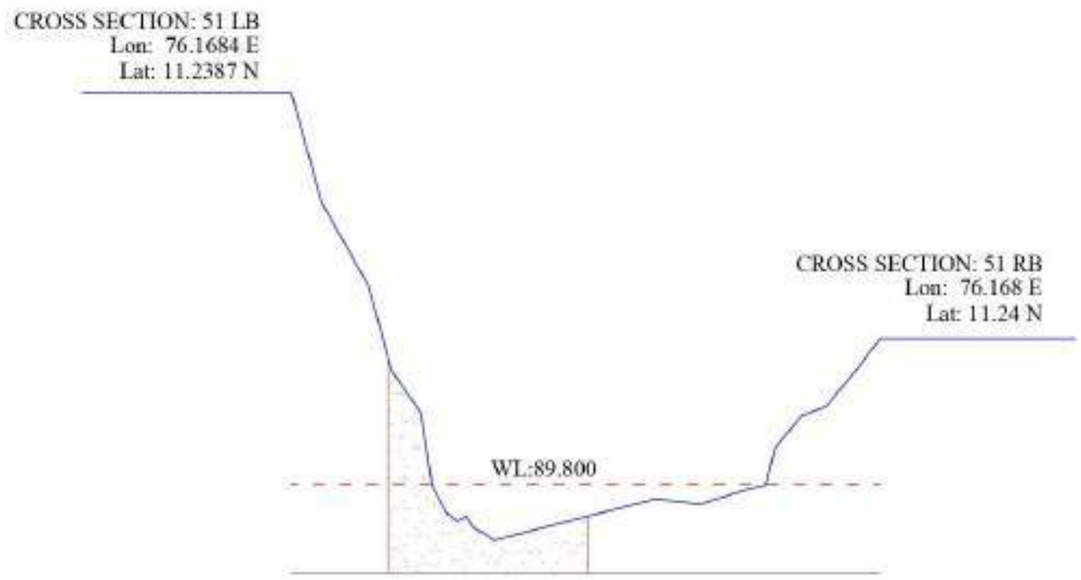
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
14.2	64.1	100	1420.00	6410.00

CHALIYAR RIVER

Cross Section 51

District : Malappuram

District : Malappuram



REMARK		Distance	Elevation
(G)	Gravel	132.226	98.597
(S)	Sand	125.524	96.149
(R)	Rock	114.876	94.251
(M)	Earth	109.711	92.360
		103.167	91.408
		100.558	89.753
		97.304	89.153
		94.927	88.981
		92.959	89.076
		91.314	88.826
		88.857	88.697
		86.711	88.547
		50.526	89.470
		45.226	89.415
		40.405	89.358
		30.537	89.668
		25.652	89.783
		23.514	90.626
		17.475	91.352
		12.123	91.547
		5.532	92.342
		0.000	93.076
CS51		CS51	REMARK
S		G	

Identification of TBM	
Note	**TBM M1** IPPOTTIKAL KADAVU, LB
Latitude	11°14'54.649'' N
Longitude	76°10'45.812'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
17.8	58.3	100	1780.00	5830.00

LR/11909/2023-LR(K1)

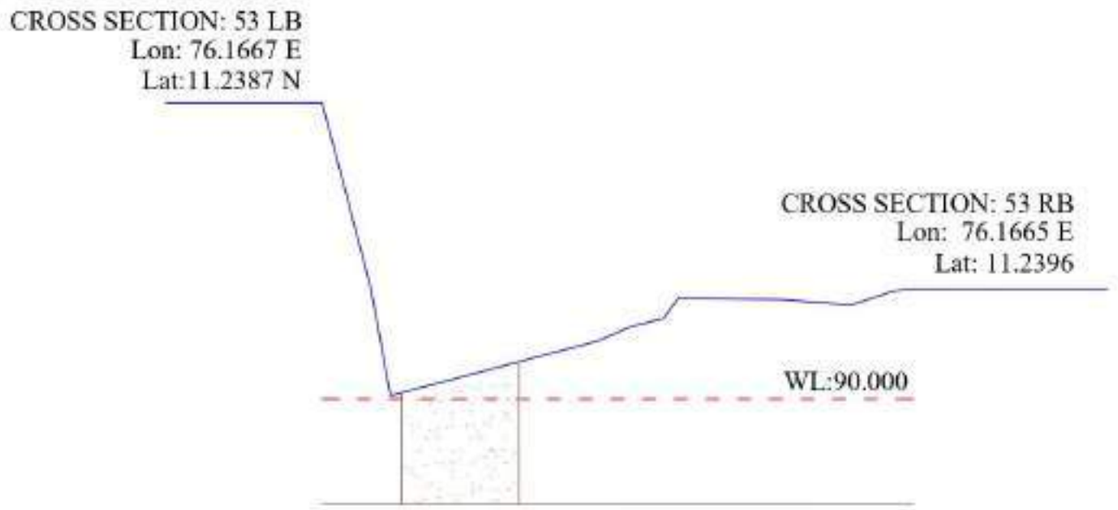
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 53

District : Malappuram

District : Malappuram



Elevation	93.807	91.158	90.306	89.873	88.930	88.265	89.299	89.571	89.728	90.105	90.084	89.980	90.244	90.288
Distance	111.887	104.903	102.695	101.913	100.186	98.949	59.564	53.366	47.152	44.485	24.921	11.692	3.587	0.000
REMARK	CS53	S	S	S	S	S	G	G	G	G	G	G	G	CS53

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM M1** IPPOTTIKAL KADAVU, LB
Latitude	11°14'54.649'' N
Longitude	76°10'45.812'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
9.2	44.6	100	920.00	4460.00

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

CHALIYAR RIVER

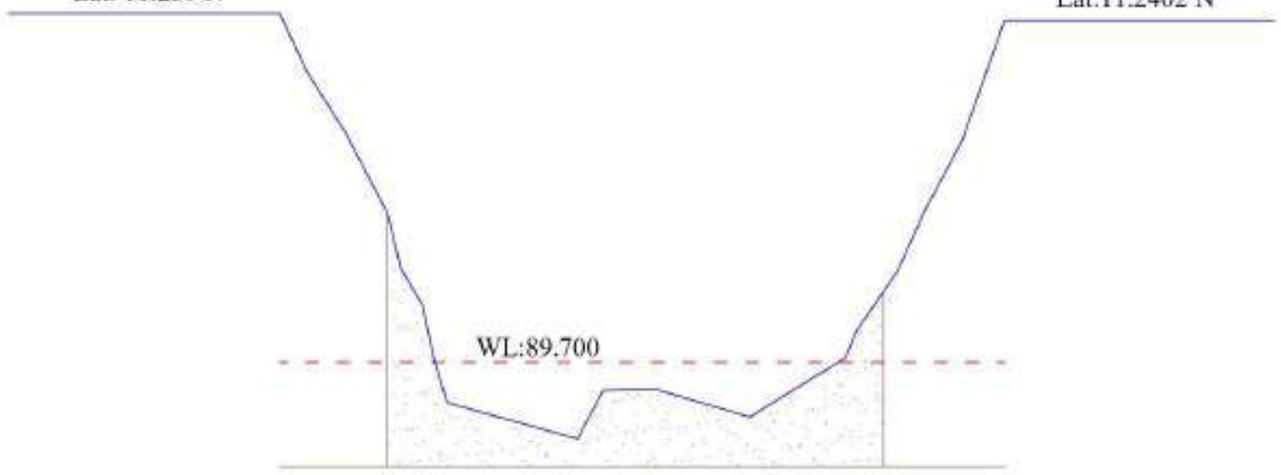
Cross Section 57

District : Malappuram

District : Malappuram

CROSS SECTION:57 LB
Lon: 76.1628 E
Lat: 11.239 N

CROSS SECTION: 57 RB
Lon: 76.163 E
Lat:11.2402 N



REMARK	Distance	Elevation
CS57	138.455	96.360
S	133.107	95.224
S	125.959	94.097
S	117.879	92.551
S	115.248	91.483
S	Lat.135	90.788
S	108.894	89.730
S	106.433	88.925
S	81.586	88.234
S	76.708	89.157
S	66.707	89.183
S	48.649	88.654
S	30.414	89.782
S	28.324	90.297
S	20.451	91.442
S	15.309	92.583
S	8.154	93.930
CS57	0.000	96.229

(G) Gravel
(S) Sand
(R) Rock
(M) Earth

Identification of TBM	
Note	**TBM M2** PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

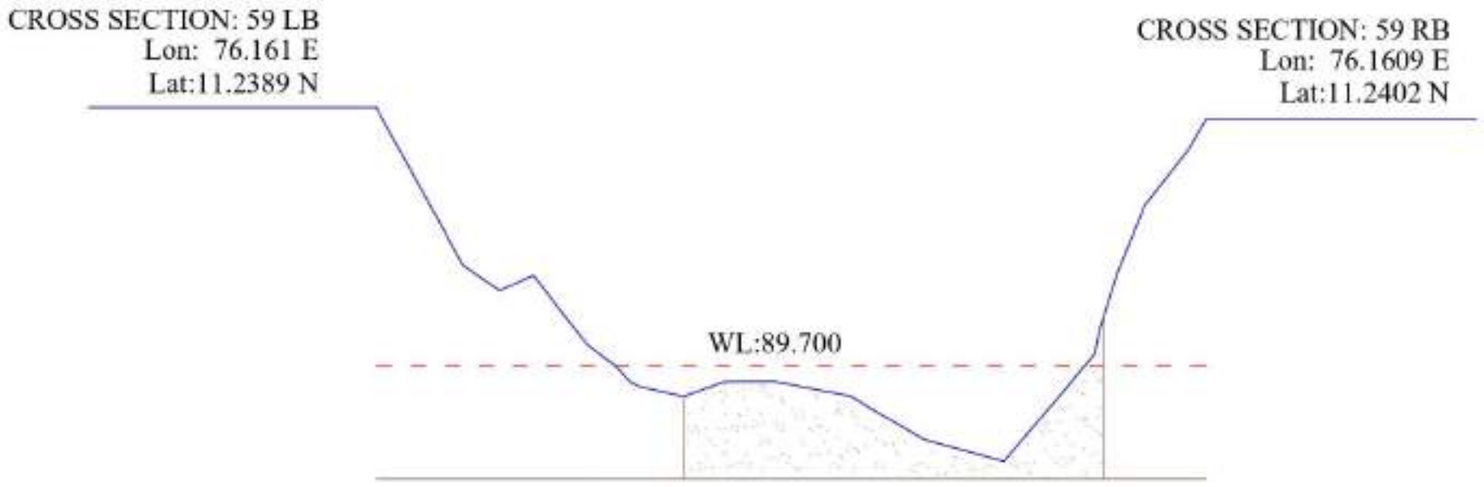
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
18.9	127.5	100	1890.00	12750.00

CHALIYAR RIVER

Cross Section 59

District : Malappuram

District : Malappuram



Elevation	94.278	91.488	91.035	91.306	90.676	90.093	89.804	89.701	89.424	89.336	89.159	89.421	89.422	89.167	88.399	88.010	89.908	90.327	91.334	92.360	92.524	93.531	94.077
Distance	146.928	131.596	125.159	119.053	114.317	109.688	106.021	104.552	102.036	100.392	92.486	85.328	76.345	63.049	50.013	35.758	19.700	18.876	15.743	11.603	10.965	3.084	0.000
REMARK	CS59	G	G	G	G	G	G	G	G	G	S	S	S	S	S	S	S	S	S	S	S	S	CS59

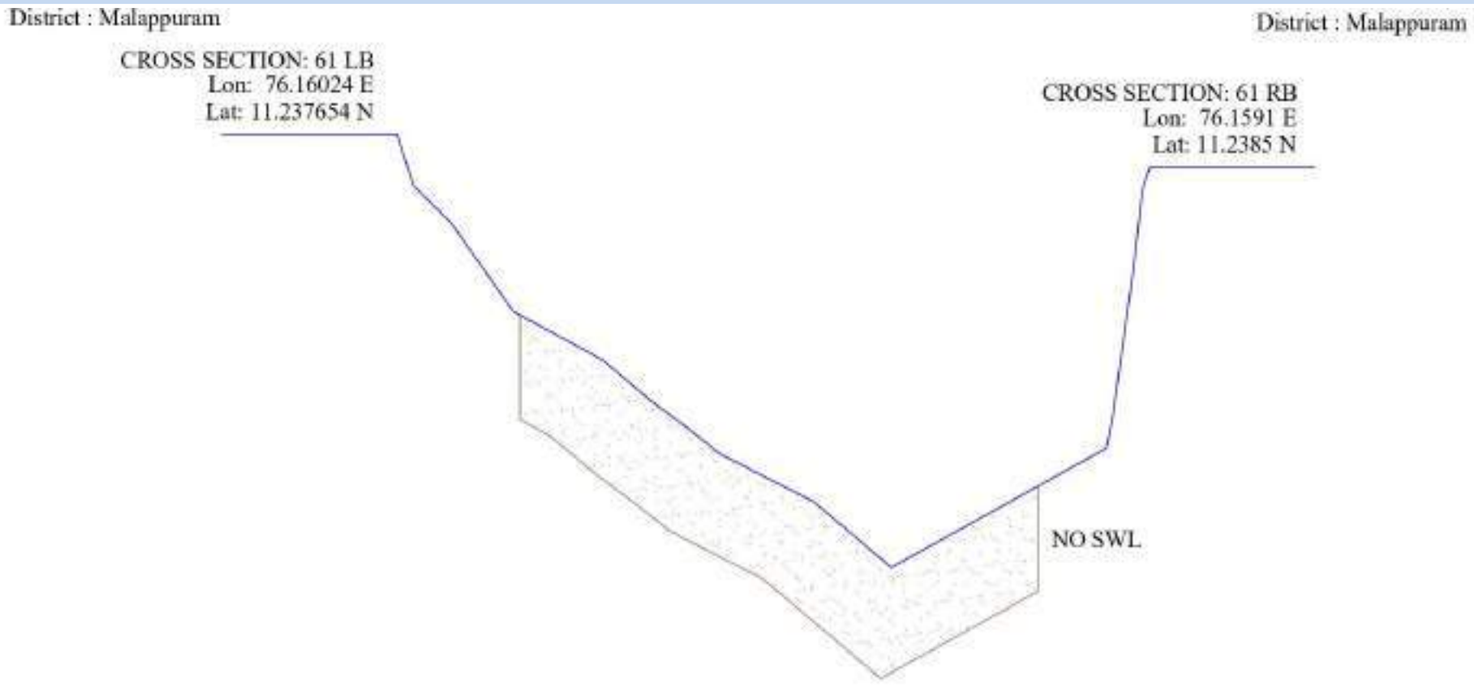
REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM M2** PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
1.1	92.6	100	110.00	9260.00

CHALIYAR RIVER

Cross Section 61



REMARK	96.248	95.128	94.312	92.387	91.324	90.443	89.792	89.276	88.244	86.809	89.407	90.142	93.343	95.024	95.540	Elevation
(G) Gravel	164.268	160.614	152.357	138.841	119.307	108.853	100.134	93.650	73.359	56.357	9.514	8.015	3.547	1.659	0.000	Distance
(S) Sand (R) Rock (M) Earth	CS61	S	S	S	S	S	S	S	S	S	S	S	S	S	CS61	REMARK

Identification of TBM	
Note	**TBM M2** PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

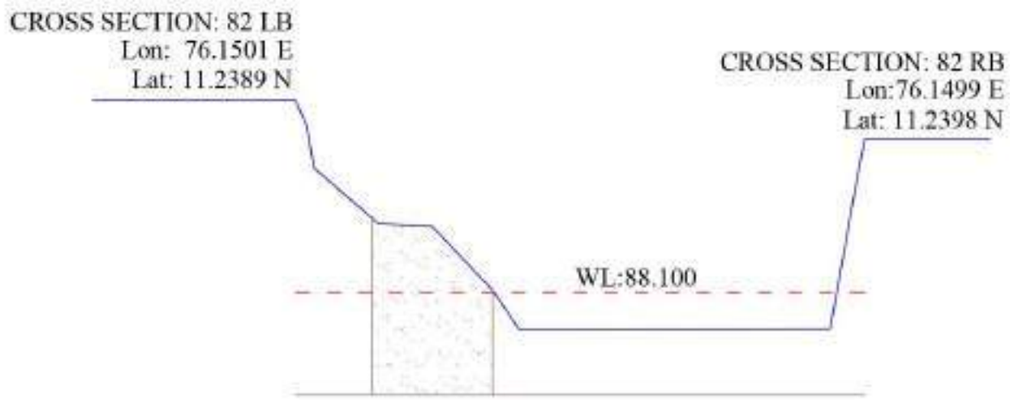
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
271.0	0.0	100	27100.00	0.00

CHALIYAR RIVER

Cross Section 82

District : Malappuram

District : Malappuram



Elevation	93.251	92.737	91.931	90.848	90.791	89.546	88.781		88.792	91.691	92.496
Distance	Lat.107	108.836	107.499	94.884	84.370	72.621	67.411		6.733	1.553	0.000
REMARK	CS82	S	S	S	S	G	G		M	M	CS82

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM M2** PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
23.4	46.9	100	2340.00	4690.00

LR/11909/2023-LR(K1)

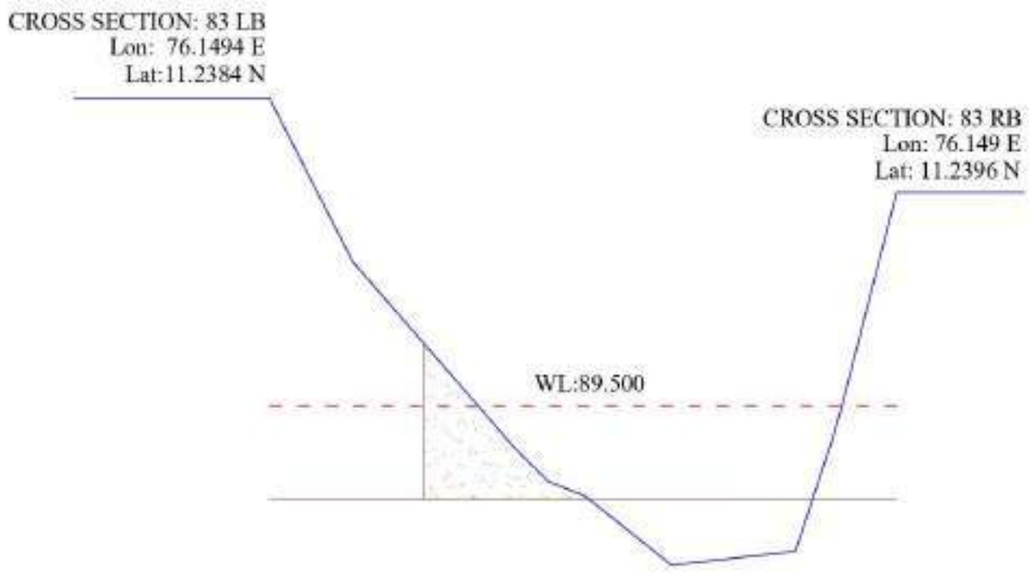
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 83

istrict : Malappuram

District : Malappuram



134.672	116.756	82.075	74.905	66.991	48.327	21.717	13.916	11.888	0.000	Distance
CS83	S	S	S	S	S	S	M	M	CS83	REMARK
96.082	92.581	88.587	87.878	87.565	86.074	86.373	88.735	89.436	94.069	Elevation

