1. ORGANISATIONAL SET UP

The Kerala Engineering Research Institute is under the Directorate of Fundamental & Applied Research, KERI, Peechi headed by the Director in the rank of Superintending Engineer with, two divisions functioning at Peechi, i.e., the Hydraulic Research and the Construction Materials & Foundation Engineering Division and another division namely the Coastal Engineering Field Studies Division at Thrissur, each headed by a Joint Director, an officer in the rank of an Executive Engineer.

The Directorate Institute is under I.D.R.B of Water Resources Department under the Chief Engineer, Investigation & Design (IDRB), Thiruvananthapuram.

The organizational set up of each Division is as follows:

I. Joint Director, Hydraulic Research

1. Hydraulics Division
2. Sedimentation Division
3. Coastal Engineering Division

II. Joint Director, CM&FE

1. Construction Materials Division
2. Soil Mechanics and Foundations Division
3. Instrumentation Division
4. Publications Division

III. Joint Director, Coastal Engineering Field Studies

1. Coastal Erosion studies Subdivision, Kozhikkode
2. Coastal Engineering Studies Subdivision, Ernakulam
3. Coastal Engineering Studies Subdivision, Kollam

These divisions are doing research works, laboratory testing and collection of field data related to their respective fields and present valuable results and also analyses results having significant implications in different fields of Civil Engineering and Water Resources Management. Each subdivision has a Deputy Director in the rank of an

Assistant Executive Engineer as its head and one or two Assistant Directors in the rank of Assistant Engineer to assist in the research activities.

The Quality Control wing attached to this Directorate has been constituted for the purpose of quality assurance of works of Irrigation Department. The jurisdiction of this wing is all over Kerala. There are two Divisions one at Thrissur and the other at Kottarakkara, nine Subdivisions at Kannur, Kozhikode, Palakkad, Thrissur, Moovattupuzha, Kottayam, Alappuzha, Kottarakkara and Thiruvananthapuram and 18 sections, at Thiruvananthapuram, Kollam, Kottarakkara, Pathanamthitta, Allappuzha, Idukki, Kottayam, Aluva, Moovattupuzha, Koothattukulam, Angamaly, Thrissur, Palakkad, Malappuram, Kozhikode, Kalpetta, Kannur and Kasaragod.

2. PERSONNEL

The Executive officers who headed the various offices under KERI during the financial year 2017-2018 are:

DIRECTOR, FUNDAMENTAL & APPLIED RESEARCH	:	Dr. A. Udayakumar
JOINT DIRECTOR, CONSTRUCTION MATERIALS & FOUDATION ENGINEERING	:	Er. Jessy Ann Francis from 1/04/17 to 31/05/2017
		Er. Jaicy Joseph Palayakkara (FAC) from 01/06/17 to 01/08/17
		Er. Rajamma. S from 02/08/17 to 05/12/17
		Er. Jaicy Joseph Palayakkara (FAC) from 06/12/17 to 17/12/17
		Er. Rajamma. S from 18/12/17 FN Onwards.
JOINT DIRECTOR, HYDRAULIC RESEARCH	:	Er. K. Radhakrishnan (from 01/04/17 to 06/07/2017AN onwards)
		Er. Shini K.K. (FAC) from 07/07/2017 FN to 06/08/17AN
	:	Er. Basant K.B (from 07/08/2017 FN onwards)
JOINT DIRECTOR, CEFS	:	Er. K.L. Thomas

DEPUTY DIRECTORS		
CONSTRUCTION MATERIALS DIVISION	:	Er. Jaicy Joseph Palayakkara
SOIL MECHANICS AND FOUNDATIONS DIVISION		Er. Geetha E.S.
INSTRUMENTATION DIVISION	:	Er. Sheeja A Andezhathu.
PUBLICATIONS DIVISION		Post Abolished
HYDRAULICS DIVISION		Er. Sujatha.P
SEDIMENTATION DIVISION	:	Er. Shini K.K.
COASTAL ENGINEERING DIVISION	:	Er. Saji Samuel
COASTAL ENGINEERING, SUB DIVISION, KOZHIKODE	:	Smt. Shyla Begum (from 1/04/2017 to 31/07/2017)
		Sri.Abbas.M.T. (in charge from 01/08/2017 to 13/09/2017)
		Smt. Asha Beegam L. (from 14/09/2017 onwards)
C.E. SUB DIVISION, ERNAKULAM	:	Er. Sandhya T.
C.E. SUB DIVISION, KOLLAM	:	Er. Hema N.S.
ASSISTANT DIRECTORS		
FUNDAMENTAL& APPLIED RESEARCH (DIRECTORATE)	:	Er. Deepa R.(from 1/04/2017 FN to 30/06/2017 AN)
		Er. Joy C. C.(from 1/07/2017 FN to 8/02/2018 FN)
		Er. Deepa R. (from 8/02/2018 FN Onwards)
CONSTRUCTION MATERIALS & FOUDATION ENGINEERING		Er. Saju Varghese (from 1/04/2017 to 31/06/2017)
		Er. Saju Varghese (In charge from 1/07/2017 to 5/07/2017)
		Er. Anitha Nelson (from 05/07/2017 to 04/12/2017 FN)
		Er. Aswathy P.S.(from 04/12/17 FN onwards)
HYDRAULIC RESEARCH	:	Er. Joy C.C. (from 01/04/2017 FN to 30/06/2017 FN)
		Er. Deepa R. (from 01/07/2017 FN to 08/02/2018 FN)
		Er. Joy C.C (from 08/02/2018 FN Onwards)
COASTAL ENGINEERING FIELD STUDIES	:	Er. Anitha B. Nair

INSTRUMENTATION SECTION	:	Er. Saju Varghese
CONSTRUCTION MATERIALS DIVISION		
ASSISTANT DIRECTOR I	:	Dr. Santhoshkumar P.T. (from 01/04/2017 to 31/08/2017)
		Er. V. R. Valasalakumary (Full additional charge from 01/09/2017 to 23/10/2017)
		Er. Siji T.V. (from 24/10/2017 onwards)
ASSISTANT DIRECTOR II		Er. V. R. Valasalakumary (from 01/04/2017 to 01/06/2017)
		Dr. Santhoshkumar P.T. (full additional charge from 01/06/2017 to 04/07/2017)
		Er. Harith Suraj (from 05/07/2017 onwards)
SOIL MECHANICS & FOUNDATIONS DIVISION		
ASSISTANT DIRECTOR I	:	Er. Miny T.M (FAC) from 1/04/2017 to 01/06/2017 FN
		Er. V. R. Valasalakumary from 01/06/2017 FN to 31/07/2017 FN
		Er. Lakshmi. V.from 31/07/2017 FN to 25/10/2017 AN
		Er. Siji T.V. (FAC)from 25/10/2017 AN to 22/11/2017 FN
		Er. Sreekumar. K.S. from 22/11/2017 FN onwards
ASSISTANT DIRECTOR II		Er. Valsalakumary V. R.
PUBLICATIONS DIVISION	:	Post Abolished
HYDRAULICSDIVISION		
ASSISTANT DIRECTOR I	:	Er. Miny T.M. (from 01/04/2017 to 20/06/2017AN)
		Er. Balu R. (from05/07/2017 FN onwards)
ASSISTANT DIRECTOR II		Er. Ajithkumar T.V. (from 01/04/17 to 11/07/17 AN)
		Er. Nandini S. Nair (from 12/07/2017 FN onwards)
SEDIMENTATION DIVISION	:	Er. Roshni S. S.
		Er. Sreejith K. S.
COASTAL ENGINEERING DIVISION	:	Er. Divya C.J.

	:	Er. Snisha T.B.
C.E.S. SECTION, KOZHIKODE.	:	Er. Sivadasan A.
C.E.S. SECTION,THALASSERY	:	Er. Anil Kumar P.
C.E.S. SECTION, PARAPPANANGADI	:	Er. Girishkumar K. (from 01/04/2017 to 24/04/2017) Er. Sivadasan A. (in charge from 24/04/2017 to 30/06/2017) Er. Abbas.M.T (from 01/07/2017 onwards
C.E.S. SECTION, ERNAKULAM		Er. Jisha A.
C.E. SECTION, CHERTHALA	:	Er. Clament Roy K.R.
C.E. SECTION, CHAVAKKAD	:	Er. Sunitha T.M. (from 08/01/2016 to 07/03/2017) Er. Jisha A. (upto 31.05.2017 in charge)
C.E. SECTION,KOLLAM	:	Er. Shillar S.J.
C.E.SECTION, THOTTAPPALLY		Er. Santhoshkumar C.
C.E. SECTION, TRIVANDRUM		Er. Jayalal V.S.

3. HUMAN RESOURCES

The human resources of KERI comprise of both technical and nontechnical personnel. During its prime, majority of the engineers working in KERI were post graduates in different disciplines of Civil Engineering. The number of fundamental researches were carried out during the period, bear witness to this. KERI was well known all over India and abroad for the research works and experimental studies carried out in this institute, especially in the field of Coastal engineering. In the past three decades, no significant fundamental studies have been carried out and the labs have gradually degenerated to the status of mere testing centres.

At present, out of the twenty-four posts of Assistant Engineers, four posts are lying vacant. The number of supporting technical staff in the category of draftsman is just Eight against a sanctioned strength of twenty-five. In the workers category, as it happens to be a vanishing category, just two workers are available at present. Workers are hired on contract basis or on daily wages as per requirement.

However, a sincere and commendable effort is being made by the staff to take up all the projects assigned to it. The vacancy position of KERI is attached as Appendix – I.

4. FUNCTIONING OF THE INSTITUTE

The Kerala Engineering Research Institute consists of seven divisions functioning at Peechi as well as Coastal Engineering and Field studies Division at Thrissur and Quality Control wing of the Irrigation Department. Generally, the activities of each division can be categorized as falling under Routine activities, Fundamental studies and Revamping and Modernization. The routine activities and fundamental studies conducted by each division are enumerated in this chapter.

A. HYDRAULICS DIVISION

A.1 Introduction

Studies on various problems in Applied Hydraulics, Irrigation Engineering and Flood Control are taken up by this division and propose solutions for the same. The work on major Irrigation and Hydro-Electric Projects in the state are undertaken only after doing model studies/research studies by this division on that project. The studies are conducted on a wide range of parameters related to spillways, sluices, chutes, energy dissipating arrangement, operation of gate, flow condition in tail-race, silt excluding arrangements, hydraulic behavior of canal structures, river training works etc. By these studies, we are able to provide hydraulically sound and economically viable solutions to various problems associated with projects. In addition, a Meteorological station is functioning at Peechi under this Division.

A.2. Activities for the year 2017-18

- Measurement of meteorological data and maintenance of a Meteorological Station at Peechi Dam site.
- Desiltation of Chulliar Reservoir – Qualitative Analysis of sediments

- Renovation and restoration of 3D model of Kerala and building housing model.
- Improvement of infrastructure facilities of the office of the Director and other offices - FTTH with RF link and LAN wiring
- Calibration of notches
- Routine works of Hydraulics Division.
- Other routine works such as maintenance of outdoor Model Area I & Model Area II
- Model study of Pattissery Dam

A.2.1 Meteorological Station, KERI, Peechi

Weather observations are necessary to improve Meteorological services in the state and enhance the predictive capability of short and long-term information for weather forecasts and climatic changes. They are used for the real-time preparation of weather analysis, forecasts and severe weather warnings, for the study of climates, for local weather dependent operations (for example local aerodrome flying operations, construction work on land and at sea) for hydrology and agricultural meteorology and for research in meteorology and climatology.

The Meteorological Station under K E R I, Peechi is located on the west bank of Peechi Dam, near the Peechi House at a Latitude of 10º 31'30'' N, Longitude 76º 21' 59'' E and height above MSL +96.03 m.

The station is equipped with the instruments for measuring manually the weather parameters namely Atmospheric Pressure, Temperature, Humidity, Rainfall, Evaporation, Wind speed, Wind direction and Bright Sunshine. As part of modernization, an automatic weather station was installed in June, 2014 and is collecting data in every 30minutes. The above weather parameters are being collected from this station daily at 8.30 AM manually.

A.2.1.1 Automatic Weather Station

Time series observations are vital to improve the understanding of weather dynamics and its variability. The Automatic Weather Station plays an important role in providing short-term and long-term time series weather observations. Automatic weather station is functioning in Meteorological Station since July, 2014 with Remote transmission facility and a Solar Panel for uninterrupted power supply.

The Automatic Weather station collects data related to Air Temperature, Air Humidity, Barometric Pressure, Ultrasonic Wind Speed, Ultrasonic Wind Direction, Global Radiation and Precipitation using different sensors. A Data Logger which is part of the Automatic Weather Station is collecting data in every 30 minutes and transferring it to a central server every 2hours using multiple protocols. These data can be accessed via., internet using a software HYDRAS. The data collected can be used to gauge current weather conditions and to make weather forecasts like temperature high/lows, cloud cover and the probability of precipitation.

Components of Automatic Weather Station

1. Ultrasonic Wind speed and Direction sensor & Compass
2. Global Radiation Sensor
3. Temperature, Humidity, Barometric Pressure Sensors
4. Rain Gauge
5. Data Logger

ULTRASONIC WIND SPEED AND DIRECTION SENSOR

SOLAR RADIATION SENSOR

TEMPERATURE, HUMIDITY & PRESSURE SENSOR

RAIN GAUGE

IP DATA LOGGER

A.2.1.2Manual Weather Station

Manual measurements of meteorological data are done using the following instruments and the readings are taken every day at 8.30 am.

- Temperature – Max.& Min. Thermometers & Bimetallic Thermograph
- Relative Humidity – Psychrometer (Dry & Wet bulb) & Hair Hygrometer
- Rainfall – Standard Rain Gauge, Self Recording Rain gauge
- Evaporation – Land Pan Evaporimeter
- Wind Direction – Wind Vane
- Wind Speed – Cup Anemometer
- Bright Sunshine – Sunshine Recorder

Max., Min. Thermometers and Psychrometer (Dry & Wet bulb)

The standard, recommended maximum and minimum thermometers are two separate thermometers mounted (in a near-horizontal position) in a special device. The unit of measurement is degree Celsius. Recorded maximum and minimum temperatures are the highest and lowest values occurring during a specified period of time, such as 24 hours.

Bimetallic Thermograph

This is used for measuring & recording atmospheric temperature as a function of time on recording chart.

Relative Humidity

Humidity measurements at the Earth's surface are required for meteorological analysis and forecasting, for climate studies, and for many special applications in hydrology, agriculture, aeronautical services and environmental studies, in general. They are particularly important because of their relevance to the changes of state of water in the atmosphere. The instruments used for measuring humidity are Psychrometer (Dry & Wet bulb) & Hair Hygrometer. Dry and wet-bulb temperature measurements are taken to calculate Relative Humidity.

A Psychrometer consists essentially of two thermometers exposed side by side, with the surface of the sensing element of one being covered by a thin film of water or ice and termed the wet or ice bulb, as appropriate. The sensing element of the second thermometer is simply exposed to the air and is termed the dry bulb. In the figure, the Psychrometer is placed vertically on either side of the box shelter.