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM M2** PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

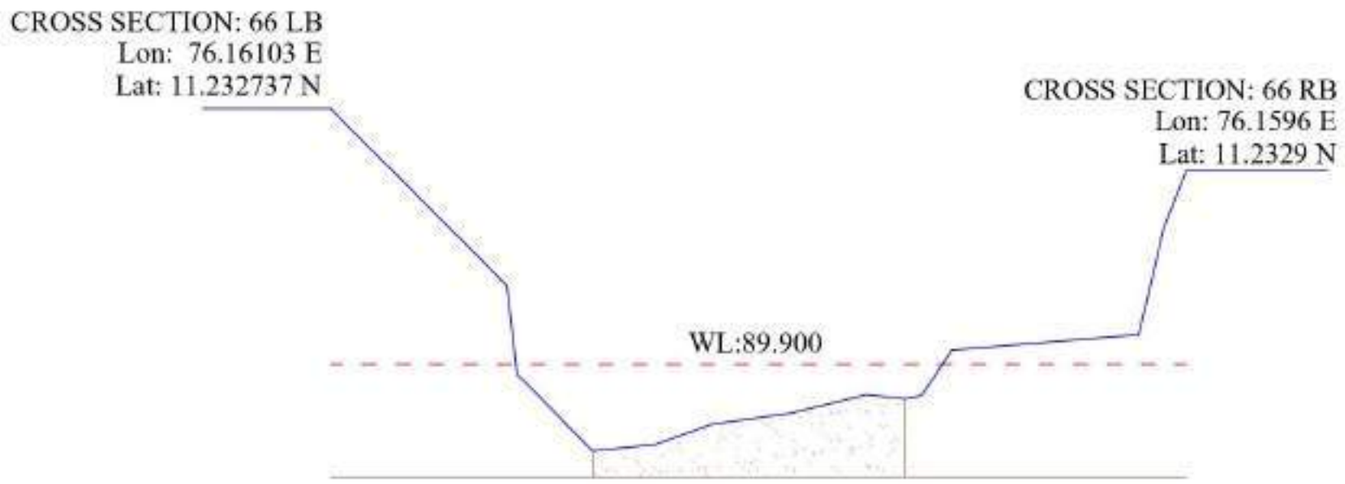
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
7.9	42.7	100	790.00	4270.00

CHALIYAR RIVER

Cross Section 66

District : Malappuram

District : Malappuram



Elevation	94.416	91.284	89.714	88.364	88.478	88.831	89.026	89.353	89.282	89.339	90.146	90.415	92.310	93.319
Distance	151.570	120.315	118.524	105.157	94.006	84.056	70.182	56.675	49.822	46.916	41.520	8.474	3.960	0.000
REMARK	CS66	M	M	R	S	S	S	S	G	G	M	M	S	CS66

REMARK

(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM M2** PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

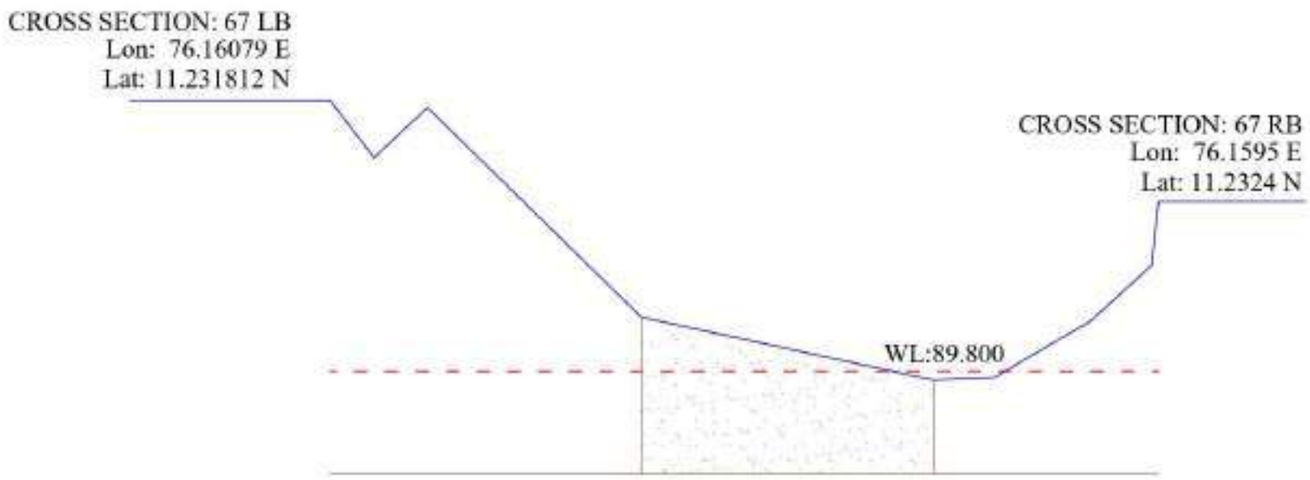
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
0.0	54.7	100	0.00	5470.00

CHALIYAR RIVER

Cross Section 67

District : Malappuram

District : Malappuram



REMARK		162.020	153.392	142.941	101.152	43.975	32.059	13.324	1.366	0.000	Distance
(G)	Gravel	CS67	M	M	M	S	G	G	G	CS67	REMARK
(S)	Sand										
(R)	Rock										
(M)	Earth										

95.097	93.978	94.956	90.856	89.632	89.682	90.782	91.872	93.116	Elevation

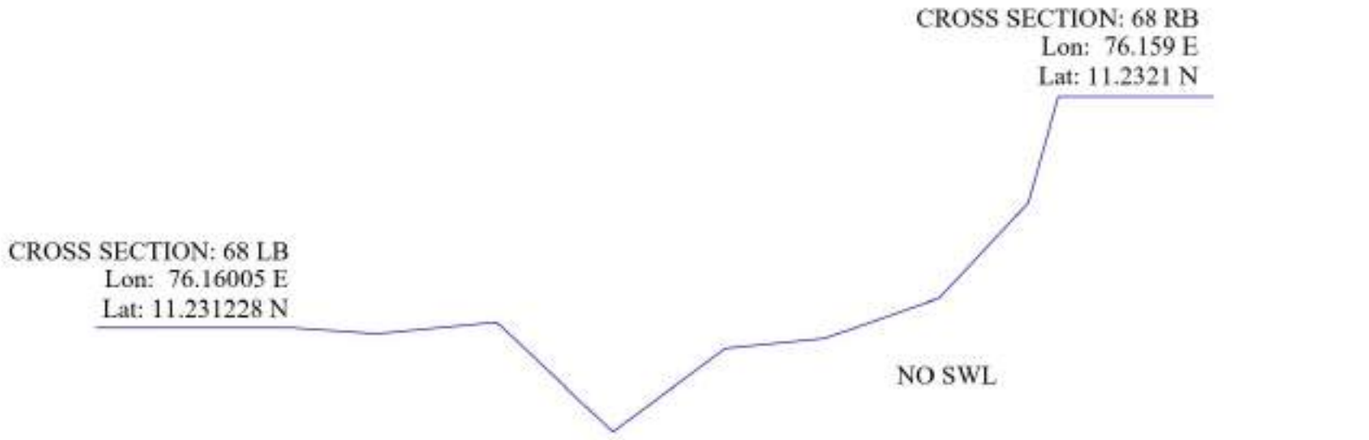
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM M2** PALLIPADY KADAVU, LB	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	11°13'50.786''N	26.2	113.6	100	2620.00	11360.00
Longitude	76°9'36.28'' E					

CHALIYAR RIVER

Cross Section 68

District : Malappuram

District : Malappuram



REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

CS68	M	G	G	G	G	G	G	CS68	REMARK
150.740	133.995	110.457	87.599	65.468	45.971	23.399	5.891	0.000	Distance
89.928	89.810	90.040	87.879	89.521	89.718	90.510	92.380	94.474	Elevation

Identification of TBM	
Note	**TBM M2** PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

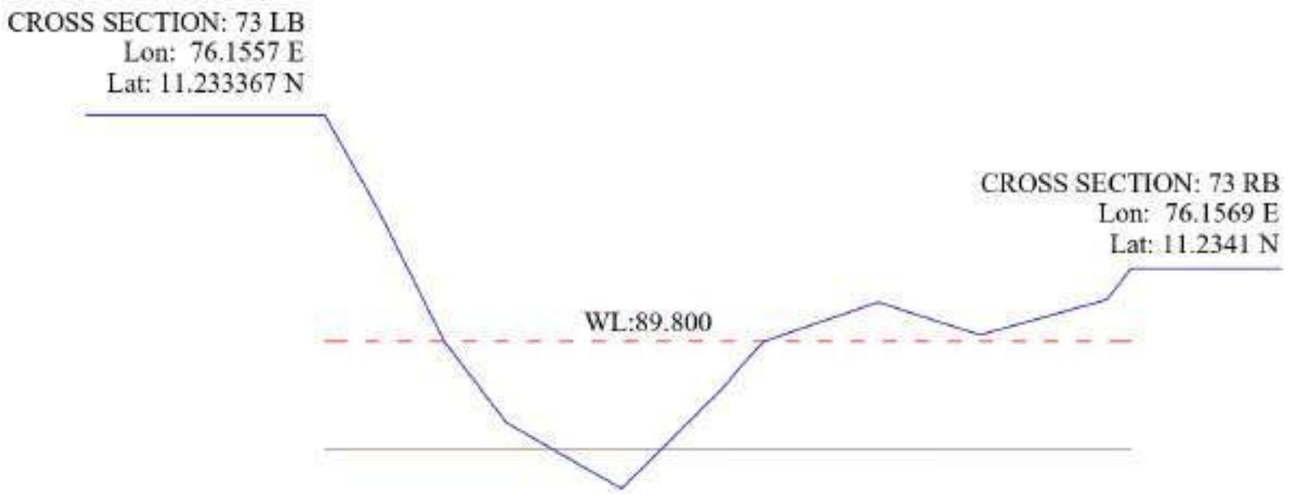
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
0.0	0.0	100	0.00	0.00

CHALIYAR RIVER

Cross Section 73

District : Malappuram

District : Malappuram



Elevation	93.998	92.262	89.791	88.297	87.072	89.007	89.292	89.803	90.527	89.921	90.574	91.150
Distance	149.634	139.870	127.408	115.960	94.576	75.074	72.856	68.159	46.943	28.042	4.576	0.000
REMARK	CS73	S	G	G	G	G	G	G	G	G	G	CS73

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	TBM M2 PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

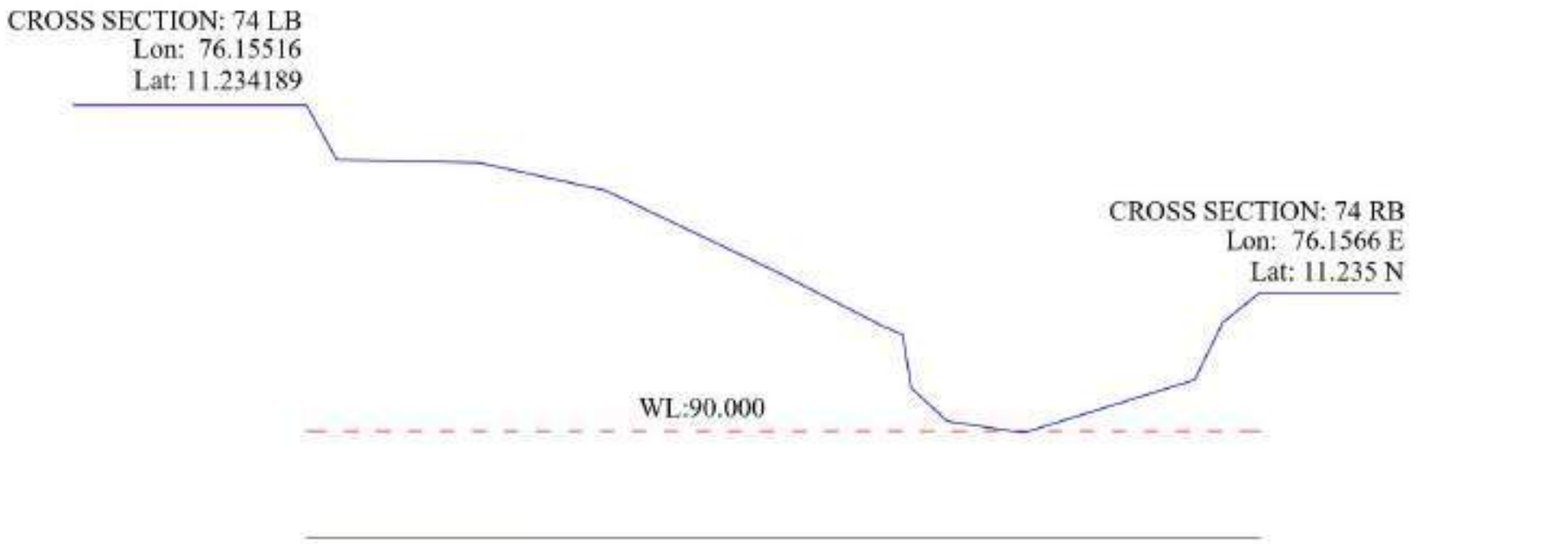
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
0.0	0.0	100	0.00	0.00

CHALIYAR RIVER

Cross Section 74

District : Malappuram

District : Malappuram



Elevation	94.308	93.286	93.229	92.707	91.123	90.161	90.011	89.010	88.385	88.168	89.160	90.232	90.795
Distance	178.820	173.163	146.425	122.652	89.356	70.577	67.010	65.383	58.561	44.318	12.197	6.986	0.000
REMARK	CS74	G	G	G	G	G	G	G	G	G	G	M	CS74

REMARK
(G) Gravel
(S) Sand
(R) Rock
(M) Earth

Identification of TBM	
Note	TBM M2 PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
0.0	0.0	100	0.00	0.00

LR/11909/2023-LR(K1)

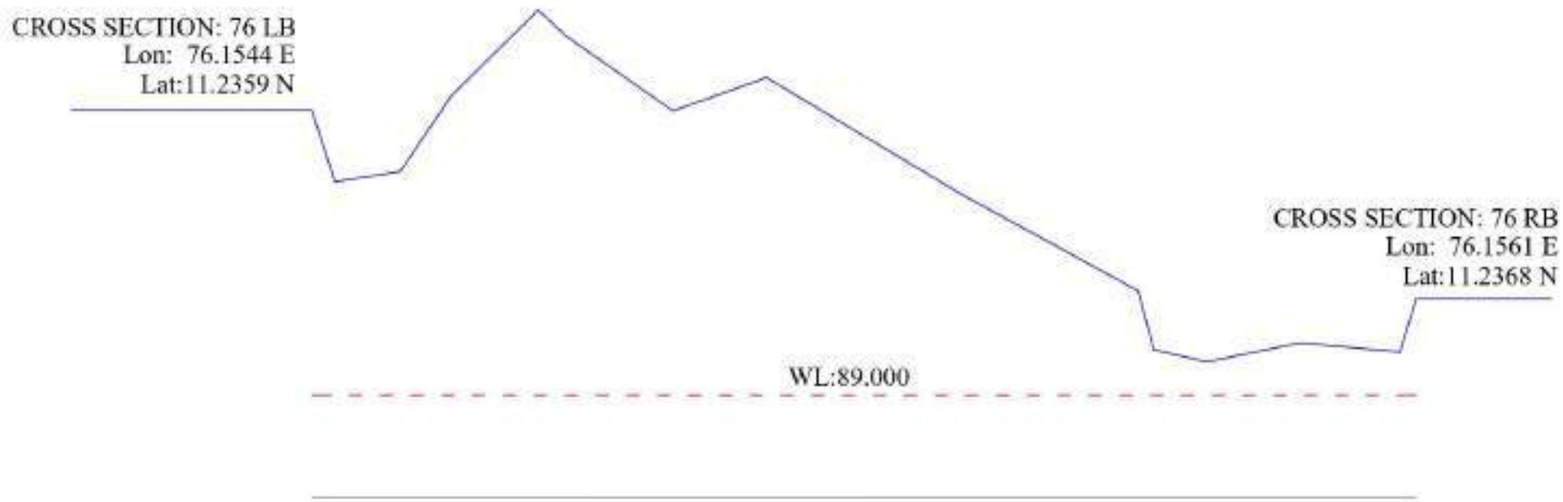
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 76

District : Malappuram

District : Malappuram



Elevation	93.635	92.246	92.444	93.919	95.591	95.082	93.625	94.273	92.009	90.124	88.975	88.742	89.107	88.935	89.964
Distance	215.028	210.518	197.841	187.876	170.935	165.606	144.710	126.509	88.661	54.144	51.084	40.765	22.603	3.150	0.000
REMARK	CS76	G	G	G	G	G	G	G	G	G	G	R	G	G	CS76

REMARK
(G) Gravel
(S) Sand
(R) Rock
(M) Earth

Identification of TBM	
Note	TBM M2 PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