Relative Humidity is found out from the calibration graph (relative humidity table) connecting dry bulb temperature and the difference between wet bulb temperature and dry bulb temperature. It is expressed in percentage.

Hair Hygrometer

The most commonly used hair hygrometer is the hygrograph. This employs a bundle of hairs held under slight tension by a small spring and connected to a pen arm in such a way as to magnify a change in the length of the bundle. A pen at the end of the pen arm is in contact with a paper chart fitted around a metal cylinder and registers the angular displacement of the arm. The cylinder rotates about its axis at a constant rate determined by a mechanical clock movement. The rate of rotation is usually one revolution per day. The chart has a scaled time axis that extends round the circumference of the cylinder and a scaled humidity axis parallel to the axis of the cylinder. The humidity scale is divided into 100 equal segments. Each segment corresponds to 1%. The cylinder normally stands vertically. So, humidity can be directly read from the recording chart.

Precipitation

Precipitation is defined as the liquid or solid products of the condensation of water vapour falling from clouds or deposited from air onto the ground. It includes rain, hail, snow, dew, rime, hoar frost and fog precipitation. The total amount of precipitation which reaches the ground in a stated period is expressed in terms of the vertical depth of water (or water equivalent in the case of solid forms) to which it would cover a horizontal projection of the Earth's surface. Snowfall is also expressed by the depth of fresh, newly fallen snow covering an even horizontal surface.

Precipitation is measured in millimeters. Precipitation gauges (or rain gauges if only liquid precipitation can be measured) are the most common instruments used to measure precipitation.

Rain gauges are of two type's standard rain gauge (non recording type) and self recording rain gauge. Standard rain gauge consists of a collector placed above a funnel leading into a container where the accumulated water and melted snow are stored between observation times and the quantity is measured manually.

Three types of automatic precipitation recorders are in general use, namely the weighing-recording type, the tilting or tipping-bucket type, and the float type.

In the float type rain gauge, the level of the collected rain water is measured by the position of a float resting on the surface of the water. This instrument is used as a recording rain gauge by connecting the float through a linkage to a pen that records on a clock driven chart.

Evaporation

The rate of evaporation is defined as the amount of water evaporated from a unit surface area per unit of time. Estimates of both evaporation from free water surfaces, from the ground and evapotranspiration from vegetation-covered surfaces are of great importance to hydrological modeling and in hydro meteorological and agricultural studies, for example, for the design and operation of reservoirs and irrigation and drainage systems.

Land Pan Evaporimeter is used for measurement of evaporation and is measured in millimeters.

Wind Direction & Wind speed

Wind observations or measurements are required for weather monitoring and forecasting, wind-load climatology, probability of wind damage and estimation of wind energy. It is taken at a fixed location using 2 parameters; wind speed and wind direction. Surface wind is usually measured by a wind vane and cup or propeller anemometer. Wind Vane is used to find the wind direction and it is measured in degrees clockwise from north. Cup anemometer is used to find the wind Speed and is measured in kilometers per hour.

Bright Sunshine

Sunshine duration or sunshine hours is a climatological indicator, measuring duration of sunshine in given period for a given location on earth. An important use of sunshine duration is to characterize the climate of sites, especially of health resorts. It is often used to promote tourist destinations. For the specific purpose of sunshine duration recording, Campbell-Stokes sunshine recorders are used, which use a spherical glass

lens to focus the sun rays on a specially designed tape. When the intensity exceeds a pre determined threshold, the tape burns. The total length of the burn trace is proportional to the number of bright hours.Duration of sunshine is in hours per day.

PSYCHROMETER

HAIR HYGROMETER

BIMETALLIC THERMOGRAPH

FLOAT TYPE SELF RECORDING RAIN GAUGE

STANDARD RAIN GAUGE

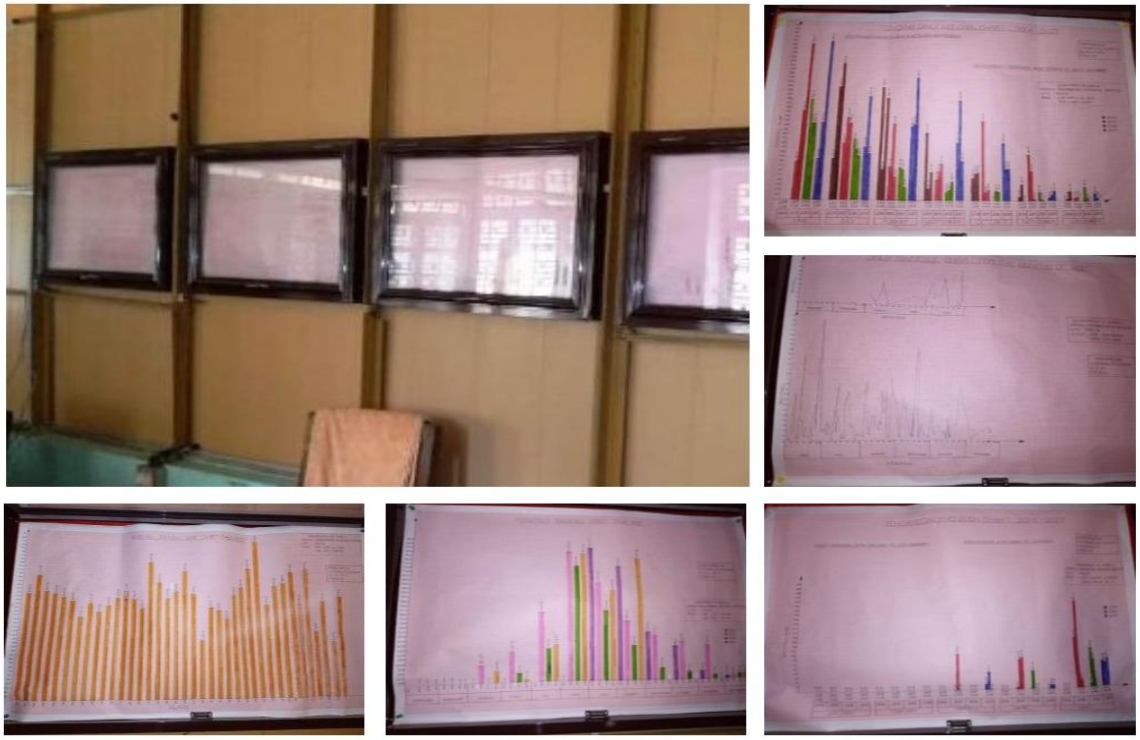
LANDPAN EVAPORIMETER

WIND VANE

CUP ANEMOMETER

SUNSHINE RECORDER

An abstract of the Weather data collected from Weather Station for the period from April, 2017 to March, 2018 are given in Appendix- II.



A.2.2 Desiltation of Chulliar reservoir – Qualitative analysis of sediments

From the reservoir sedimentation studies conducted by Sedimentation Division, it was revealed that most of the reservoir got silted up beyond their dead storage level. This fact prompted the Government to initiate desilting of reservoirs and the Standard Operation Procedure (SOP) was promulgated by the Government for Desiltation of reservoirs. Chulliyar and Mangalam reservoirs were selected as pilot projects for desilting. As per SOP, the water spread area of the reservoir is to be divided into zones of size 200m x 200m and each zone is to be divided into grids of size 50m x 50m and samples should be extracted from the center of each grid. KERI was entrusted with the work qualitative analysis of sediments extracted from Chulliyar and Mangalam Reservoirs. Since the facility for extraction of sediment samples underwater is not available with KERI, support from other agencies was sought and the National Centre for Earth Science Studies (NCESS) was entrusted with the sample collection. NCESS used gravity corer method for underwater sample extraction and other suitable ground

sampling methods for areas where water level has receded. A Memorandum of Understanding (MoU) was signed between Irrigation Design and Research Board, Thiruvananthapuram on behalf of Irrigation Department, Kerala and the Director, NCESS, Thiruvananthapuram, on 13/12/2017 for sample collection from reservoir.

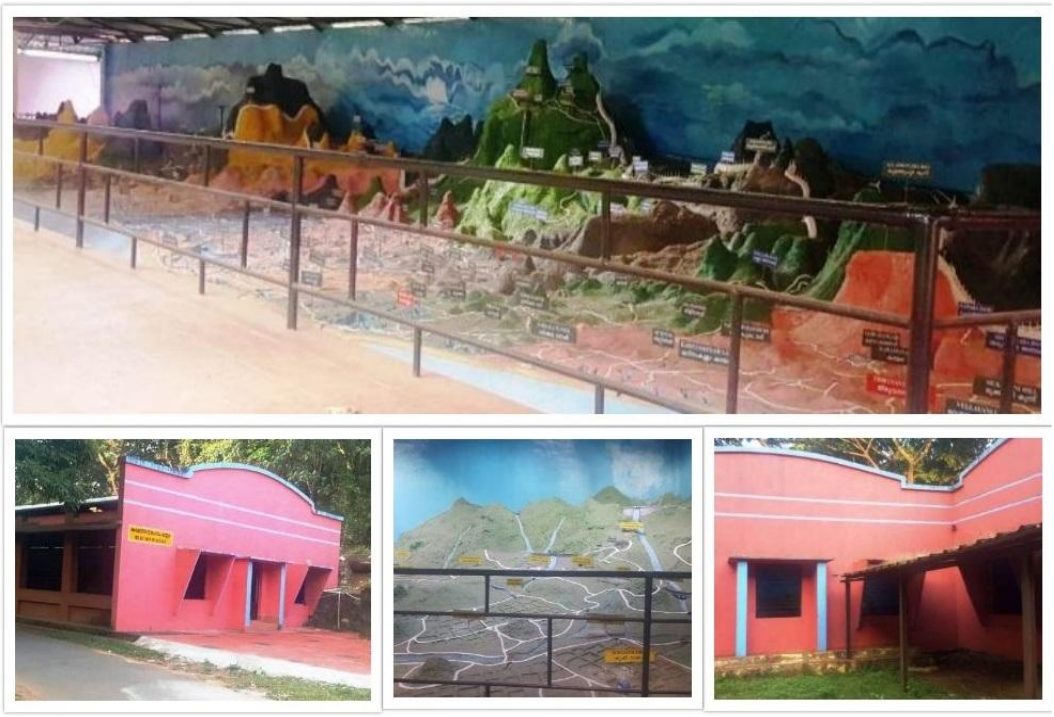
As part of the pilot project, the responsibility of extracting sediment samples and transporting the samples to Soil Mechanics laboratory, KERI was entrusted with this division under the Joint Director, Hydraulic Research, KERI, Peechi and the responsibility of conducting qualitative analysis of sediments samples was vested with Deputy Director, Soil Mechanics and Foundation Division, under Joint Director, Construction Materials and Foundation Engineering Division, KERI, Peechi.

Chulliyar dam situated 40km away from the District Headquarters, Palakkad, is located at 10º35′N Latitude and 76º50′E Longitude. It is the second stage of Gayathri scheme. This dam across Chulliyar River along with its canal system was completed in 1964 and was commissioned in 1966. Catchment area of river at the dam site is 29.78sq.km. The water spread area of the reservoir is 1.65sq.km. Maximum storage capacity of Chulliyar Reservoir is 13.733Mm^3 and based on the study the storage capacity has reduced to 12.60 Mm^3.

Sediment sample collection started on 8th February, 2018 and concluded in second week of March, 2018. Qualitative analysis of sediments samples was completed by the 3rd week of March, 2018 and the report completed by 31st march 2018. As per the analysis, even though it is observed that 56.106% of sediment constitutes sand, of which medium sand (2mm-0.425mm size) is only 13.69%, this can be used for construction purpose only after mixing with sufficient quantity of fine sand. Also, the sediments predominantly consist of clay and other finer particles constituting more than 42%. Further tests have to be performed for determining the properties of clay and other residues for assessing their suitability.

A.2.3 Renovation and restoration of 3D model of Kerala and the building housing the model

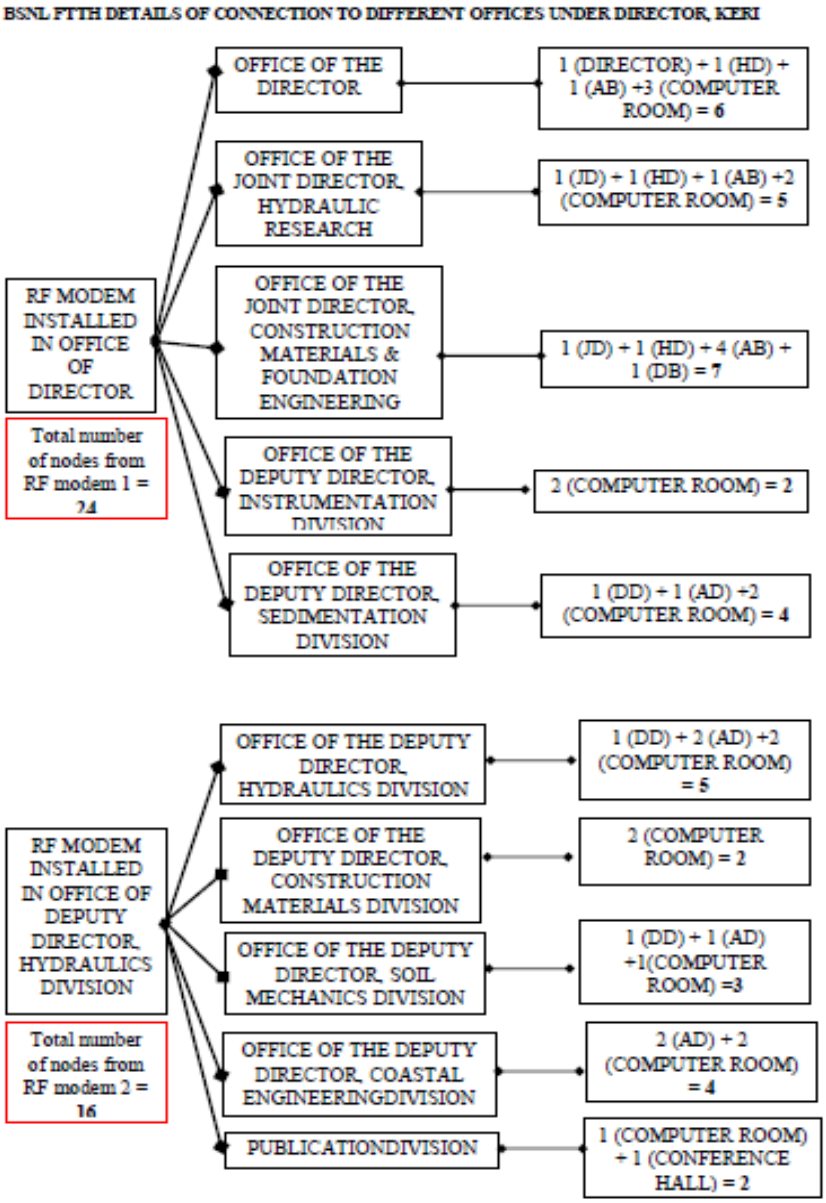
The Relief map of Kerala (Kerala model) at K.E.R.I. is a three dimensional model of Kerala and a centre of attraction in Peechi, with lot of people visiting it on a daily basis. The building housing the model went to a distressed state with portions of the wall and roofing having collapsed in the rains. The repair and renovation of this model and the building housing it was done emphasizing on reconstruction of the dilapidated brick wall of building, plastering and painting of the reconstructed wall, felling of a few trees (which are very close to building wall and posing threat to the structure), repairing of plastering in damaged portions of the wall, renewal of roofing, painting of trusses, grills and walls, painting of the 3D models, renewal of name boards provided on model, ceramic tile flooring to area housing the 3D model of irrigation project and paving the approach to the building. This maintenance work was carried out in two parts with a part of work under the head of account Maintenance – Peechi scheme and the other part under Development of KERI Stage II on tender basis.