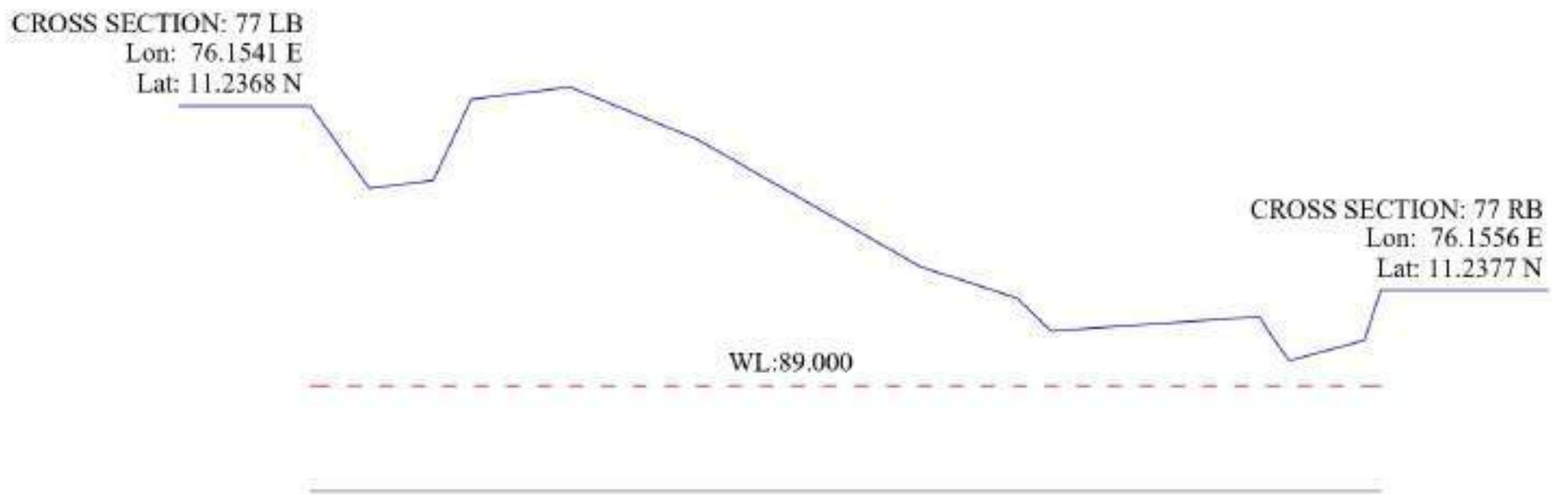
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
0.0	0.0	100	0.00	0.00

CHALIYAR RIVER

Cross Section 77

District : Malappuram

District : Malappuram



Elevation	93.393	91.828	91.987	93.517	93.751	92.756	90.354	89.754	89.135	89.403	88.977	88.572	88.955	89.908
Distance	202.818	191.609	179.484	172.334	153.620	129.454	87.286	68.908	62.535	22.990	20.291	17.329	3.136	0.000
REMARK	CS77	G	G	G	G	G	G	G	G	G	G	M	R	CS77

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM M2** PALLIPADY KADAVU, LB
Latitude	11°13'50.786''N
Longitude	76°9'36.28'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
0.0	0.0	100	0.00	0.00

LR/11909/2023-LR(K1)

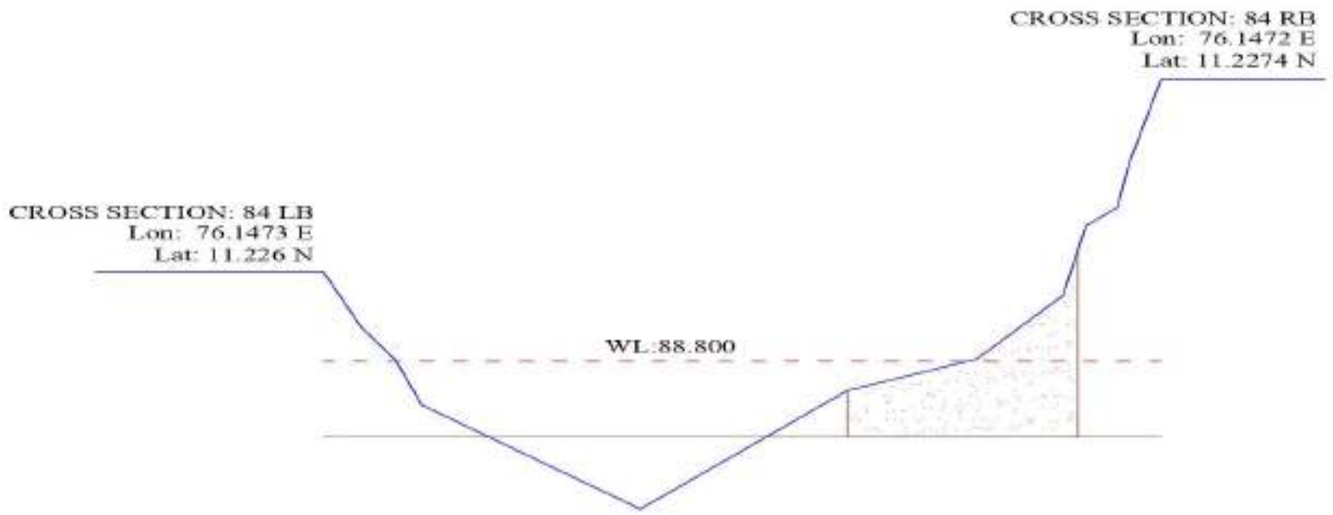
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 84

District : Malappuram

District : Malappuram



REMARK	91.186	89.698	88.830	87.649	84.880	88.025	88.866	90.550	92.399	92.891	94.025	96.289	Elevation
	151.503	144.561	138.348	133.663	94.181	56.774	33.351	17.705	13.594	7.901	5.851	0.000	Distance
(G) Gravel (S) Sand (R) Rock (M) Earth	CS84	M	M	M	M	M	S	S	S	S	S	CS84	REMARK

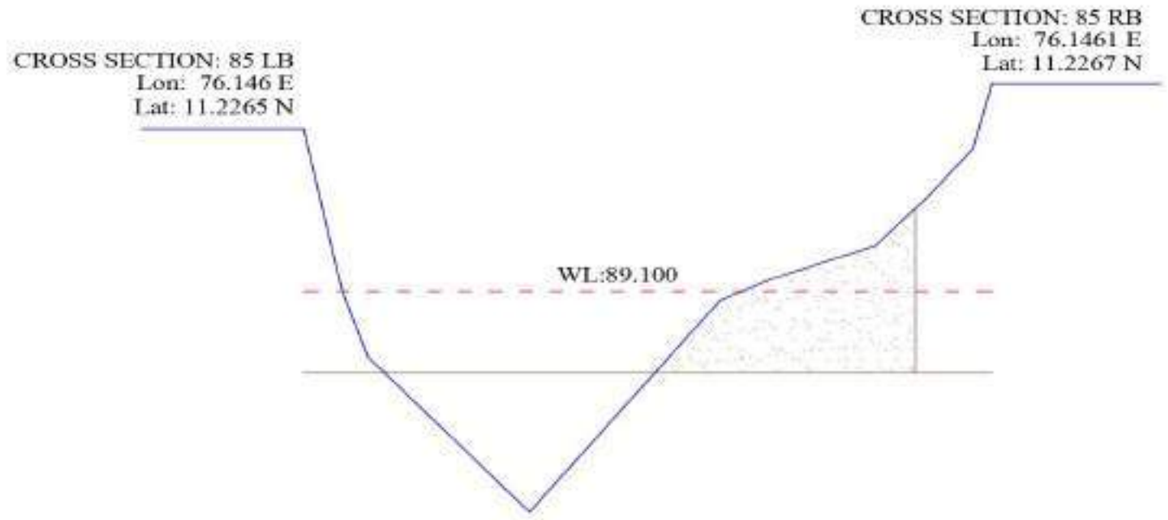
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	11°13'32.52'' N					
Longitude	76°7'12.06'' E	20.6	75.1	100	2060.00	7510.00

CHALIYAR RIVER

Cross Section 85

District : Malappuram

District : Malappuram



Elevation	94.158	92.571	91.394	90.206	89.374	88.871	83.709	87.487	88.961	89.658	92.223	93.063
Distance	0.000	3.716	12.684	22.926	43.846	53.497	90.992	122.776	127.410	129.039	133.912	135.455
REMARK	CS85	S	S	S	G	G	S	S	S	M	M	CS85

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

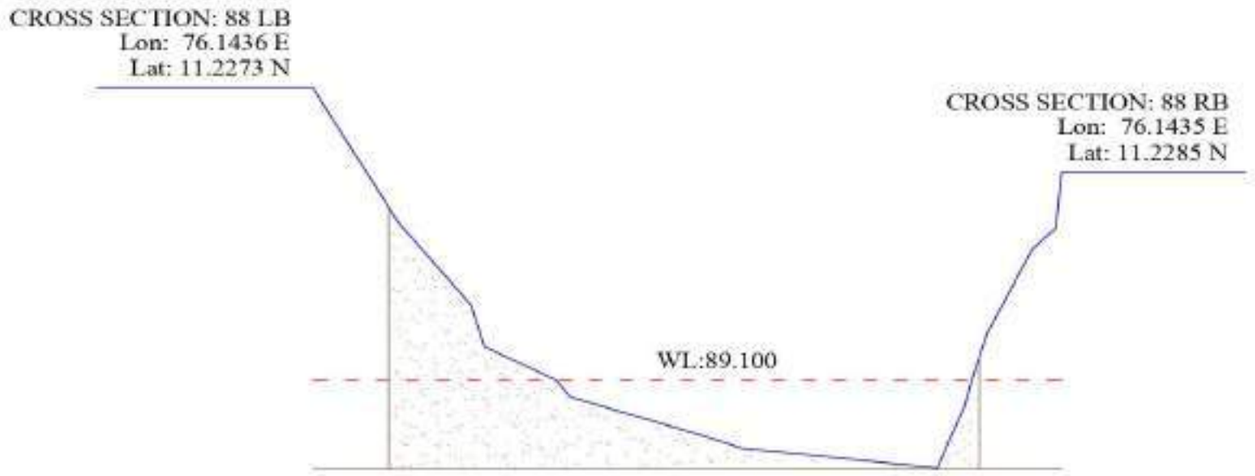
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	11°13'32.52'' N	27.5	87.8	100	2750.00	8780.00
Longitude	76°7'12.06'' E					

CHALIYAR RIVER

Cross Section 88

District : Malappuram

District : Malappuram



Elevation	95.700	94.782	92.649	90.784	89.848	89.110	88.718	87.902	87.567	87.122	88.508	89.093	90.152	92.053	92.520	93.787
Distance	147.370	142.340	130.460	116.148	113.587	99.541	96.707	72.032	63.042	24.518	19.083	17.683	14.698	5.766	1.194	0.000
REMARK	CS88	S	S	S	S	S	S	S	S	S	S	S	S	S	S	CS88

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

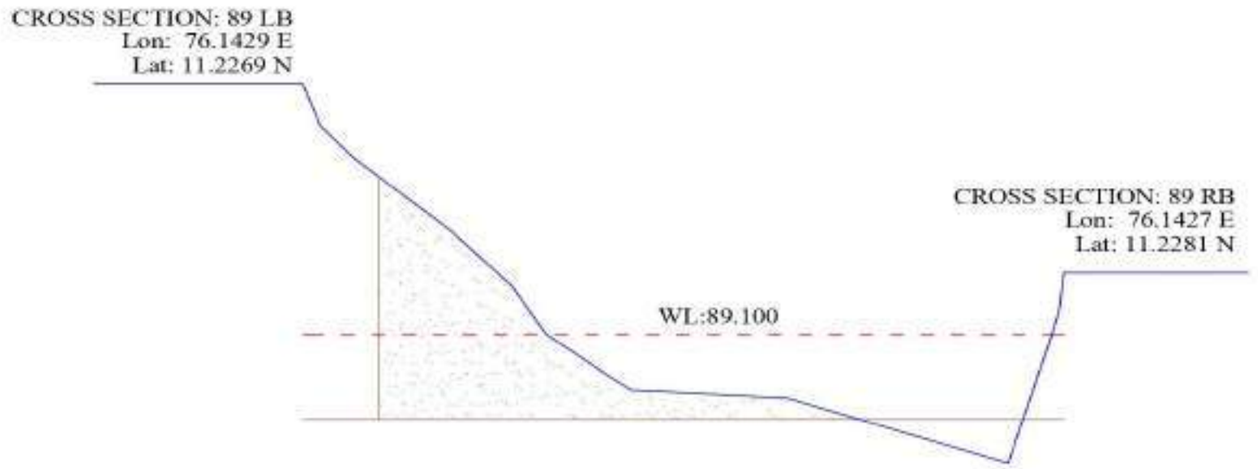
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
52.9	125.0	100	5290.00	12500.00

CHALIYAR RIVER

Cross Section 89

District : Malappuram

District : Malappuram



Elevation	95.045	94.060	93.309	91.571	90.251	89.123	88.103	87.801	87.607	86.063	89.075	89.710	90.566
Distance	149.760	146.364	139.922	120.608	108.545	101.838	89.262	85.224	54.383	10.981	2.416	0.865	0.000
REMARK	CS89	S	S	S	S	S	S	S	S	S	S	S	CS89

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

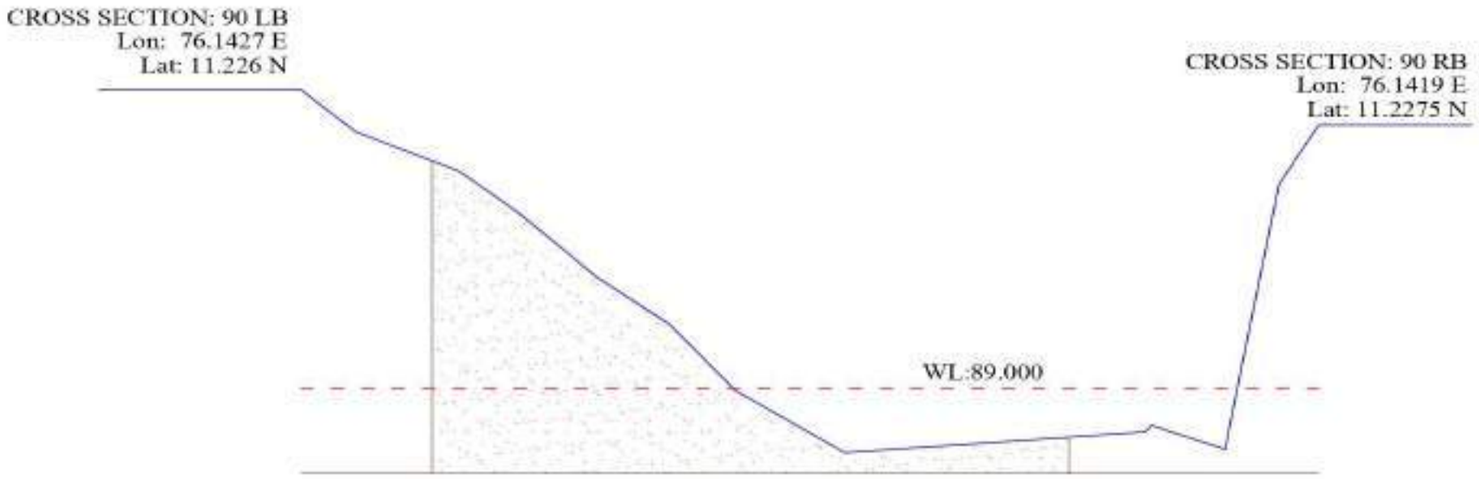
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
69.7	110.5	100	6970.00	11050.00

CHALIYAR RIVER

Cross Section 90

District : Malappuram

District : Malappuram



95.977	94.992	94.070	93.088	91.567	90.503	88.960	87.486	87.976	88.128	87.566	93.765	95.150	Elevation
200.229	189.471	169.094	157.357	141.853	127.971	114.986	93.245	34.186	32.932	18.432	7.848	0.000	Distance
CS90	S	S	S	S	S	S	S	R	R	R	S	CS90	REMARK

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	TBM A1 ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

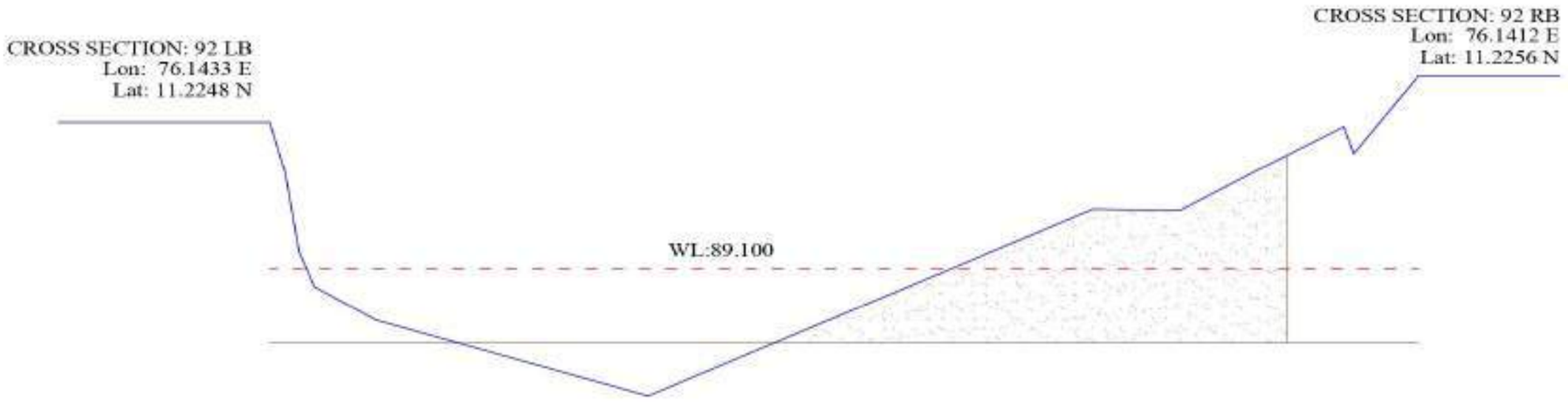
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
171.0	175.0	100	17100.00	17500.00