A.2.4 Improvement of infrastructure facilities of the office of the Director and other offices - FTTH with RF link and LAN wiring

The Kerala Engineering Research Institute, Peechi complex consist of the Director's office, Office of the Joint Director (Hydraulic Research), Office of the Joint Director (Construction Materials & Foundation Engineering), Office of the Deputy Director (Sedimentation Division), Office of the Deputy Director (Instrumentation Division), Office of the Deputy Director (Coastal Engineering Division), Office of the Deputy Director (Soil Mechanics & Foundations Division), Office of the Deputy Director (Construction Materials Division) and Office of the Deputy Director (Hydraulics Division) functioning in five buildings. The offices are engaged in various Research, investigation and quality ensuring activities and contribute to the Government in the form of revenue. The institute is also engaged in organizing training programs in the seminar hall of KERI Building. Various Government agencies, Private agencies and other institutions utilize the resources at KERI for ensuring quality in construction. Also, K.E.R.I. is in the process of accreditation from NABL which is expected to boost the status of the Laboratories and is likely to increase the revenue to Government. High speed and stable internet connection is essential for smooth functioning of these offices

and their activities. Further, most of the processes of the Department are being switched over to the web platform. Thus, be it the estimation software (PRICE), or accounting software (BIMS/BAMS), employee transfer details (e-monitoring), plan expenditure and progress (PLANSPACE), salary software (SPARK), HRMS etc., all are web based and need uninterrupted and high speed internet to work at optimum level. Thus a stable and sufficiently speedy internet infrastructure is a bare necessity for an institute like KERI.



There were connectivity issues with the then internet connection plans subscribed by the aforementioned offices which hindered the routine activities. Hence proposal was given for high speed internet connectivity from BSNL through FTTH with RF link including LAN cabling and UPS. The provisions in the estimate were given as per recommendations from the Principal General Manager, BSNL, Thrissur and the execution of the work was monitored and completed under the charge of this division.

A.2.5 Calibration of notches

Notches are used for measurement of discharge through open channels by placing or constructing them across the stream or channel. The discharge over notch is measured by measuring the head acting over the notch. The actual discharge and theoretical discharge will be equated using a suitable coefficient of discharge and a factor for the head of flow. The process of assessing these constants is called calibration. Once the equation relating discharge and head of flow over the notch is established by calibration experiment, the discharge at any point in a channel can be estimated by fixing the notch across the channel and measuring the head of flow.

Notches can be of different shapes such as triangular, rectangular, trapezoidal, stepped notch, etc. The bottom of the notch over which the water flows is known as crest or sill and the thin sheet of water flowing through the notch is known as nappe or vein. The edges of the notch are bevelled on the downstream side so as to have sharp-edged sides and crest resulting in minimum contact with the flowing fluid. As water approaches the notch, its surface becomes curved. Therefore, the head over the notch is to be measured at the upstream of the notch where the effect of curvature is minimum. Also, it should be close to the notch so that the loss of energy between head measuring section and notch is negligible. In practical, the head over notch is measured at a distance of 3 to 4 times the maximum head from the notch.

The notch calibration tank situated at outdoor Model Area I is generally used for the calibration of notches from received from various irrigation projects of Kerala. In 2017-18 span two triangular notches received from Pothundy dam were calibrated.

A.2.6 Model study of proposed dam

The Chief Engineer I&D had instructed KERI to conduct the model studies of stilling basin and river outlet work of Pattisseri Dam and available details were collected from IDRB required to fix the scale of the physical model. The terms of reference for the study, DPR, Topographic survey details and longitudinal and cross-sectional details of canals were provided to this office by November, 2017. As the division has not conducted any physical model studies for the past 15years owing to different factors like retirement of experienced engineers in this kind of work from the department and the division lacks skilled labourers on regular appointment, proposal for a proper regular guidance from an expert was sought for executing the study. Experts in field as well as academic institutions were contacted for assistance and guidance with regard to physical as well as numerical model study.

In order to carry out the numerical modelling for Pattissery Dam, the faculty at Government Engineering College, Thrissur were contacted to explore the possibility of engaging M.Tech students to do this study as their M.Tech thesis and give us the result based on the hydraulic details to be provided by us. Subsequently, a part of the numerical model study of Pattissery dam was entrusted to a PG student in GEC Thrissur (with specific objectives of 2D and 3D analysis of the Pattissery dam spillway (revised design) for different spillway gate opening condition and optimization of the height of training walls in stilling basin by numerically stimulating the flow over the

spillway and stilling basin using ANSYS FLUENT software) and 70% of that part of study was completed by March, 2018. To get the analysis of all the remaining parameters, faculty at GEC Thrissur agreed in principle to assign these objectives as M.Tech thesis work for their students in coming batches.

Proposals were also put up for physical model study in collaboration with CWPRS Pune, IRI Roorkee, NIT Calicut, NIT Surathkal and College of Engineering Trivandrum. The faculty at Department of Civil Engineering, College of Engineering, Trivandrum expressed willingness in collaborating with KERI and also agreed to act as subject experts for the revival of physical model studies at KERI.

B. COASTAL ENGINEERING DIVISION

B.1 Introduction

Coastal Engineering Division was established for the purpose of conducting research works on behavior of Kerala Coast. This division has been started functioning from the beginning of the institute itself. Several research works on coastal protection measures, experimental study of wave run up on beaches, experiments to evolve suitable artificial blocks, study on mud banks, wave action on beaches, waves and currents, littoral drifts, artificial nourishment etc., had been conducted by this division. The model study of fishing gaps, design of fishing harbours like Mopla bay, Ponnani, Vizhinjam etc., were also conducted by this division during 70's and 80's. Collection of wave data and observation of beach characteristics have been carried out at several stations along the Kerala coast in the new moon day of all month for assessing the changes of Kerala Coast over years. Among these stations, observations at two stations i.e., at Padinjare Vemballore and Anchangadi in Kodungallur Taluk used to be carried out by this division till December, 2013.

As a part of modernization of Kerala Engineering Research Institute (KERI), a Smart Station from Leica Geosystems has been purchased in the financial year 2013-14 which is a new revolutionary surveying system in which high performance Total Station

(TS11) and a powerful GNSS Receiver (GS14 satellite receiver) are perfectly integrated. The main components of Smart Station are Base station GNSS and Smart Antenna, RTK Rover GNSS with Pole, Antenna and CS10 Field Controller (Smart Pole) and Total station with back sight Tripod kit. For the fast progressing of survey, one more Smart Pole has been purchased during this financial year 2016-17. Presently this division is engaged in conducting topographical survey works for investigations related to Kerala Irrigation Department.

The works carried out by this division under the action plan for the financial year 2017-18 can be grouped under two categories.

I. Fundamental studies using Smart Station

All topographical survey works related to Kerala Irrigation Department carried out using Smart Station has been included in this category**.**

II. Routine activities of the Coastal Engineering Division

The works under this category include maintenance of the Division office including maintenance of computers, purchase of essential furniture, consumable office supplies, small repair works to division office etc., maintenance of Director's and Joint Director, Hydraulic Research's Office including maintenance of computers, purchase of consumable office supplies etc., and maintenance of an outdoor model area which was used for physical model studies on Kerala Coast in past years.

Apart from the works in action plan, several investigation works under KIIFB scheme, a deposit work of Agricultural Department at District Agricultural farm Neriyamangalam etc., has also been carried out during the financial year, 2017-18.

The highlights of works taken up by this division during the year 2017-18 are as follows:

I. Fundamental Studies using Smart Station

A. Topographical Survey for the construction of a Check Dam across Puzhakkal River at Thrissur.

This estimate is prepared based on the request received from the Executive Engineer Irrigation Division, Thrissur. The purpose of this investigation survey was to assess the possibility of construction of a Regulator/Check Dam to store the water in summer season. The proposed site is in Puzhakkal River approximately 400m downstream of PWD Bridge at Puzhakkal in front of Sobha City in Kunnamkulam–Thrissur Road. The position (i.e., latitude and longitude) of these sites has been fixed and connected with Mean Sea Level (MSL).Required cross sections and longitudinal section of river and banks has been plotted for designing the structure.

B. Survey of site at Vandipperiyar for connecting to MSL

This work has been taken up as per the verbal direction of the Chief Engineer, ISW which is conveyed by the Director, F&AR, KERI, Peechi through telephone. The purpose of this work is to connect a site at Vandipperiyar to MSL. The level has to be connected from the permanent benchmark point at CWC office, Vandipperiyar. The distance from the known BM point to the point where the level is to be transferred is about 17km. Out of this 17km, last 8km is thick forest area. The proposal was to take fly level from the known point using Smart station.

The highlights of the work are:

- ***Located a permanent benchmark connected to MSL at Central Water Commission, Vandipperiyar.***
- ***Located a higher altitude point near Vallakkadavu (near CSI church/earthquake office) from where both Mullapperiyar Dam and Vandipperiyar is visible and Base station set up there.***
- ***Altitude of base is corrected with respect to the permanent bench mark at Vandipperiyar.***
- ***Bench Mark Stone at Mullapperiyar is connected from the corrected base station using Rover GPS.***

C. Topographical Survey for the construction of a Regulator in the downstream side of Enamakkal regulator at Kolumad

This Topographical Surveywork is done based on the letter received from the Executive Engineer, Additional Irrigation Division, Thrissur. The proposed site is for the Construction of regulator across Puzhakkal Thodu, downstream of Enamakkal Regulator at Kolumad, which is approximately 3km downstream of Enamakkal regulator. Chettuva sea mouth is approximately 11km downstream of proposed structure and Kandasamkadavu Bridge is nearly 4km downstream. The purpose of regulators is the prevention of salt water intrusion and makes sure the availability of clean water at upstream side.

The highlights of the work are:

- ***Fixing of position (i.e., latitude and longitude) of these sites.***
- ***Connecting the site with Mean Sea Level (MSL)***
- ***Conducted survey in river and bank for cross sections at particular intervals(at 30m interval for a length of 200m in u/s, 50m interval for next 500m, 250m interval for a total of 3.3km including d/s 1km and u/s balance 2.3km) for Designing the structure.***


D. Topographical Survey for the construction of a checkdam at Kalleppadam - Kallamkadavu across Gayathripuzha at Pazhayannur Gramapanchayath

This work has been taken up based on request received from the Executive Engineer, Additional Irrigation, Thrissur. The topographical survey is proposed for investigating the possibility of Construction of a Checkdam across Gayathri River at Kalleppadam-Kallamkadavu in Pazhayannur Gramapanchayath. The proposed site is approximately 3.3km upstream of existing Cheerakuzhi Weir and 0.5km downstream of confluence of two tributaries of Gayathri River namely Tharurpuzha and Plazhipuzha. The highlights of the work are:

- ***The top level of existing Cheerakuzhi weir has been connected in order to determine the effect of back up water in the proposed structure when Cheerakuzhi Weir is in FRL.***
- ***The position of the site has been fixed(i.e., latitude and longitude),survey has been carried out for finding the required cross sections and longitudinal section of river and banks at particular intervals(30m, 50m & 100m)for designing the structure.***

E. Fixing FRL of Neyyar Reservoir near Kerala –Tamil Nadu Boundary

The Executive Engineer, Irrigation Division, Thiruvananthapuram requested to assist Project Authorities to conduct a survey for supporting arguments in a Supreme Court Case regarding Neyyar Irrigation Project. So this work has been taken up. The main aims of the project were

- ***To find out whether the FRL is within the Kerala Boundary by fixing the Kerala - Tamil Nadu Border as per the direction of Project Authorities under the guidance of Revenue Authorities.***
- ***To demarcate FRL of Reservoir near Kerala – Tamil Nadu border using Smart station.***
- ***To stake out the points i.e., locating the points at state border and FRL near border (18Nos.) as per geo-referenced GTS map which had been supplied by ISW officials.***

The above tasks have been done satisfactorily and the report has been submitted.


F. Topographical Survey for estimating capacity of Pathazhakundu Reservoir in Thekkumkara Panchayath of Thrissur District

This work has been taken up as per the request of Executive Engineer, Minor Irrigation Division, Thrissur for estimating the present capacity of Pathazhakkundu Reservoir in Thekkumkara Panchayathat at full reservoir level (FRL).

The works done are:

- **Existing dam structure and associated features has been plotted.**
- **Entire area (in water and in land portion) at FRL has been surveyed in cross sections at 25m intervals with points at 2m intervals.**
- **The site has been connected with MSL from permanent bench mark available at Shobha City nearly 16km away, where we had established a permanent bench mark for a work under this division.**


G. Topographical Survey for estimating capacity of Asurakkundu Reservoir in Mullurkkara Panchayath of Thrissur District

This work has been taken up as per the request of Executive Engineer, Minor Irrigation Division, Thrissur for estimating the present capacity of Asurakkundu Reservoir in Thekkumkara Panchayathat at Full Reservoir Level (FRL).

The works done are:

- **Existing dam structure and associated features has been plotted.**
- **Entire area (in water and in land portion) at FRL has been surveyed in cross sections at 25m intervals with points at 2m intervals.**
- **The site has been connected with MSL from permanent bench mark available at Cheruthuruthy Bridge, where we had already established a permanent bench for a work under this division.**

III. Routine activities of the Coastal Engineering Division for the year 2017-18.

Routine activities of the Coastal Engineering Division office and the Offices of the Director, F & AR and the Joint Director, Hydraulic Research

This work has been included in the action plan for meeting the routine activities of Coastal Engineering Division office and offices of the Director, F&AR and Joint Director, Hydraulic Research.Maintenance and repairing of computer and related accessories, purchase of computer related items, purchasing of Photostat + Scanner + Printer machine, purchasing stationary items, purchasing of Steel shelf to Joint Director's office etc., has been done. Providing grill in the backside of the Director Office building has also been done.

III. Maintenance of the model area of the Coastal Engineering Division

A model area where physical model studies related to Kerala Coast had been conducted in previous years is maintained by this division. All works such as clearing the bushes, routine cleaning of model trays, overall upkeep of model sheds for keeping this area spick and span had been done.