CHALIYAR RIVER

Cross Section 92

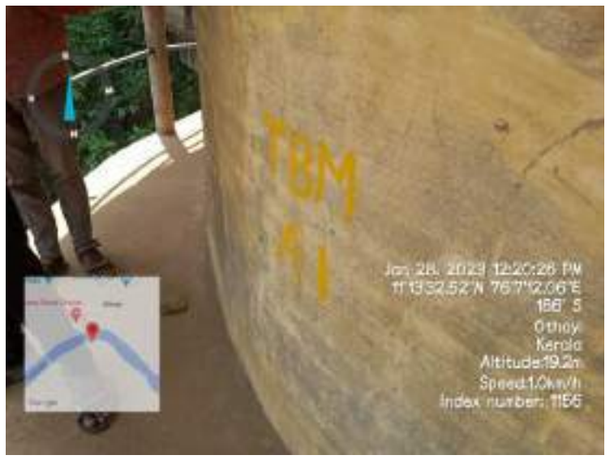
District : Malappuram

District : Malappuram



Elevation	93.053	91.690	89.552	88.609	87.716	85.667	90.701	90.663	91.899	92.928	92.197	94.307
Distance	258.926	255.448	252.320	248.804	235.046	173.676	73.467	53.893	33.990	16.896	14.644	0.000
REMARK	CS92	M	M	M	M	R	R	S	S	S	S	CS92

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth



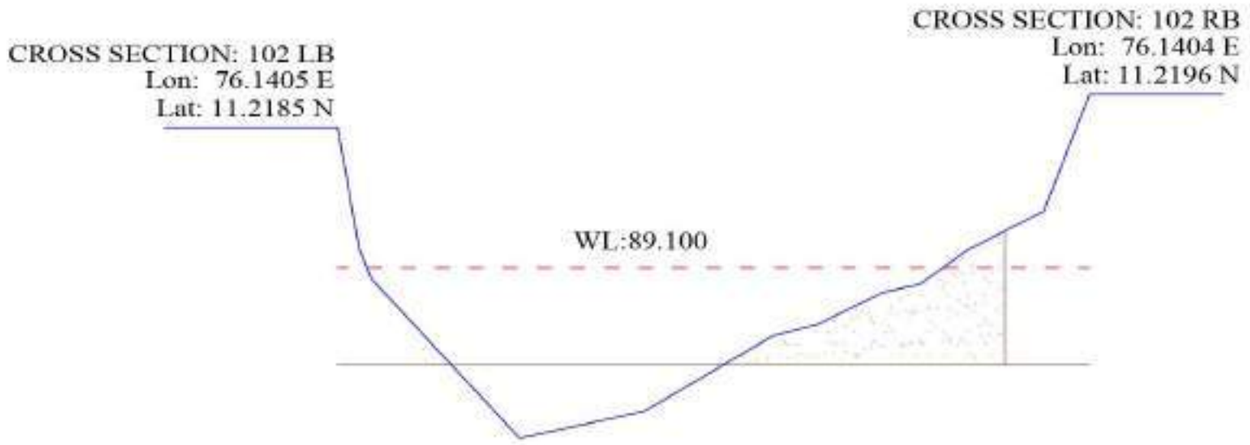
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	11°13'32.52'' N					
Longitude	76°7'12.06'' E	112.6	191.2	100	11260.00	19120.00

CHALIYAR RIVER

Cross Section 102

District : Malappuram

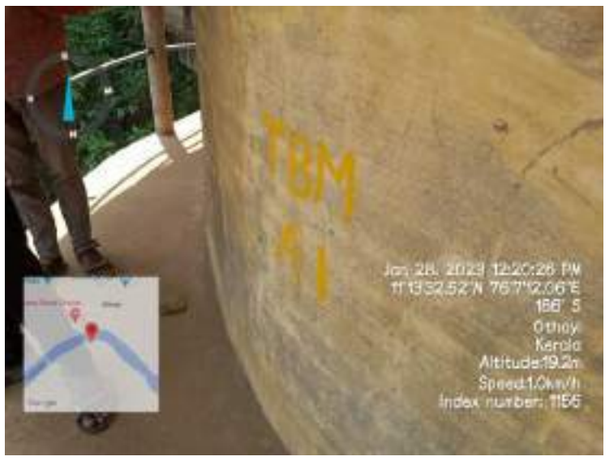
District : Malappuram



Elevation	91.981	89.476	88.859	85.604	86.146	87.699	87.934	88.595	88.762	89.463	90.260	92.656
Distance	133.184	129.260	127.096	100.904	78.881	56.107	48.229	36.545	29.959	21.612	8.143	0.000
REMARK	CS102	M	M	S	S	S	S	S	S	S	S	CS102

REMARK

(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth



Identification of TBM	
Note	TBM A1 ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

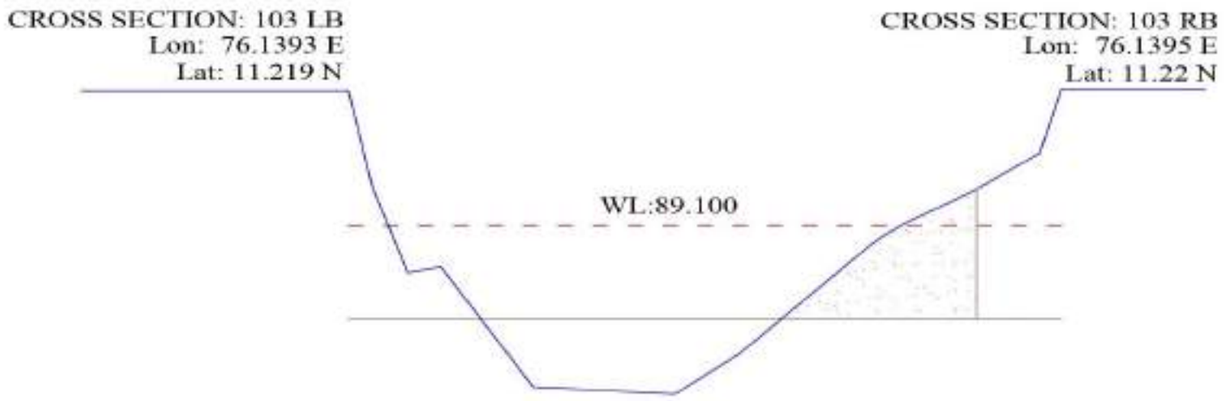
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
4.4	61.5	100	440.00	6150.00

CHALIYAR RIVER

Cross Section 103

District : Malappuram

District : Malappuram



Elevation	91.983	89.932	88.084	88.208	85.636	85.481	86.339	88.774	89.081	89.872	90.647	92.011
Distance	122.597	118.530	112.385	106.693	90.843	66.498	55.467	31.923	27.823	14.622	3.749	0.000
REMARK	CS103	M	M	R	S	S	S	S	S	S	S	CS103

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	11°13'32.52'' N	4.9	47.4	100	490.00	4740.00
Longitude	76°7'12.06'' E					

LR/11909/2023-LR(K1)

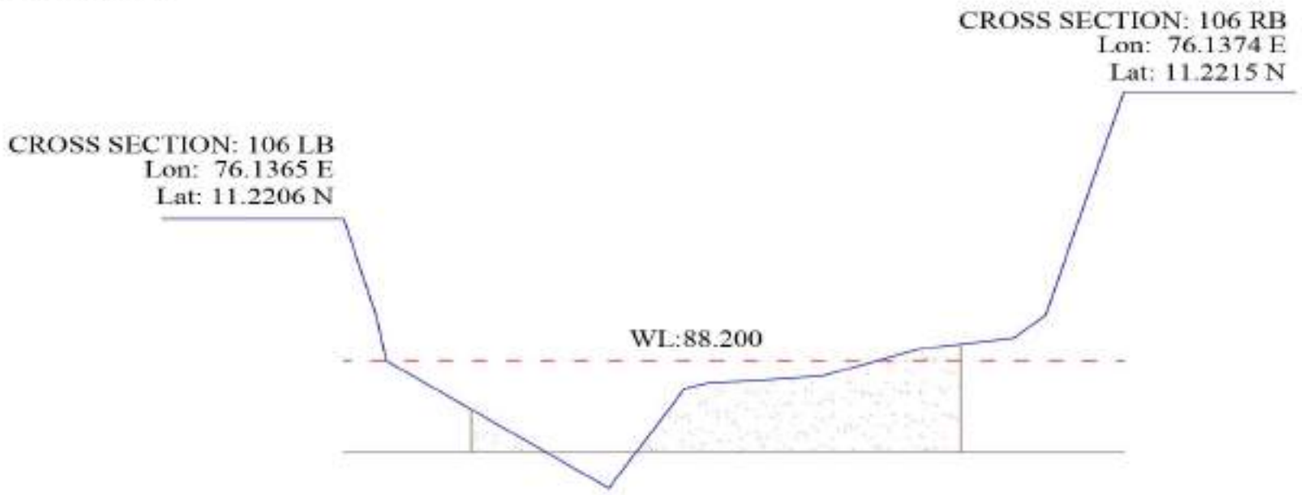
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 106

District : Malappuram

District : Malappuram



Elevation	91.296	89.169	88.195	85.412	87.587	87.714	87.765	87.866	88.458	88.689	89.191	94.067
Distance	138.178	132.340	130.583	91.184	77.747	73.387	64.646	53.382	35.955	19.401	13.850	0.000
REMARK	CS106	R	R	S	S	S	S	S	S	S	S	CS106

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
		Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE					
Latitude	11°13'32.52'' N					
Longitude	76°7'12.06'' E	3.1	97.4	100	310.00	9740.00

LR/11909/2023-LR(K1)

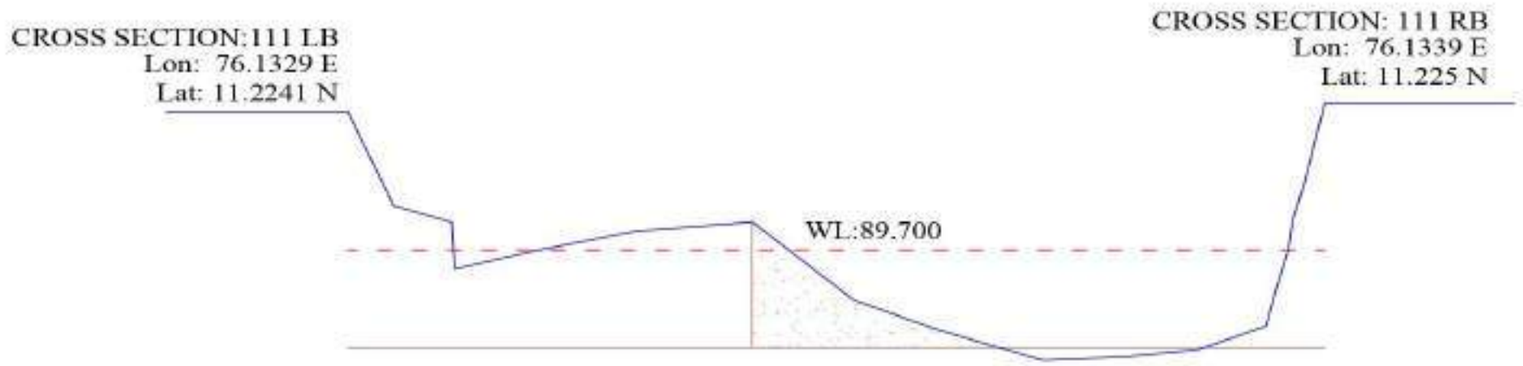
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 111

District : Malappuram

District : Malappuram



Elevation	Distance	REMARK
92.515	168.558	CS111
90.598	160.651	S
90.259	150.641	S
89.304	150.125	M
89.678	136.230	G
90.081	118.738	G
90.268	98.753	G
88.669	81.279	S
88.055	66.658	S
87.436	48.599	S
87.508	34.560	S
87.647	22.028	S
88.134	10.080	S
88.985	8.125	S
89.736	6.177	S
90.304	5.493	S
91.046	3.519	S
92.680	0.000	CS111

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

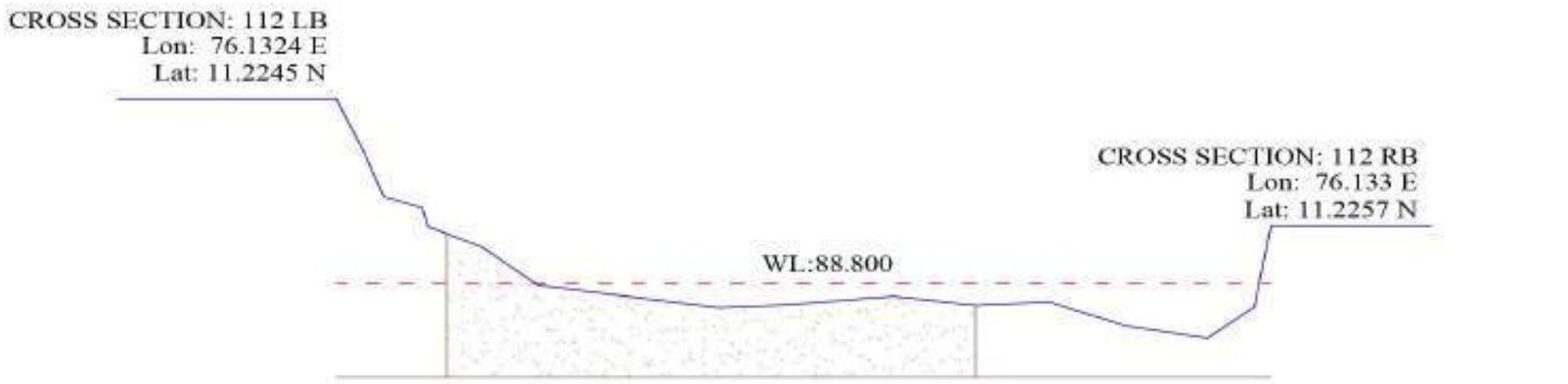
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	11°13'32.52'' N	1.7	40.6	100	170.00	4060.00
Longitude	76°7'12.06'' E					

CHALIYAR RIVER

Cross Section 112

District : Malappuram

District : Malappuram



Elevation	92.741	91.607	90.653	90.418	90.008	89.593	88.755	88.287	88.347	88.526	88.338	88.407	87.899	87.631	88.305	90.027
Distance	169.270	164.260	160.609	153.708	152.703	143.012	132.680	99.933	87.629	68.416	53.546	40.117	26.428	11.468	3.065	0.000
REMARK	CS112	S	S	S	S	S	S	S	S	S	S	G	G	M	M	CS112

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

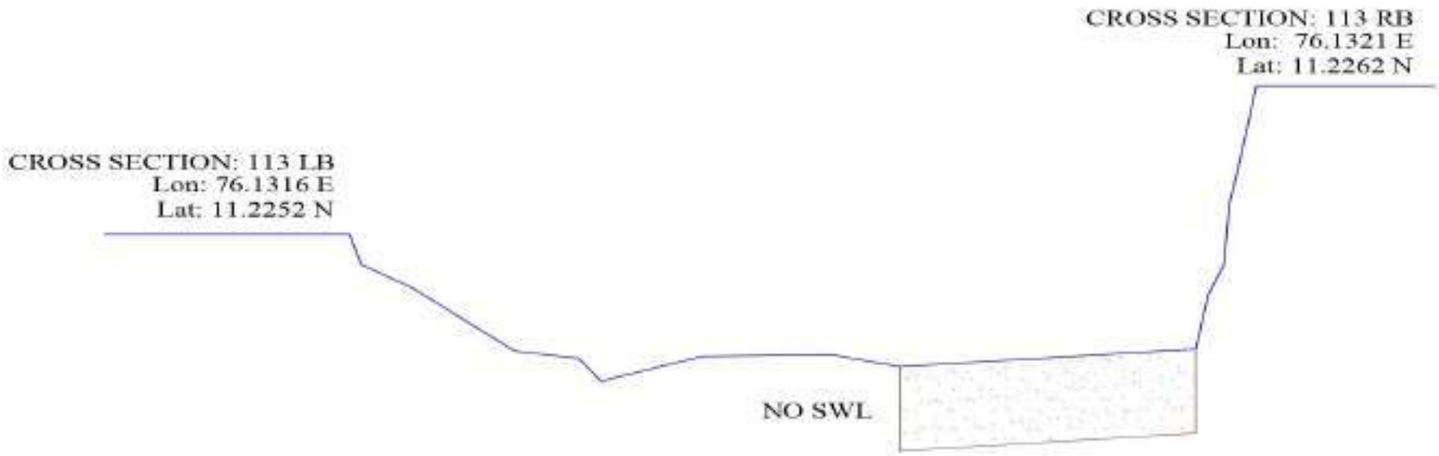
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
9.6	163.8	100	960.00	16380.00

CHALIYAR RIVER

Cross Section 113

District : Malappuram

District : Malappuram



Elevation	Distance	REMARK
91.710	160.547	CS113
90.981	158.496	G
90.450	149.729	G
88.925	131.296	G
88.749	119.982	G
88.206	115.982	G
88.799	98.140	G
88.840	75.290	G
88.550	63.155	G
88.972	10.689	S
90.260	8.534	S
90.970	5.768	S
92.430	4.787	S
93.271	3.272	S
95.245	0.000	CS_113

REMARK
(G) Gravel
(S) Sand
(R) Rock
(M) Earth

Identification of TBM	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

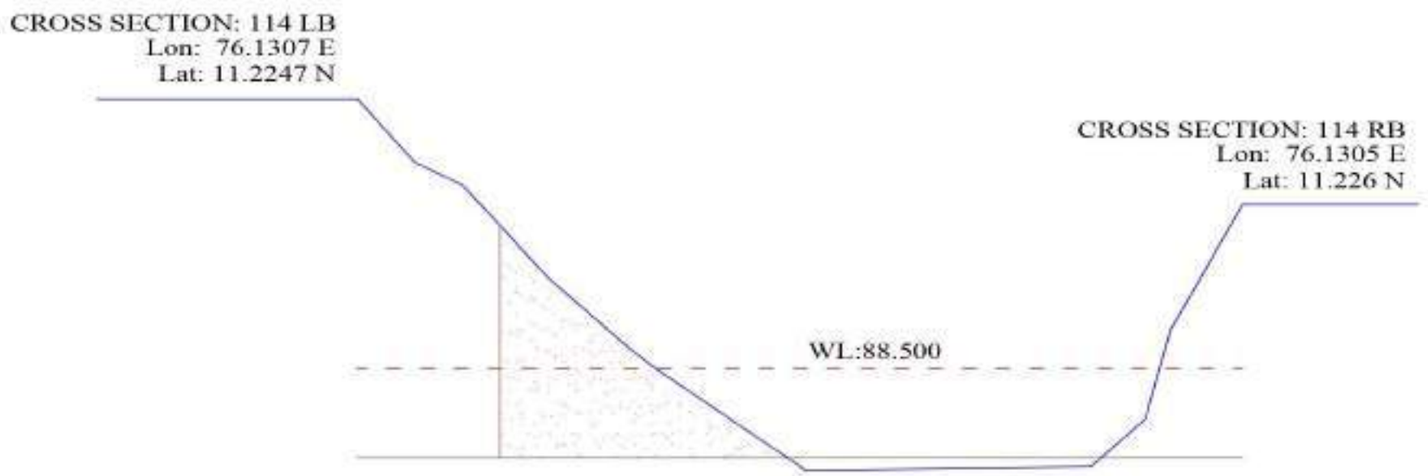
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
105.2	0.0	100	10520.00	0.00

CHALIYAR RIVER

Cross Section 114

District : Malappuram

District : Malappuram



Elevation	94.528	93.109	92.606	90.509	88.900	88.518	86.219	86.308	87.371	89.359	92.167
Distance	156.739	146.534	138.109	122.794	108.119	104.149	77.297	26.807	17.213	12.764	0.000
REMARK	CS114	S	S	S	S	S	S	S	M	M	CS114

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
41.2	78.5	100	4120.00	7850.00

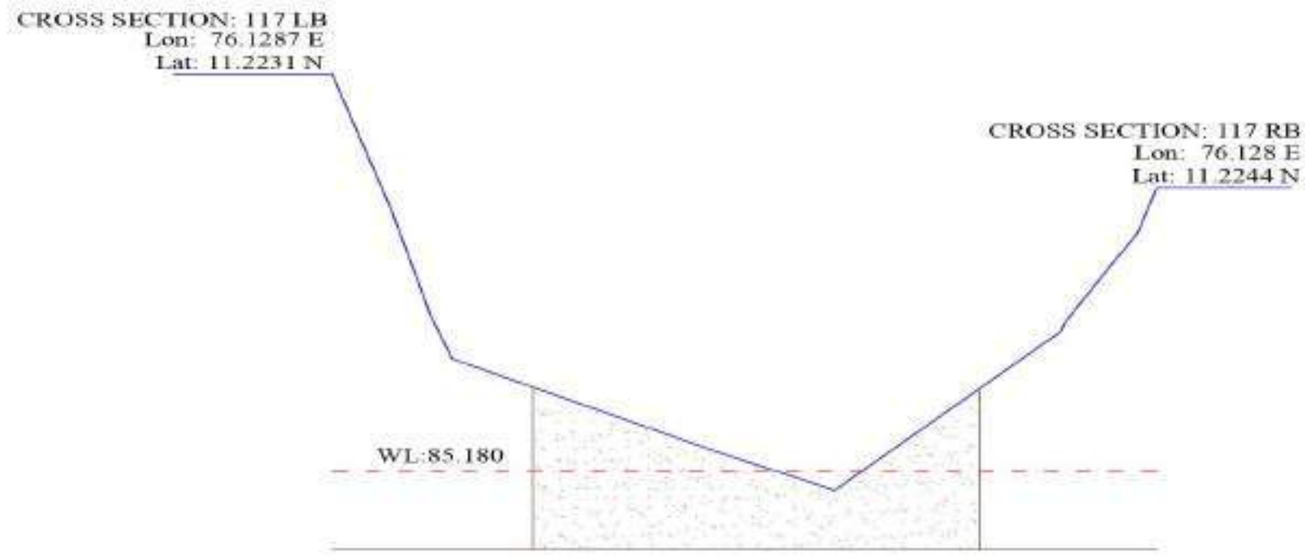
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 117

District : Malappuram

District : Malappuram



Elevation	95.272	91.854	89.126	88.029	85.672	84.690	88.717	88.973	90.299	91.204	92.365
Distance	153.289	142.353	134.941	130.930	81.906	59.843	17.881	16.923	9.165	3.636	0.000
REMARK	CS117	S	M	M	S	S	M	M	S	S	CS117

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	TBM A1 ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

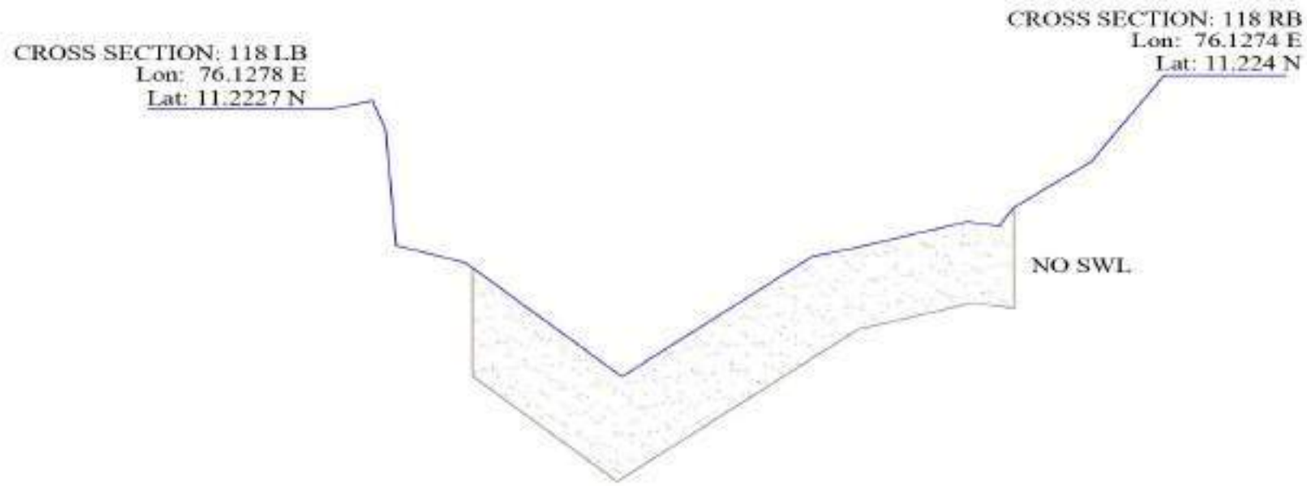
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
70.1	162.1	100	7010.00	16210.00

CHALIYAR RIVER

Cross Section 118

District : Malappuram

District : Malappuram



Elevation	91.576	91.797	91.045	88.130	87.695	84.807	87.853	88.055	88.739	88.625	89.089	90.256	92.438
Distance	164.412	155.804	153.140	151.109	137.471	106.676	69.196	61.333	38.678	32.482	29.594	14.322	0.000
REMARK	CS118	S	S	S	S	S	S	S	S	S	S	S	CS118

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
262.3	0.0	100	26230.00	0.00

LR/11909/2023-LR(K1)

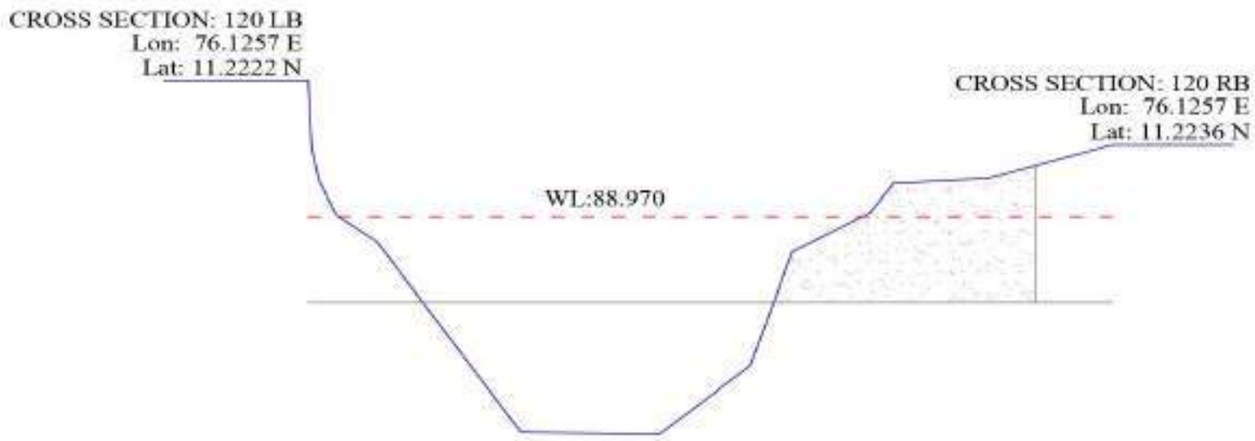
518256/2024/Tapal CLR

CHALIYAR RIVER

Cross Section 120

District : Malappuram

District : Malappuram



Elevation	92.122	90.570	89.816	89.050	88.968	88.383	83.946	83.904	85.493	88.152	89.056	89.733	89.854	90.481	90.637
Distance	158.136	157.460	156.077	152.880	152.171	144.656	116.322	88.993	71.177	62.877	47.573	43.044	24.328	4.625	0.000
REMARK	CS120	M	M	M	M	M	S	S	S	S	S	S	S	S	CS120

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

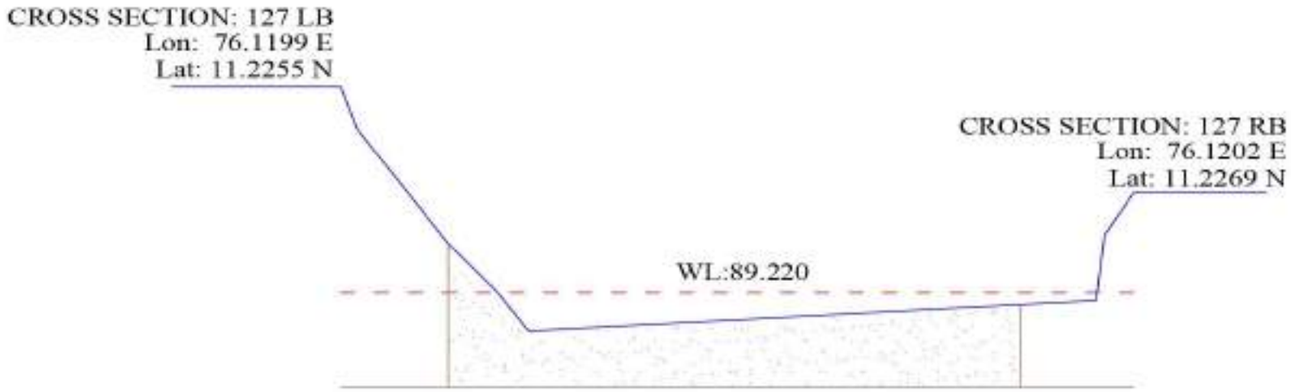
Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	11°13'32.52'' N	27.3	92.2	100	2730.00	9220.00
Longitude	76°7'12.06'' E					

CHALIYAR RIVER

Cross Section 127

District : Malappuram

District : Malappuram



Elevation	93.600	92.716	90.268	89.175	88.569	88.414	88.634	88.868	89.058	90.451	91.354
Distance	140.483	137.614	121.425	112.274	108.228	107.177	72.800	36.400	6.703	5.190	0.000
REMARK	CS127	M	S	S	S	S	S	S	S	M	CS127

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	TBM A1 ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

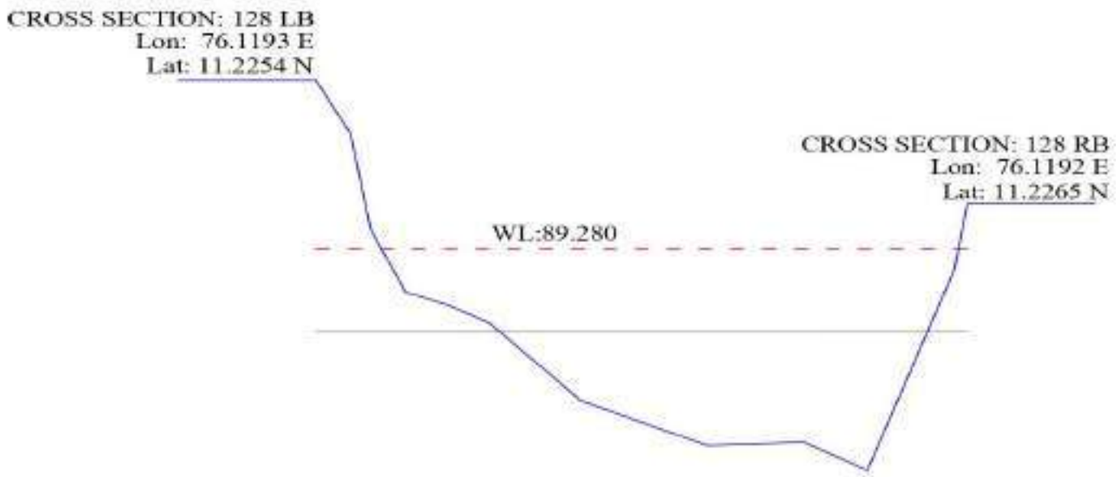
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
4.5	154.4	100	450.00	15440.00

CHALIYAR RIVER

Cross Section 128

District : Malappuram

District : Malappuram



CS128	M	M	M	M	M	M	M	M	M	R	CS128	REMARK
122.783	116.242	112.417	105.818	97.992	90.149	72.692	48.914	30.851	18.812	2.497	0.000	Distance
93.302	92.022	89.727	88.233	87.928	87.508	85.629	84.565	84.647	83.983	88.757	90.345	Elevation

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE
Latitude	11°13'32.52'' N
Longitude	76°7'12.06'' E

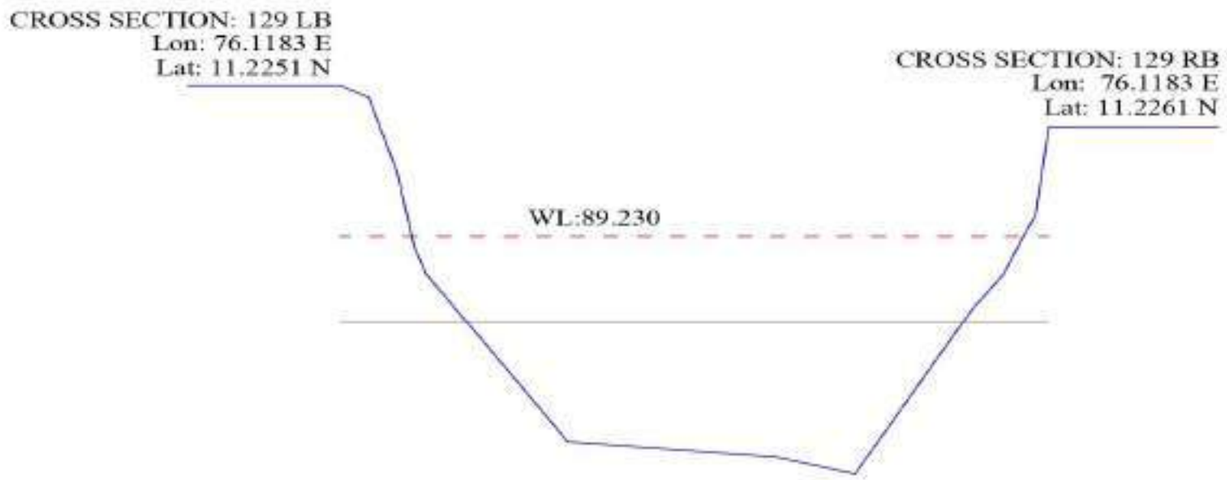
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
0.0	0.0	100	0.00	0.00

CHALIYAR RIVER

Cross Section 129

District : Malappuram

District : Malappuram



REMARK		Elevation	Distance	REMARK
		92.790	127.328	CS129
		92.517	122.169	S
		90.741	117.035	S
		88.985	113.962	S
		88.341	Lat.775	S
		84.402	86.406	S
		84.047	48.986	S
		83.653	34.797	S
		87.556	13.601	M
		88.346	8.143	M
		89.127	5.022	M
		89.744	2.416	M
		91.818	0.000	CS129

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM		Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Note	**TBM A1** ARIYANTHODIKA PUMB HOUSE	Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
Latitude	11°13'32.52'' N	0.0	0.0	100	0.00	0.00
Longitude	76°7'12.06'' E					

CHALIYAR RIVER

Cross Section 137

District : Malappuram

District : Malappuram

Elevation	92.269	89.493	88.966	88.653	87.992	87.873	87.927	88.023	88.102	88.153	87.992	88.251	88.810	89.290	90.276	90.542	92.297	93.986
Distance	180.236	161.811	158.920	157.856	156.478	38.773	37.781	36.301	34.563	32.757	29.825	27.997	25.057	22.462	21.193	12.082	5.899	0.000
REMARK	CS37	M	M	M	M	S	S	S	S	S	S	S	S	S	S	S	S	CS137

REMARK
(G) Gravel
(S) Sand
(R) Rock
(M) Earth

Identification of TBM	
Note	**TBM K1** PUTHALAM SAALIGRAM KADAVU, LB
Latitude	11°13'30.776'' N
Longitude	76°3'25.939'' E

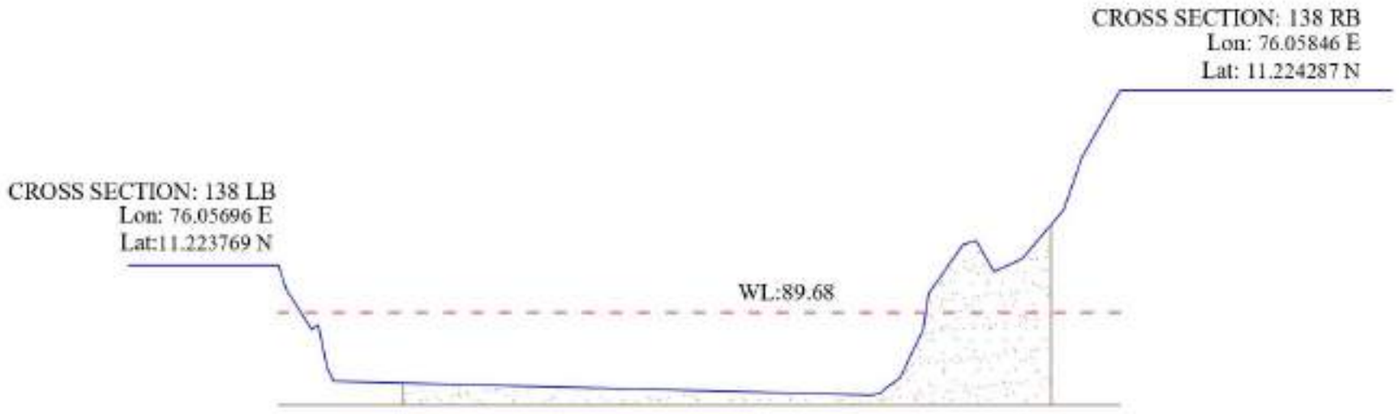
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
4.8	57.2	100	480.00	5720.00