IV. Annual Maintenance and purchase of accessories for Smart Station

This work has been included for the annual maintenance of Smart station and for the purchase of accessories and any spare parts if required. As the Smart station is a sophisticated electronic equipment, annual calibration and maintenance are essential so as to ensure the accuracy of the position data given by the instrument. Internal batteries for the instrument have been purchased as spares to avoid delay in works. Life jackets, buoys etc., has been purchased so as to ensure the safety of the persons involving in the river surveys.

ADDITIONAL WORKS USING SMART STATION

A. KIIFB WORKS

1. Construction of Regulator across Manimala River on the downstream side of intake well of RWSS to Nedungunnam and Kangazha at Kulathoormuzhy, Kottangal Panchayath in Ranni Constituency.

The purpose of this topographical investigation survey is to assess the possibility of construction of a regulator across Manimala River at Kulathoormuzhy. This work of topographical survey using smart station under KIIFB projects has been done as per the instruction of Chief Engineer, Irrigation & Administration through E-mail dated: 1st June, 2017 forwarded by the Joint Director, Dam Design, IDRB by E-mail dated: 9th June, 2017.

The highlights of the execution of survey and its outcomes are as follows:

- ***The survey has been progressed from proposed site towards upstream till it reaches the existing check dam at a distance of 2km.***
- ***River bank has also been surveyed for ascertaining enough bank height for water storage.***
- ***Plan, Cross sections, longitudinal section and contour maps at 2m interval have been prepared as per design requirement.***
- ***Roads, buildings and other permanent structures have been plotted.***
- ***The existing PWD bridge is only 180m upstream of proposed site.***
- ***The bed level varies from +3.75m to +5.00m at proposed site.***
- ***The ground level at banks at proposed site is above +11.00m***
- ***Sufficient bank height for water storage is observed throughout the surveyed length.***
- ***Observed an irregular bed level pattern due to excessive sand mining and due to this, no gradual bed slope is observed in longitudinal section.***

2. Construction of a Regulator across Manimala River at Pullukuthy on downstream side of intake well of RWSS to Mallappally, Anikkadu and Kottangal (part) Panchayath Phase I.

This work has been done as per the instruction of Chief Engineer, Irrigation & Administration through E-mail dated: 1st June, 2017 forwarded by the Joint Director, Dam Design, IDRB by E-mail dated: 9th June, 2017.

The highlights of the execution of survey and its outcomes are as follows:

- ***The survey has been conducted for 5.8km upstream of proposed regulator at Pullukuthy.***
- ***River bank has also been surveyed for ascertaining enough bank height for water storage.***
- ***Plan, Cross sections, longitudinal section and contour maps at 2m interval have been prepared as per design requirement.***
- ***Roads, buildings and other permanent structures have been plotted.***
- ***The average bed level at site is 0.00m MSL.***
- ***The ground level at banks at proposed site is above +8.00m***
- ***Sufficient bank height is available except near some cross sections.***
- ***Observed an irregular bed level pattern due to excessive sand mining and due to this, no gradual bed slope is observed in longitudinal section.***

3. Construction of regulators across Manimala river on the downstream side of Paduthodu bridge for the benefit of RWSS to Puramuttom and Ezhumattoor

This topographical survey using smart station under KIIFB projects has been done as per the instruction of Chief Engineer, Irrigation & Administration through E-mail dated: 1st June, 2017 forwarded by the Joint Director, Dam Design, IDRB by E-mail dated: 9th June, 2017.

The highlights of the execution of survey and its outcomes are as follows:

- ***The survey has been conducted from 800m downstream of proposed structure till it meets the site for proposed structure at Pullukuthy, which is 6.8km upstream.***
- ***River bank has also been surveyed for ascertaining enough bank height for water storage.***
- ***Plan, Cross sections, longitudinal section and contour maps at 2m interval have been prepared as per design requirement.***
- ***Roads, buildings and other permanent structures have been plotted.***
- ***The existing PWD bridge is only 180m upstream of proposed site.***
- ***The bed level varies from -0.30m to +1.26m at proposed site.***
- ***The ground level at banks at proposed site is above +9.00m.***
- ***The bank height is more than +5.00m throughout the surveyed stretch except some places where streams meets the main river.***

Sand mining on the river bed has led to irregular bed levels and due to this the longitudinal section is not showing natural slope.

4. Construction of Regulator across Ummenchira puzha at Chekkupalam in Pinarayi panchayath, Kannur District

This topographical survey for the Construction of Regulator across Ummenchira River in Pinarayi Grama Panchayath in Kannur District using smart station under KIIFB projects has been done as per the instruction of Chief Engineer, Irrigation & Administration through E-mail dated: 1st June, 2017.

The highlights of the execution of survey and its outcomes are as follows:

- ***The survey has been progressed from proposed site towards upstream for about 3.4km and downstream about 0.84km.***
- ***River bank has also been surveyed for ascertaining enough bank height for water storage.***
- ***Plan, Cross sections, longitudinal section and contour maps at 2m interval have been prepared as per design requirement.***
- ***Roads, buildings and other permanent structures have been plotted.***
- ***There is an existing Bridge at the proposed site.***
- ***The bed level varies from -5.0m to -0.5m at proposed site.***
- ***The top level of existing bridge is +4.65m.***
- ***There is not much change in bed level in this stretch of survey and hence a flat slope is observed.***

5. Construction of Regulator at Parapram across Anjarakandy River in Pinaray Grama Panchayath in Kannur District

The work has been done as per the instruction of Chief Engineer, Irrigation & Administration, Thiruvananthapuram through E-mail dated: 1st June, 2017.

The highlights of survey are:

- ***The survey has been progressed from proposed site towards upstream for about 5.4km and downstream about 1.1km.***
- ***River bank has also been surveyed for ascertaining enough bank height for water storage.***
- ***Plan, Cross sections, longitudinal section and contour maps at 2m interval have been prepared as per design requirement.***
- ***Roads, buildings and other permanent structures have been plotted.***
- ***The existing Regulator cum Bridge is only 17m downstream of proposed site.***
- ***The lowest bed level is-4.501m at proposed site.***
- ***The ground level at banks at proposed site is above +0.50m.***
- ***There is not much change in bed level in this stretch of survey and hence a flat slope is observed.***

5. **Investigation for the construction of RCB across Neyyar River at Mavilakkadavu, d/s of KWA pump house prevent salinity intrusion**.

The aim of this investigation work is the construction of regulator cum bridge across Neyyar River at Mavilakkadavu, downstream of KWA pump house to prevent salinity intrusion. This has been done as per the instruction of the Director, Fundamental and Applied Research, KERI, Peechi.

The highlights of the execution of survey and its outcomes are as follows:

- ***The survey has been conducted from 0.9km downstream of proposed structure and 5.9km upstream.***
- ***River bank has also been surveyed for ascertaining enough bank height for water storage.***
- ***Plan, Cross sections, longitudinal section and contour maps at 2m interval have been prepared as per design requirement.***
- ***Roads, buildings and other permanent structures have been plotted.***
- ***There is an existing PWD bridge and a water authority pipeline bridge which is only 36.60m downstream of proposed site***
- ***The bed level varies from -2.370m to -0.485m at proposed site.***
- ***Sand mining on the river bed has led to irregular bed levels and due to this the longitudinal section is not showing natural slope.***
- ***The width of river course at some places is 4 to 5 times of river width at proposed site which may be due to encroachments.***
- ***On local enquiry it is understood that some land at banks will be flooded during spilling of Neyyar Dam. Hence construction of the regulator can be done only after assessing the impact of storage on banks at upstream of proposed structure***

A. Deposit works

1. Survey at District Agricultural farm Neryamangalam using Smart Station.

The object of this work is to conduct topographical survey of the proposed site inside District Agricultural Farm, Neryamangalam where a natural seasonal stream is draining to a valley and prepare plan, cross sections & contour maps at suitable intervals to explore the possibility of constructing a check dam for effective management of available water and further developing this site as a tourist spot.