CHALIYAR RIVER

Cross Section 138

District : Malappuram

District : Malappuram



REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

CS138	182.209	90.700
M	180.303	90.160
M	174.934	89.314
M	173.538	89.415
S	171.574	88.469
M	170.182	88.191
S	53.769	87.891
S	52.046	87.923
S	50.818	88.026
S	47.477	88.276
S	44.958	88.835
S	42.677	89.291
S	41.420	90.105
S	33.946	91.148
S	31.173	91.235
S	27.372	90.564
S	21.168	90.842
S	12.293	91.901
S	8.303	93.023
CS138	0.000	94.490
REMARK	Distance	Elevation

Identification of TBM	
Note	TBM K1 PUTHALAM SAALIGRAM KADAVU, LB
Latitude	11°13'30.776'' N
Longitude	76°3'25.939'' E

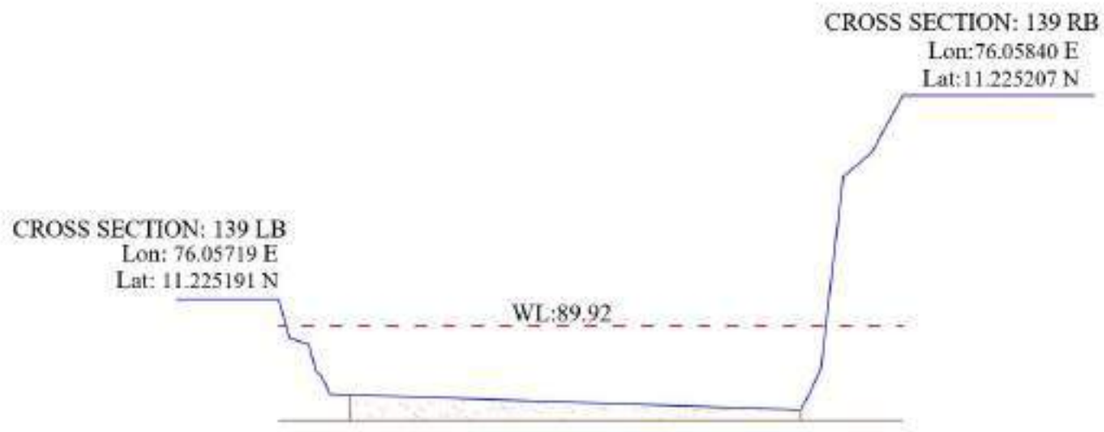
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
31.8	97.5	100	3180.00	9750.00

CHALIYAR RIVER

Cross Section 139

District : Malappuram

District : Malappuram



Elevation	Distance	REMARK
90.490	132.188	CS139
89.662	129.893	S
89.534	125.806	S
88.955	124.235	S
88.879	123.372	S
88.723	122.522	S
88.479	121.424	S
88.147	21.645	M
88.530	19.595	M
89.024	17.344	M
93.086	12.659	S
93.604	6.543	S
94.805	0.000	CS139

REMARK	
(G)	Gravel
(S)	Sand
(R)	Rock
(M)	Earth

Identification of TBM	
Note	TBM K1 PUTHALAM SAALIGRAM KADAVU, LB
Latitude	11°13'30.776'' N
Longitude	76°3'25.939'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
36.8	0.0	100	3680.00	0.00

KADALUNDI RIVER

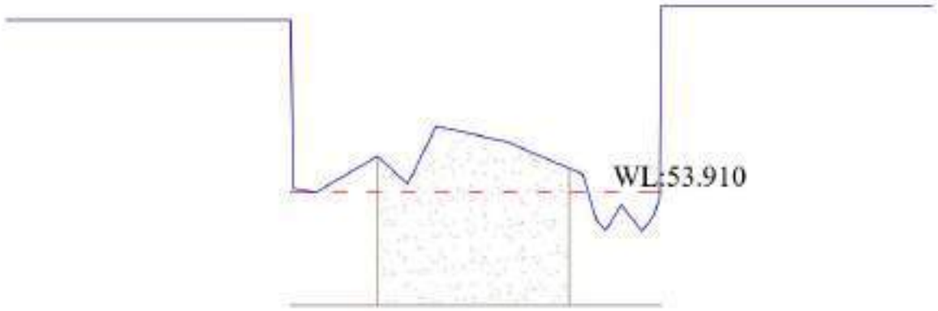
Cross Section 93

District : Malappuram

District : Malappuram

CRSS SECTION: 93 LB
Lon: 76.148575 E
Lat: 11.089527 N

CRSS SECTION: 93 RB
Lon: 76.14842 E
Lat: 11.090082 N



Elevation	56.959	53.985	53.914	54.554	54.059	55.087	54.807	54.237	53.407	53.241	53.694	53.222	53.518	53.812	57.208
Distance	0.000	0.484	4.490	15.372	20.656	25.721	38.141	51.592	54.073	55.670	58.413	62.116	64.250	65.144	65.482
REMARK	CS93	RB	S	S	S	S	S	S	S	S	S	S	M	RB	CS93

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 1 MARKED ON THE ROCK CHITTETHPAARA LB SIDE
Latitude	11°05'23.9'' N
Longitude	76°09'01.6'' E

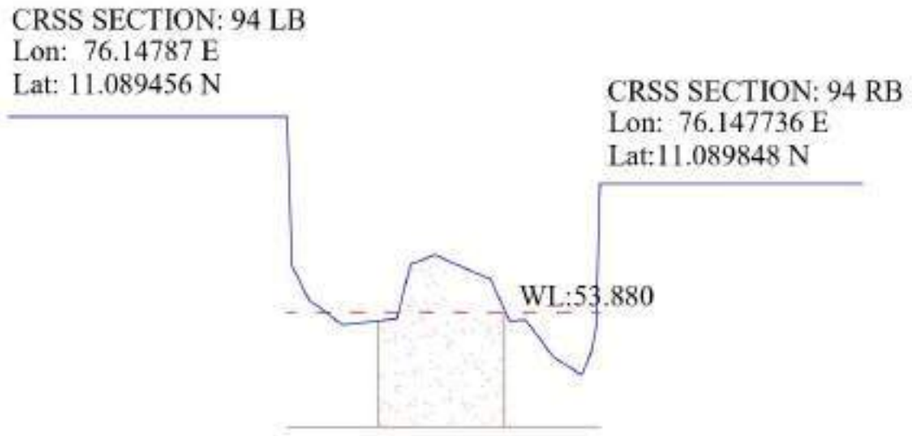
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
25.6	67.7	80	2048.00	5416.00

KADALUNDI RIVER

Cross Section 94

District : Malappuram

District : Malappuram



Elevation	57.283	54.687	54.090	53.661	53.768	54.717	54.880	54.446	53.732	53.747	53.098	52.786	53.137	53.596	56.120
Distance	0.000	0.910	3.868	9.704	19.185	21.540	25.823	35.554	38.798	41.575	46.470	51.373	52.937	53.892	54.611
REMARK	CS94LB	RB	S	S	S	S	S	S	S	S	S	S	M	RB	CS94RB

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 1 MARKED ON THE ROCK CHITTETHPAARA LB SIDE
Latitude	11°05'23.9'' N
Longitude	76°09'01.6'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
13.1	43.6	80	1048.00	3488.00

LR/11909/2023-LR(K1)

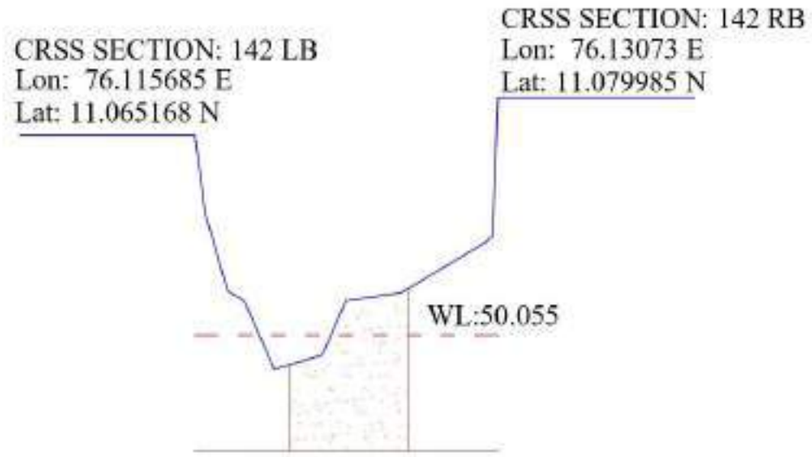
518256/2024/Tapal CLR

KADALUNDI RIVER

Cross Section 142

District : Malappuram

District : Malappuram



Elevation	53.601	52.227	50.838	50.658	49.446	49.703	50.665	50.806	51.687	51.810	54.274
Distance	0.000	1.819	5.811	8.801	14.112	22.615	26.820	36.589	51.387	52.855	53.747
REMARK	CS142	RB	S	S	S	S	S	S	S	RB	CS142

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 1 KODUGAYAM KADAVU MARKED ON ROCK
Latitude	11°04'13.4" N
Longitude	76°06'59.3" E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
8.4	40.4	80	672.00	3232.00

KADALUNDI RIVER

Cross Section 143

District : Malappuram

District : Malappuram

Elevation	52.968	50.024	49.538	50.118	50.164	49.908	51.236	52.050	52.382
Distance	0.000	1.851	4.299	9.749	20.869	35.143	43.335	44.929	50.711
REMARK	CS143	RB	S	S	S	S	S	L	CS143

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 1 KODUGAYAM KADAVU MARKED ON ROCK
Latitude	11°04'13.4" N
Longitude	76°06'59.3" E

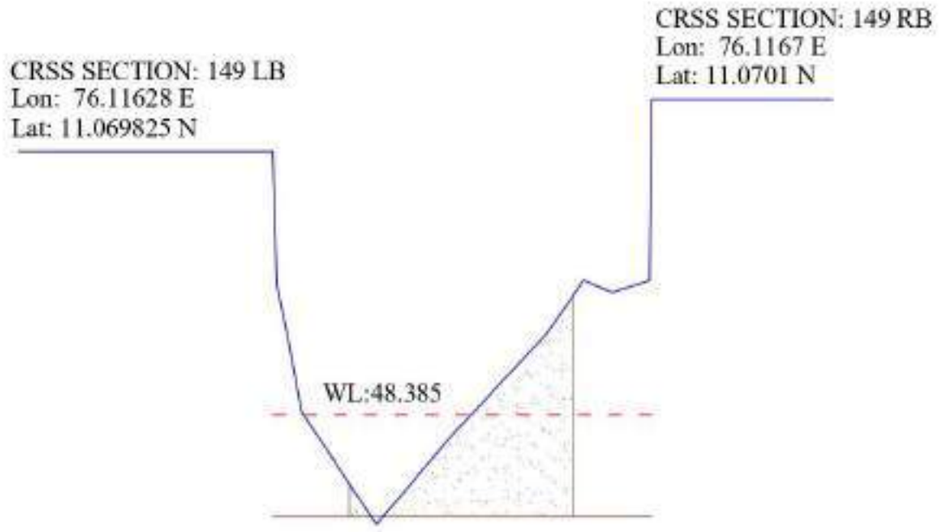
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
1.5	26.1	80	120.00	2088.00

KADALUNDI RIVER

Cross Section 149

District : Malappuram

District : Malappuram



Elevation	53.568	50.967	49.880	48.448	46.233	48.073	48.214	49.978	51.034	50.800	51.030	54.597
Distance	0.000	0.771	2.999	5.622	20.344	35.951	37.391	53.766	61.126	66.715	74.034	74.479
REMARK	CS149	S	S	S	S	S	S	S	S	S	RB	CS149

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 1 KODUGAYAM KADAVU MARKED ON ROCK
Latitude	11°04'13.4" N
Longitude	76°06'59.3" E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
22.1	59.1	80	1768.00	4728.00

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

KADALUNDI RIVER

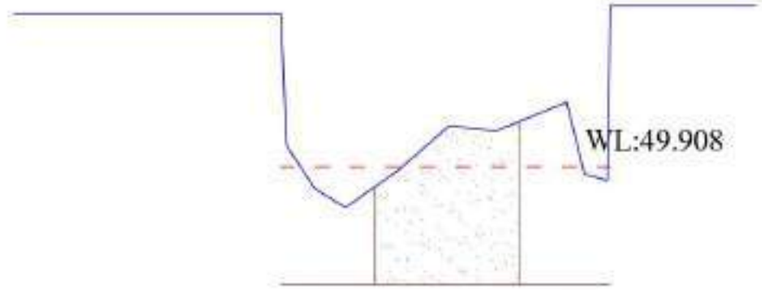
Cross Section 155

District : Malappuram

District : Malappuram

CRSS SECTION: 155 LB
Lon: 0.00.00 E
Lat: 0.00.00 N

CRSS SECTION: 155 RB
Lon: 76.113266 E
Lat: 11.067991 N



Elevation	52.511	50.273	49.531	49.216	49.836	50.607	50.516	51.004	49.780	49.677	52.645
Distance	0.000	0.967	5.808	10.979	19.812	28.635	36.574	48.580	51.594	55.503	56.012
REMARK	CS155	RB	S	S	S	S	S	S	S	RB	CS155

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 1 KODUGAYAM KADAVU MARKED ON ROCK
Latitude	11°04'13.4" N
Longitude	76°06'59.3" E

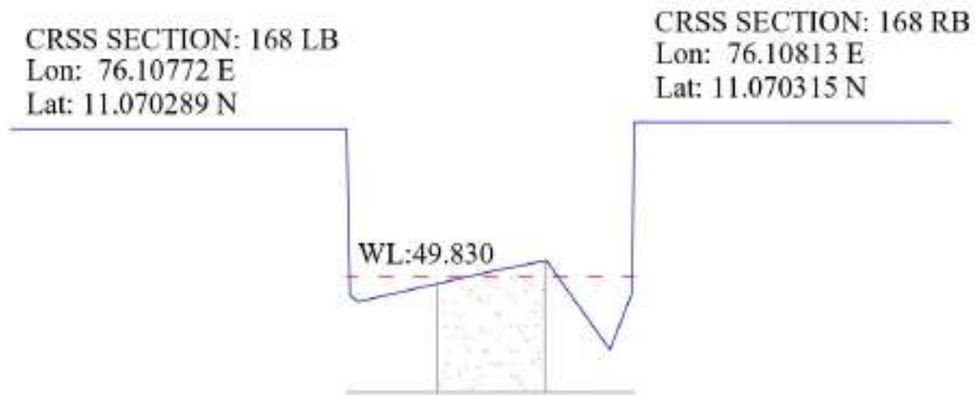
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
10.6	48.2	80	848.00	3856.00

KADALUNDI RIVER

Cross Section 168

District : Malappuram

District : Malappuram



Elevation	52.371	49.504	49.395	49.931	50.104	48.571	49.541	52.495
Distance	0.000	0.600	2.006	25.590	34.431	45.428	49.209	49.635
REMARK	CS168	RB	S	S	S	S	RB	CS168

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	**TBM 2** MARKED ON THE ROCK
Latitude	11°03'57.1''N
Longitude	76°06'39.0'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
1.8	36.8	80	144.00	2944.00

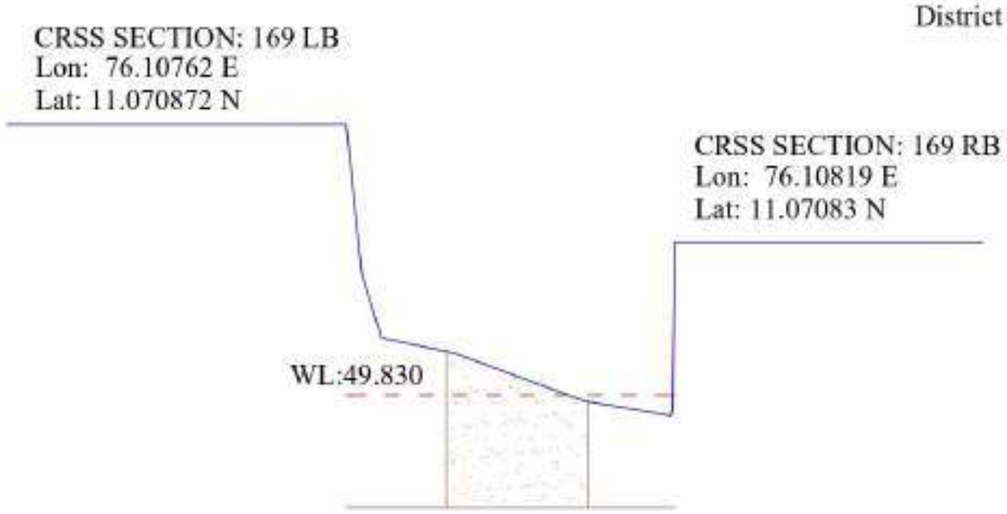
LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

KADALUNDI RIVER

Cross Section 169

District : Malappuram



District : Malappuram

Elevation	54.641	51.982	50.850	50.586	49.726	49.469	49.566	52.556
Distance	0.000	2.747	6.260	19.002	42.361	57.708	57.945	58.332
REMARK	CS169	RB	S	S	S	S	RB	CS169

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	**TBM 2** MARKED ON THE ROCK
Latitude	11°03'57.1''N
Longitude	76°06'39.0'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
8.7	50.1	80	696.00	4008.00

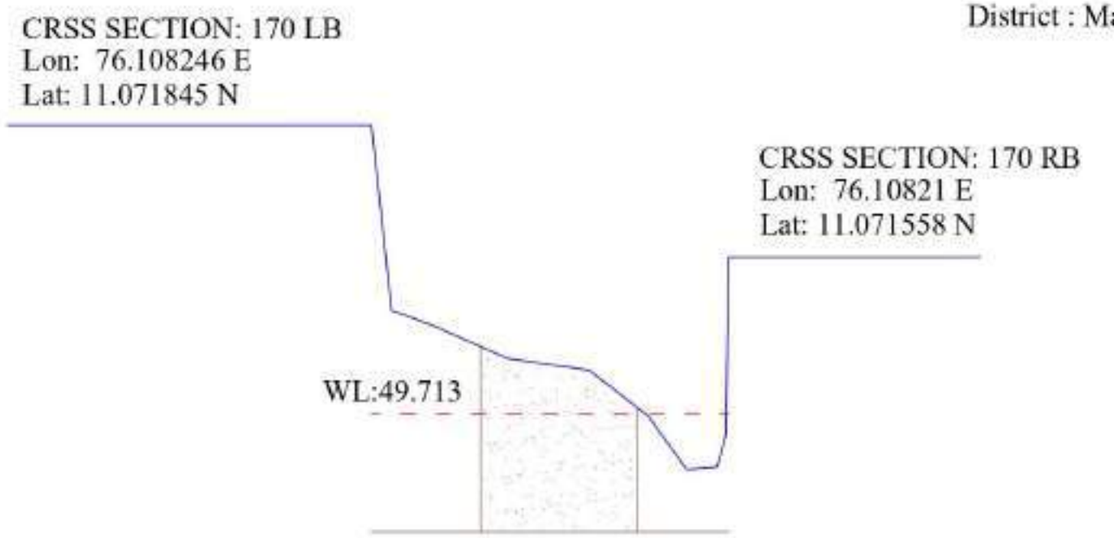
LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

KADALUNDI RIVER

Cross Section 170

District : Malappuram



District : Malappuram

Elevation	54.587	51.455	51.188	50.646	50.441	49.670	48.770	48.811	49.345	52.352
Distance	0.000	3.371	10.599	22.890	36.783	46.726	53.213	58.338	59.867	60.296
REMARK	CS170	RB	S	S	S	S	S	S	RB	CS170

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	**TBM 2** MARKED ON THE ROCK
Latitude	11°03'57.1''N
Longitude	76°06'39.0'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
19.5	52.9	80	1560.00	4232.00

LR/11909/2023-LR(K1)

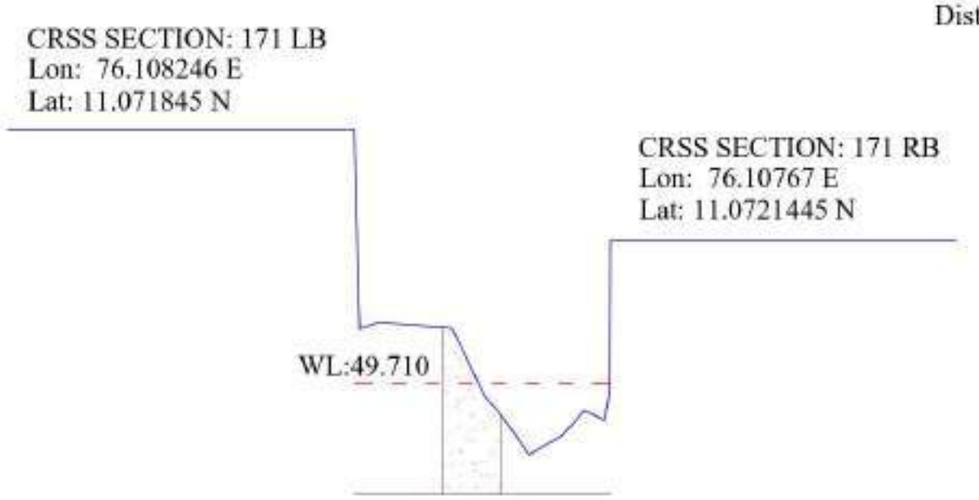
518256/2024/Tapal CLR

KADALUNDI RIVER

Cross Section 171

District : Malappuram

District : Malappuram



Elevation	54.292	50.692	50.812	50.703	49.509	49.078	48.422	48.777	49.215	49.047	49.566	52.281
Distance	0.000	0.930	4.441	17.626	23.314	26.909	31.537	37.636	41.436	45.162	46.024	46.145
REMARK	CS171	RB	S	S	S	S	S	S	R	R	RB	CS171

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 2 MARKED ON THE ROCK
Latitude	11°03'57.1''N
Longitude	76°06'39.0'' E

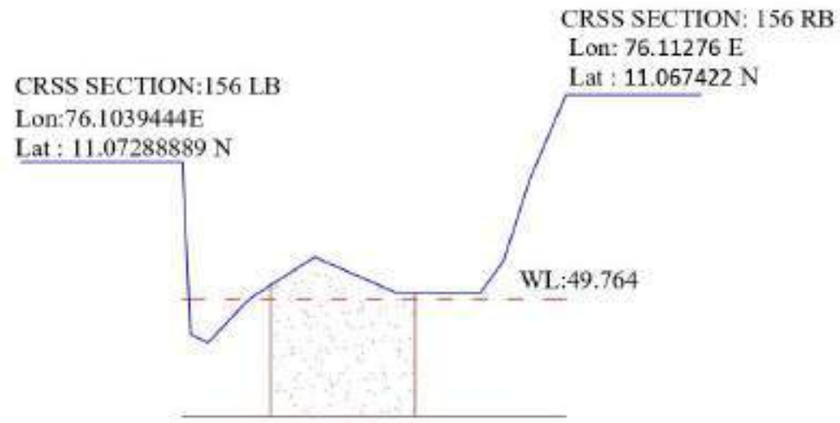
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
4.0	19.7	80	320.00	1576.00

KADALUNDI RIVER

Cross Section 156

District : Malappuram

District : Malappuram



Elevation	52.086	49.163	49.016	49.764	50.471	49.859	49.877	50.407	51.795	53.217
Distance	0.000	1.353	4.275	11.414	22.400	36.385	50.519	54.503	59.000	65.054
REMARK	CS156	RB	S	S	S	S	S	R	R	CS156

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	**TBM 1** MARKED ON THE ROCK RB SIDE IRUMBADI KADAVU
Latitude	11°04'23.1" N
Longitude	76°06'12.5" E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
9.3	49.0	80	744.00	3920.00

LR/11909/2023-LR(K1)

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KADALUNDI RIVER

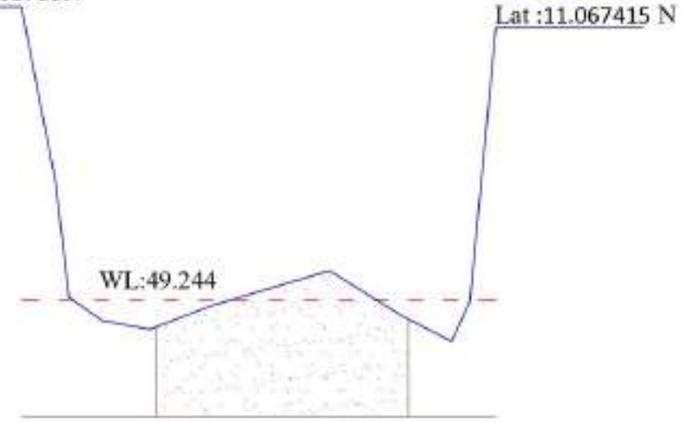
Cross Section 164

District : Malappuram

CRSS SECTION: 164LB
Lon: 76.10312 E
Lat : 11.068760N

CRSS SECTION: 164RB
Lon: 76.10863 E
Lat :11.067415 N

District : Malappuram



Elevation	54.287	51.278	49.295	48.894	48.744	49.149	49.750	48.962	48.534	49.223	53.921
Distance	0.000	5.865	8.187	13.830	22.021	32.661	52.914	65.560	73.869	77.026	81.499
REMARK	CS164	L	RB	S	S	S	S	S	S	RB	CS164

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 2 MARKED ON THE STEP PANAMPATTA KADAVU LB SIDE
Latitude	11°04'08.2'' N
Longitude	76°06'14.7'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
6.3	82.9	80	504.00	6632.00

LR/11909/2023-LR(K1)

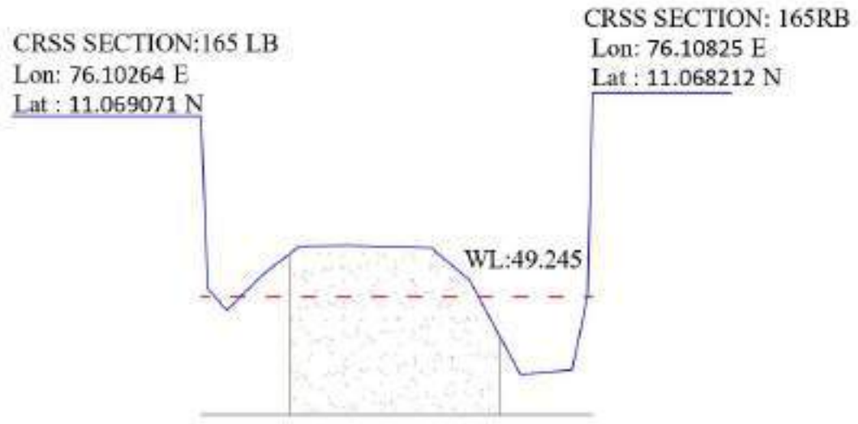
518256/2024/Tapal CLR

KADALUNDI RIVER

Cross Section 165

District : Malappuram

District : Malappuram



Elevation	52.318	49.391	49.019	49.637	50.105	50.120	50.074	49.538	47.929	48.008	49.258	52.705
Distance	0.000	1.129	4.358	10.630	16.721	25.021	39.037	45.469	54.194	62.973	65.593	66.443
REMARK	CS165	RB	S	S	S	S	S	S	S	S	RB	CS165

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 2 MARKED ON THE STEP PANAMPATTA KADAVU LB SIDE
Latitude	11°04'08.2'' N
Longitude	76°06'14.7'' E

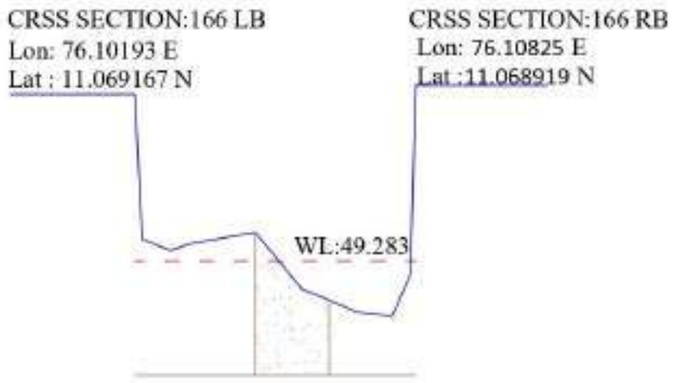
Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
24.3	70.0	80	1944.00	5600.00

KADALUNDI RIVER

Cross Section 166

District : Malappuram

District : Malappuram



Elevation	52.187	49.663	49.465	49.583	49.779	48.797	48.389	48.317	49.045	52.339
Distance	0.000	1.224	6.204	9.579	20.991	29.025	38.756	44.856	48.018	48.933
REMARK	CS166	RB	CLAYA	S	S	S	S	S	RB	CS166

REMARK	
Gavel	(G)
Sand	(S)
Rck	(R)
Earth	(M)

Identification of TBM	
Note	TBM 2 MARKED ON THE STEP PANAMPATTA KADAVU LB SIDE
Latitude	11°04'08.2'' N
Longitude	76°06'14.7'' E

Area of Cross Section (m^2)		Zone of Influence (m)	Sand Volume (m^3)	
Above water level (A1)	Below water level (A2)		Volume (V1)	Volume (V2)
1.0	22.0	80	80.00	1760.00

ANNEXURE-III

Sub-divisional committee (SDC) inspection report

INSTITUTE OF LAND AND DISASTER MANAGEMENT
(An Autonomous body constituted by Revenue Department, Govt of Kerala)
P.T.P Nagar P.O, Vettamukku, Thiruvananthapuram– 38
E-mail – ildm.revenue@gmail.com, Website - www.ildm.kerala.gov.in

ILDM/3009/2022/E1 27.09.2023

From

Executive Director
Institute of Land and Disaster Management
Thiruvananthapuram

To

Director
CSIR-NIIST
Thiruvananthapuram

Sir,

Sub: Submission of Sub-Divisional Committee (SDC) Inspection Report-Annexure V-VII-Tirur-reg

Ref: 1. G.O (Rt) No.694/2022/RD dated 14.02.2022
2. M.O.U signed between Commissioner of Land Revenue and CSIR-NIIST on 20.04.2022
3. Letter No. RDOTIR/1581/2023-L1 dated 27.09.2023

Kind attention is invited to the reference cited above. The Sub-Divisional Committee (SDC) Inspection Report of potential sand mining sites included in the draft District Survey Report (DSR) of Malappuram within Tirur Revenue Division in Annexure V, VI and VII of EMGSM-2020 submitted by Sub-Collector Tirur as per the reference 3rd cited is forwarded herewith for necessary revision of DSR based on the provisions of Enforcement and Monitoring Guidelines on Sand Mining-2020 and EIA Notification-2006.

Yours faithfully

Executive Director

Copy to:
1) Land Revenue Commissioner (C/L)
2) District Collector, Malappuram

LR/11909/2023-LR(K1)

518256/2024/Tapal CLR

RDOTIR/1581/2023-L1

I/295007/2023

ഭരണഭാഷ-മാതൃഭാഷ

സബ് കളക്ടറുടെ കാര്യാലയം, മിനി സിവിൽ സ്റ്റേഷന് സമീപം തിരൂർ -676101

ഫോൺ 0494-2421200, ഇ മെയിൽ- rdotirmlp.ker@nic.in

തിയതി: 27-09-2023

പ്രേഷകൻ

സബ് കളക്ടർ

തിരൂർ

സ്വീകർത്താവ്

1) ഡയറക്ടർ,
ILDM, തിരുവനന്തപുരം.

2) ഡയറക്ടർ, CSIR- National Institute for Interdisciplinary Science and Technology (NIIST), തിരുവനന്തപുരം.

സർ,

വിഷയം :- മണൽവാരുന്നതിനുള്ള പാരിസ്ഥിതികാനുമതി ലഭ്യമാക്കുന്നത് - സബ് ഡിവിഷണൽ കമ്മിറ്റി സ്ഥലപരിശോധന നടത്തിയത് - Annexure V,VI,VII സമർപ്പിക്കുന്നത് - സംബന്ധിച്ച്.

സൂചന :- 1) മലപ്പുറം ജില്ലാ കളക്ടറുടെ 12.06.2023 ലെ DCMPM/6278/2022-DM4 നം നടപടിക്രമം.

2) ഈ കാര്യാലയത്തിലെ 14.08.2023 ലെ ഇതേ നമ്പർ കത്ത്.

.....

സൂചനയിലേക്ക് സാദരം ശ്രദ്ധ ക്ഷണിക്കുന്നു. നിയമാനുസൃത മണൽ ഖനനത്തിന് പാരിസ്ഥിതികാനുമതി നേടിയെടുക്കുന്നതിന്റെ ഭാഗമായി തിരൂർ സബ് ഡിവിഷണൽ കമ്മിറ്റി 21.07.2023, 29.07.2023, 01.08.2023 തിയതികളിൽ സംയുക്തസ്ഥലപരിശോധന നടത്തി തയ്യാറാക്കിയ റിപ്പോർട്ട് സൂചന (2) പ്രകാരം സമർപ്പിച്ചിരുന്നതാണ്. ടി റിപ്പോർട്ടോന്നിച്ച് Annexure II, III, IV എന്നിവ മാത്രമാണ് ഉള്ളടക്കം ചെയ്തിട്ടുണ്ടായിരുന്നത്. ആയതു പ്രകാരമുള്ള നിർദ്ദേശിച്ചതനുസരിച്ച് Annexure V,VI,VII എന്നിവ ഇതു സഹിതം സമർപ്പിക്കുന്നു.

വിശ്വാസപൂർവ്വം

സബ് കളക്ടർ

ഉള്ളടക്കം : Annexure V,VI,VII.

Signed by
Sachin Kumar Yadav I A S
Date: 27-09-2023 14:04:18

LR/11909/2023-LR(K1)

RDOTIR/1581/2023-L1

518256/2024/Tapal CLR

I/295007/2023

Annexure-V

Final List of Potential Mining Leases (existing & proposed)

Rivers

River Details	Lease Details	Area (in Ha)	Distance (in km) from PA/ BR/WC	Distance from Forest Area (in km)	Mining leases within 500 meters (if yes, cluster area)	Total excavation in (MT/Yr) (Mine depth max as 3 m)	Mineral to be mined (Sand/Bajri/ RBM etc.)	Existing/ proposed
Bhararathapuzha	S1	7.0777		25.14			Sand	proposed
Bhararathapuzha	S2	3.0855		24.75			Sand	proposed
Bhararathapuzha	S3	10.094		25.09			Sand	proposed
Bhararathapuzha	S4	41.9958		26.48			Sand	proposed
Bhararathapuzha	S5	7.593		26.60			Sand	proposed
Bhararathapuzha	S6	12.2385		27.39			Sand	proposed
Bhararathapuzha	S7	40.2513		27.04			Sand	proposed
Bhararathapuzha	S8*	34.2962		27.99			Sand	proposed
Bhararathapuzha	S9	47.9284		26.11			Sand	proposed
Bhararathapuzha	S10	165.4893		28.32			Sand	proposed
Bhararathapuzha	S11	2.5607		27.19			Sand	proposed
Bhararathapuzha	S12	2.8786		26.68			Sand	proposed
Bhararathapuzha	S13	23.9634		28.11			Sand	proposed

- Palakkad District

I/295008/2023

Annexure-VI

Final List of Cluster & Contiguous Cluster
Clusters:

River Name	Cluster No.	Lease No.	Location (Riverbed/Patta Land)	Village	Area (in Ha)	Total Excavation (Ton)	Total Mineral Excavation (Ton)
Bhararathapuzha	C1	S1	Riverbed	Irimbiliyam	7.0777		
Bhararathapuzha		S2	Riverbed	Kuttippuram	3.0855		
Bhararathapuzha		S3	Riverbed	Kuttippuram	10.094		
Bhararathapuzha	C2	S4	Riverbed	Kuttippuram	41.9958		
Bhararathapuzha		S5	Riverbed	Kuttippuram	7.593		
Bhararathapuzha		S6	Riverbed	Kuttippuram	12.2385		
Bhararathapuzha	C3	S7	Riverbed	Kuttippuram	40.2513		
Bhararathapuzha		S8*	Riverbed	-	34.2962		
Bhararathapuzha	C4	S9	Riverbed	Kuttippuram	47.9284		
Bhararathapuzha		S10	Riverbed	Tavanur	165.4893		
Bhararathapuzha		S11	Riverbed	Naduvattom	2.5607		
Bhararathapuzha		S12	Riverbed	Naduvattom	2.8786		
Bhararathapuzha		S13	Riverbed	Naduvattom	23.9634		

*Palakkad District.

Annexure-VII

Final Transportation of Routes for individual leases and leases in Cluster

Lease No.	Transportation Route	Number of tippers/day of lease	Number of tippers/day of all the lease on route	Length of Route in km	Type of Road (Black Topped/ unpaved)	Recommendation for road (Black Topped/ unpaved)	The road will be constructed by Govt/Lease Owner	Route Map & Location
S1					unpaved			Near Mankeri LIS pump house
S2	accessible							Near Mankeri LIS pump house
S3					unpaved			Near Perassannur Railway Station
S4					unpaved			Near Pisharikkal Durga Temple
S5					unpaved			Chettarippalam-Mannathippara Road.

S6	accessible							Near GHSS, Kuttippuram
S7	accessible							Mallur Kadavu
S8*								
S9	Not accessible							Near Nilayoram Park
S10	accessible							Vellancheri Kadavu
S11					unpaved			Pallippadi-Kuttippuram-Tirur Road
S12					unpaved			Rangattur Company padi Kuttippuram-Tirur Road
S13					unpaved			Kuttippuram-Tirur Road Near old Tile Company.

* Palakkad District

Signed by
Sachin Kumar Yadav I A S
Date: 27-09-2023 14:04:52

Sub Collector, Tirur

Tirur
Dated: 27.09.2023

RDOPTM/1859/2023-S1

Sub Collector Office, Perinthalmanna
Email: rdopmna.rev@kerala.gov.in
Phone.04933227214
Dated: 14-08-2023

From

The Sub Collector
Perinthalmanna

To

1. The Director
Institute of Land & Disaster Management
PTP Nagar, Thiruvananthapuram-38

2. The District Collector
Malappuram

Sir,

Sub: Submission of the Inspection report of Sub Divisional Committee, Perinthalmanna Regarding

Ref: (1) Proceedings number DCMPM/6278/2022/DM4 dated 12.06.2023 of the District Collector, Malappuram
(2) D.O letter number ILDM/3009/2022/E1 dated 04.07.2023 of the Director, ILDM, Thiruvanathapuram.

I would like to draw your kind attention to the above references. As referenced in the first point, a Sub-Divisional Committee has been established under the leadership of the Sub Collector, Perinthalmanna, with the objective of assessing the viability of potential sand mining sites identified in the district survey report. The committee's evaluation takes into account the potential environmental impact, the presence of protected areas, critical infrastructure such as bridges, as well as the environmentally safe depth of mining and safeguards of riverbanks.

The Sub-Divisional Committee has diligently conducted comprehensive site visits on both 22nd July 2023 and 26th July 2023 to evaluate the viability of potential sand mining sites situated along the Kadalundy and Chaliyar rivers as pinpointed in the district survey report. The observations and findings of the Sub-Divisional Committee are enclosed herewith in Appendix I- report. The said report is submitted for perusal and further necessary actions.

Yours faithfully

Signed by
Sreedhanya Suresh I A S
Date: 14-08-2023 12:25:17

Sub Collector
Perinthalmanna

APPENDIX -1

REPORT OF THE SUB DIVISIONAL COMMITTEE, PERINTHALMANNA

River details	Lease details	Area (in Ha)	Distance from Forest Area (in km)	Total excavation proposed in the DSR (in Tonnes)	Date of Physical inspection	Environmentally safe depth of mining	Whether safeguarding of banks are required	Whether suitable for mining ?	Remarks
Chaliyar	S-14	3.738301	Adjacent to Panangode RF	20130	26.07.2023	1.9 metres	Yes,because there is a 50 metre steep slope to the riverbank.	Yes	The kadavu is locally known as Thandungal. It is located 10 metre below from the surface. Road access is only through a private property.
Chaliyar	S-15	6.49309	Adjacent to Nilambur RF	65130	26.07.2023	**NA**		**No**	**Near to the Water authority pump house.**
Chaliyar	S-16*	1.495494	Within Nilambur RF	31515	26.07.2023	**NA**		**No**	**Inside the reserve forest**
Chaliyar	S-17*	1.005098	Within Nilambur RF	5175	26.07.2023	**NA**		**No**	**Inside the reserve forest**
Chaliyar	S-18	0.90564	-	5550	22.07.2023	1.9 metres		Yes	

Chaliyar	S-19	1.154592	-	21600	22.07.2023	1.9 metres		Yes	
Chaliyar	S-20	4.974194	-	24555	22.07.2023	1.9 metres		Yes	Access has to be ensured through private land.
Chaliyar	S-21	0.658703	-	1380	22.07.2023	1.9 metres		Yes	There is no proper pathway to the site. Access has to be ensured through private land.
Chaliyar	S-22	5.523645	-	66135	22.07.2023	1.9 metres		Yes	
Chaliyar	S-23	1.643374	-	4695	22.07.2023	1.9 metres		Yes	There is no proper pathway to the site. Access has to be ensured through private land.
Chaliyar	S-24	2.683266	-	7215	22.07.2023	1.9 metres		Yes	There is no proper pathway to the site. Access has to be ensured through private land.
Chaliyar	S-25	1.978395	-	44040	22.07.2023	1.9 metres		Yes	
Chaliyar	S-26	1.229615	-	16890	22.07.2023	1.9 metres		Yes	
Chaliyar	S-27	2.026941	-	1395	22.07.2023	1.9 metres		Yes	There is no proper pathway to the site. Access has to be

									ensured through private land.
Chaliyar	S-28	3.151973	-	465	22.07.2023	1.9 metres		Yes	
Chaliyar	S-29	1.103321	-	23655	22.07.2023	1.9 metres		Yes	
Chaliyar	S-30	1.801206	-	49860	22.07.2023	**NA**		**No**	**The site is within 500 metre downstream side of Edavanna Seethi Haji Bridge.**
Chaliyar	S-31	0.881006	-	4095	22.07.2023	1.9 metres		Yes	There is no proper pathway to the site. Access has to be ensured through private land.
Chaliyar	S-32	5.70181	-	675	22.07.2023	1.9 metres		Yes	
Chaliyar	S-33	2.438881	-	15405	22.07.2023	1.9 metres		Yes	
Chaliyar	S-34	1.228133	-	8250	22.07.2023	1.9 metres	Yes, because there is a 30 metre steep slope to the riverbank.	Yes	There is no proper pathway to the site. Access has to be ensured through private land.
Chaliyar	S-35	0.985554	-	7035	22.07.2023	1.9 metres		Yes	
Chaliyar	S-36	3.321486	-	7665	22.07.2023	1.9 metres		Yes	

Chaliyar	S-37	3.711156	-	11010	22.07.2023	**NA**	**NA**	**No**	**The site is within 500 metre upstream side of Maithra Kadavu Bridge.**
Kadalundi	S-38	0.444095	-	4644	26.07.2023	1.9 metres		Yes	Road access need to be ensured through private property.
Kadalundi	S-39	0.309901	-	1188	26.07.2023	**NA**	**NA**	**No**	• **There is no proper pathway to the site.** • **The site is located 500 meters downstream from a check dam known as "Modi Padinjattumuri."** • **Mining activities must not take place within 300 meters upstream and 600 meters downstream of the dam.**
Kadalundi	S-40	0.233368	-	2652	26.07.2023	1.9 metres		Yes	This site is locally known as perimbalam -pottammal masjid Kadavu. Proper road access is available.

/281570/2023

Kadalundi	S-41	0.285779	-	1272	26.07.2023	1.9 metres	Yes, there is a steep 40-meter slope to the riverbank.	Yes	There is no proper pathway to the site. Access has to be ensured through private property.
Kadalundi	S-42	0.786413	-	4080	26.07.2023	1.9 metres		Yes	The site is locally known as pottikkuzhi kadavu. Existing footpath needs to be widened to ensure access.
Kadalundi	S-43	0.26266	-	1116	26.07.2023	1.9 metres		Yes	The site is locally known as muttil kadavu. There is no proper pathway to the site. Access has to be ensured through private property.
Kadalundi	S-44	0.845509	-	3792	26.07.2023	1.9 metres		Yes	The site is locally known as Panambatta Kadavu. There is proper road access to the site.

Signed by
Sreedhanya Suresh I A S
Sub Collector
Date: 14-08-2023 12:25:58

ANNEXURE-IV

Final list of potential sand mining sites

Final list of potential sand mining sites

River details	Lease details	Area (in Ha)	Distance (in km) from PA/BR/WC	Distance from forest area (in km)	Mining leases within 500 meters (if yes cluster area)	Total excavation in Tonnes	Mineral to be mined (Sand/ Bajri/ RBM etc.)	Existing / Proposed
Bharathapuzha	S-1	7.0777	-	-	Yes (10.16 Ha)	65505	Sand	Proposed
Bharathapuzha	S-2	3.0855	-	-	Yes (10.16 Ha)	119865	Sand	Proposed
Bharathapuzha	S-3	10.0938	-	-	-	74010	Sand	Proposed
Bharathapuzha	S-4	41.9958	-	-	-	975675	Sand	Proposed
Bharathapuzha	S-6	12.2385	-	-	-	315645	Sand	Proposed
Bharathapuzha	S-7 LB	40.2513	-	-	-	959610	Sand	Proposed
Bharathapuzha	S-9	47.9284	-	-	Yes (242.82 Ha)	980565	Sand	Proposed
Bharathapuzha	S-10 LB	165.4893	-	-	Yes (242.82 Ha)	1686615	Sand	Proposed
Bharathapuzha	S-11	2.5607	-	-	Yes (242.82 Ha)	19080	Sand	Proposed
Bharathapuzha	S-12	2.8786	-	-	Yes (242.82 Ha)	33585	Sand	Proposed
Bharathapuzha	S-13	23.9634	-	-	Yes (242.82 Ha)	225390	Sand	Proposed
Chaliyar	S-14	3.738301	-	Adjacent to Panangode RF	-	20130	Sand	Proposed
Chaliyar	S-18	0.90564	-	-	Yes (13.22 Ha)	5550	Sand	Proposed
Chaliyar	S-19	1.154592	-	-	Yes (13.22 Ha)	21600	Sand	Proposed
Chaliyar	S-20	4.974194	-	-	Yes (13.22 Ha)	24555	Sand	Proposed
Chaliyar	S-21	0.658703	-	-	Yes (13.22 Ha)	1380	Sand	Proposed

Chaliyar	S-22	5.523645	-	-	Yes (13.22 Ha)	66135	Sand	Proposed
Chaliyar	S-23	1.643374	-	-	Yes (7.53 Ha)	4695	Sand	Proposed
Chaliyar	S-24	2.683266	-	-	Yes (7.53 Ha)	7215	Sand	Proposed
Chaliyar	S-25	1.978395	-	-	Yes (7.53 Ha)	44040	Sand	Proposed
Chaliyar	S-26	1.229615	-	-	Yes (7.53 Ha)	16890	Sand	Proposed
Chaliyar	S-27	2.026941	-	-	Yes (6.28 Ha)	1395	Sand	Proposed
Chaliyar	S-28	3.151973	-	-	Yes (6.28 Ha)	465	Sand	Proposed
Chaliyar	S-29	1.103321	-	-	Yes (6.28 Ha)	23655	Sand	Proposed
Chaliyar	S-31	0.881006	-	-	Yes (10.25 Ha)	4095	Sand	Proposed
Chaliyar	S-32	5.70181	-	-	Yes (10.25 Ha)	675	Sand	Proposed
Chaliyar	S-33	2.438881	-	-	Yes (10.25 Ha)	15405	Sand	Proposed
Chaliyar	S-34	1.228133	-	-	Yes (10.25 Ha)	8250	Sand	Proposed
Chaliyar	S-35	0.985554	-	-	-	7035	Sand	Proposed
Chaliyar	S-36	3.321486	-	-	-	7665	Sand	Proposed
Kadalundi	S-38	0.444095	-	-	-	4644	Sand	Proposed
Kadalundi	S-40	0.233368	-	-	Yes (0.52 Ha)	2652	Sand	Proposed
Kadalundi	S-41	0.285779	-	-	Yes (0.52 Ha)	1272	Sand	Proposed
Kadalundi	S-42	0.786413	-	-	Yes (1.89 Ha)	4080	Sand	Proposed
Kadalundi	S-43	0.26266	-	-	Yes (1.89 Ha)	1116	Sand	Proposed
Kadalundi	S-44	0.845509	-	-	Yes (1.89 Ha)	3792	Sand	Proposed

ANNEXURE-V

Final list of cluster and contiguous cluster

Final list of cluster and contiguous cluster

River name	Cluster no	Sand mining sites falling under cluster	Panchayath Name	Area (Ha)	Total sand (Tonne)	Mineable sand (Tonne)
Bharathapuzha	C-1	S1, S2	Irinpiliyam	10.16	457688	185370
Bharathapuzha	C-2	S9, S10 LB, S11, S12, S13	Kuttippuram	242.82	8667240	2945235
Chaliyar	C-3	S18, S19, S20, S21, S22	Mambad	13.22	290835	119220
Chaliyar	C-4	S23, S24, S25, S26	Mambad-Edavanna	7.53	200970	72840
Chaliyar	C-5	S27, S28, S29	Edavanna	6.28	98895	25515
Chaliyar	C-6	S31, S32, S33, S34	Edavanna	10.25	124860	28425
Kadalundi	C-7	S40, S41	Koottilangadi	0.52	16800	3924
Kadalundi	C-8	S42, S43, S44	Koottilangadi	1.89	54996	8988

River name	Contiguous cluster number	Cluster no	Number of sand mining site in the cluster	Distance between the cluster	Area (Ha)	Total sand (Tonne)	Mineable sand (Tonne)
Chaliyar	CG-1	C-3 to C-6	16	<2.5 km	37.28	715560	246000
Kadalundi	CG-2	C-7 to C-8	5	<2.5 km	2.41	71796	12912

ANNEXURE-VI

State Environment Impact Assessment Authority (SEIAA), Kerala approval

Environment Impact Assessment Authority (SEIAA) Kerala

K.S.R.T.C Bus Terminal Complex, 4th Floor, Thampanoor,
Thiruvananthapuram - 695 001
Ph: +91471-2334262 (Off) +91471-2334265 (Fax)
e-mail:seacseiaakerala@gmail.com
web:www.seiaakerala.in

No.3162/A1/2021/SEIAA **Date: 10.01.2024**

From

The Administrator
State Environment Impact Assessment Authority
Thiruvananthapuram

To

District Collector
Malappuram

Sir,

Sub: - SEIAA - District Survey Report for river sand mining in Malabar District - Approved - reg.

Ref:- 1) Letter No. DCMPM/6278/2022 - DM4 dtd.26.10.2023 from District Collector, Malappuram.
2) Minutes of 153rd State Expert Appraisal Committee meeting held on 14th & 15th November 2023.
3) Minutes of 135th State Environment Impact Assessment Authority meeting held on 22nd & 23rd December 2023.

Attention is invited to the reference cited and to inform the following decision on District Survey Report (DSR) for river sand mining in Malappuram District.

The 153rd State Expert Appraisal Committee deliberated the DSR for river sand mining and decided to approve the report subject to the following conditions.

1) Ascertain the sand demand based on cement supply figures instead of cement production within Kerala as the proxy variable while estimating the demand supply gap for sand in Malappuram district.
2) The provisions in "The Kerala Protection of River Banks and Regulation of Removal of Sand Act, 2001", should be adopted for the protection of river banks and bio-physical environment systems of the river and for regulation to upkeep the biophysical environment.

3) The report form only the resource base for mining application and the environmental safeguards to be adopted shall be stipulated separately while appraising projects for environmental clearance.

It is also informed that the 135th State Environment Impact Assessment Authority decided to approve the District Survey Report (DSR) of Malappuram District with the observation of State Expert Appraisal Committee. Copy of the minutes is forwarded herewith for information and further necessary action.

Yours faithfully,
Sd/-
HARIKUMAR A.S
Administrator, SEIAA

Approved for issue.

Section Officer

Copy to: Director, ILDM: (You are requested to take necessary action for publishing the final document in the website of all department/agencies concerned.)

Clarifications sought by State Expert Appraisal Committee (SEAC), Kerala

The following clarifications were sought by State Expert Appraisal Committee (SEAC), Kerala in its 153rd SEAC meeting held on 14-11-2023

S.No.	Clarification sought	Compliance/Response
1.	Ascertain the sand demand based on cement supply figures instead of cement production within Kerala as the proxy variable while estimating the demand supply gap for sand in Malappuram district	We appreciate your feedback on our recently submitted District Survey Report, specifically regarding the suggestion to calculate sand demand based on cement supply and consumption. We have carefully considered your recommendation and would like to provide a scientific response addressing the points raised. **Data Collection Challenges:** Collecting comprehensive and authentic data on cement consumption and supply poses a significant challenge. The complexities in obtaining precise figures from various sources may result in data gaps, leading to an inaccurate representation of the actual cement market dynamics. This limitation could compromise the reliability of our analysis. **Stakeholder Discussions:** Through our discussions with various stakeholders, it has become evident that there is a consistent demand for sand in construction activities across Kerala. These insights from industry participants, including builders, contractors, and other key players, substantiate the necessity for a reliable source of sand for construction purposes. **Nature of the District Survey Report:** The report we have submitted serves as a preliminary documentation outlining the general demand for sand in the region. It is essential to clarify that our intention was to present an overview rather than an exhaustive demand-supply analysis. The report indicates the need for sand in construction, based on the discussions and observations made during the survey. We acknowledge the importance of a thorough demand-supply analysis but would like to emphasize that the scope of our report aligns with the preliminary documentation of the sand demand. A more detailed analysis, especially involving complex factors such as cement supply and consumption, would necessitate additional

		resources, time, and extensive data collection efforts
2.	The provisions in "The Kerala Protection of River Banks and Regulation of Removal of Sand Act, 2001", should be adopted for the protection of river banks and bio-physical environment systems of the river and for regulation to upkeep the biophysical environment	The sand mining sites were recommended based on the provisions in "The Kerala Protection of River Banks and Regulation of Removal of Sand Act, 2001" along with the Sustainable Sand Mining Management Guidelines (SSMMG-2016) along with the Enforcement and Monitoring Guidelines for Sand Mining (EMGSM-2020) during preparation of the DSR.
3.	The report form only the resource base for mining application and the environmental safeguards to be adopted shall be stipulated separately while appraising projects for environmental clearance	The DSR forms the catalogue of the district's river sand resources within an overview of environmental safeguards. However, individual mine site EIA/EMP studies shall be carried out prior to submission to environmental clearance application by the consultant.