Assistant Executive Engineer (Agriculture), CSEZ, Ernakulam vide letter AE(3) 480/16 dated:16/02/2017 requested Director, Fundamental & Applied Research, KERI to conduct investigation works for the feasibility study of construction of pond and check dam in District Agricultural Farm, Neryamangalam to ensure the water availability during summer seasons too. As per Director's instruction, the topographical survey of the proposed site has been taken up by this Division. The survey had been conducted during June, 2017.

The results of the execution of survey and its outcomes are as follows:

- ***Topographical Survey has been conducted over an area of 11.86 Hectares.***
- ***Plan, Cross sections and contour maps at 2m interval have been prepared.***
- ***Roads, buildings and other permanent structures have been plotted.***
- ***Elevation of boreholes at centre line of proposed structure and at abutment portion have been determined.***

2. Name of work: Topographical survey for regulators at Vamanapuram River using smart station

Kerala Irrigation Infrastructure Development Corporation (KIIDC) requested the technical assistance of Kerala Engineering Research Institute (KERI) in conducting topographical survey of three regulators in Vamanapuram River vide their letter dated: 12/04/2017. The proposed sites as per their request letter are regulators at Ayilamkadavu in Mudakkaj Panchayath and Koottapparakkadavu in Vamanapuram Panchayath. Detailed discussions have been carried out with IDRB officials who are in charge of design of these structures and estimate is prepared based on the design requirement.

The proposal included fixing of position (i.e., latitude and longitude) of these sites, connecting these sites with Mean Sea Level (MSL) and carrying out survey for finding the required cross sections and longitudinal section of river and banks for designing the structure.

Other works

1. **Name of work: De siltation of Chulliar Dam – Qualitative Analysis – Fixing Ground Level at Borehole Locations**

Due to the silting up of reservoirs in Kerala, the total quantity of water storage is affected considerably which in turn affected the Irrigation and Drinking water distribution. Discussions were held at Government level regarding the desiltation of reservoirs in Kerala and it is decided to carry out desilting of reservoirs of Chulliar and Mangalam dams as pilot projects. As per the decisions taken at higher level meetings, it is decided to carry out the work of qualitative analysis of sediments deposited in the reservoir of these Dam by KERI.

Samples are collected and analyzed from a grid of size 50m x 50m and position of each sample location has to be specified in terms of latitude, longitude and altitude with respect to MSL. This Division has conducted the borehole location mapping work of Chulliyar dam.

2. **Conducting induction training to the Assistant Engineers of Irrigation department at Kerala Engineering Research Institute**

The Chief Engineer, Irrigation and Administration, Thiruvananthapuram, has given direction to conduct a training to the newly appointed Assistant Engineers (63 Nos.) of Irrigation Department about the various activities of KERI, its relevance in Irrigation Department and its future prospects. As per the Order No.D2.129/08 Part III dated:21/12/2017, the Director, Fundamental and Applied Research, KERI, Peechi assigned the duty of coordinating the training to the Deputy Director, Coastal Engineering Division. The training has been conducted for 3days on 14th, 15th and 16th of February, 2017.

C. SEDIMENTATION DIVISION

C.1 Introduction

The Kerala Engineering Research Institute, (KERI) Peechi, one of the pioneering research institutions of its kind in our country, plays a vital part in fundamental and applied research studies in the field of Civil Engineering. KERI conducts studies and research in the field of Civil Engineering for the State Government, Quasi Government Institutions and Private Organizations. The institute also undertakes project funded by organizations like Central Board of Irrigation and Power (CBIP), Indian National Committee for Hydraulic Research (INCH).

Sedimentation Division, of KERI conducts studies to compute the present capacity of reservoirs and other water bodies. Such studies are conducted using modern electronic equipment called 'Integrated Bathymetric System' (IBS). In 2004, KERI completed 30studies with this IBS including Mullapaeriyar and Vembanad Lake. In order to ascertain the availability of water and to estimate the siltation a new equipment called Sub Bottom profiler was purchased.

The main sources supplying the sediment, transported within the reservoirs, are the catchment, the river system, and various human activities. Sediment yield of a catchment is a result of natural processes such as soil erosion caused by water, wind and ice, reservoir shore degradation and landslides.

There are nine major factors affecting sediment yield of a drainage area. They are, rainfall amount and intensity, soil type, ground cover (vegetation, litter and rock fragments),land use, topography, erosion history, runoff, sediment characteristics and channel hydraulics.

In order to ascertain the availability of water and to estimate the siltation a new equipment called **Sub Bottom profiler** was used for the study.

KERI constituted a team consisting

THE SURVEY TEAM

Director	Er. Dr.A. Udayakumar
Joint Director	Basant K.B.
Team Leader	Shini K.K., Deputy Director

Technical Team

Roshni S S	Assistant Director
Sreejith K S	Assistant Director
Francy V Antony	Research Assistant
Devidath S Punnakkal	Research Assistant
Dhanya M P	IInd Grade Overseer
Ashok Kumar K S	Dept. Jeep Driver

Equipments used

- **Sub Bottom Profiler**

The system SES-2000 Sub-bottom profiler, which is a mobile parametric sediment sounder, was used for bathymetric and sub-bottom profiling survey. The SES-2000 hardware component and transducers are shown in Fig. 1 & 2.

Fig.1 Top-side Unit

Fig.2 Transducer

DGPS MX400

DGPS MX400 (Refer **Fig.3**) is highly reliable and it receives correction from a permanent reference station, which is approved by Government of India, Department of Light house and Light ship. It can also track up to 12satellites to achieve maximum

positional accuracy. The received position is transferred to Echo Sounder and Sub Bottom Profiler.

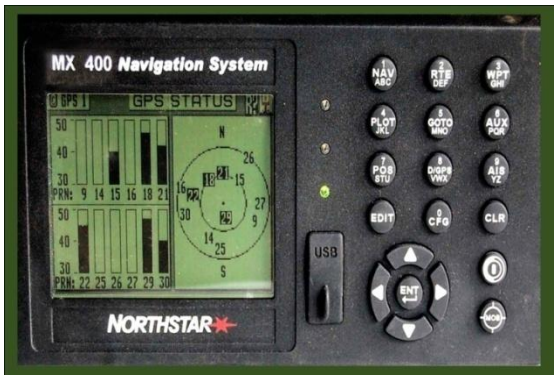


Fig.3 MX400 Navigation System

NS-415 Echo-sounder.

Navitronic Echo-sounder NS 415 is designed to measure under water depth up to 1200m. Accuracy of instrument is 1centimeter. A dual frequency echo-sounder is specified to distinguish between fluff top depth and the consolidated bottom. The high frequency (200 KHz) is used to detect the top of the mud/sediment. Under favorable conditions the low frequency signal (33KHz) can penetrate the bottom and reveal information about the bottom structure.

Fig.4 Echo Sounder

- **FRP Boat (mobile station)**

Survey Boat

A Fibre Reinforced Plastic (FRP) boat with two 60 HP petrol out board engines is used as the Survey Boat. The boat has dimension of 7.5m x 2.66m x 1.20m and 8persons

capacity with the equipment. The boat with all the survey equipment is referred as the 'mobile station'. For the power supply, two solar panels of 80Watt each are mounted on the roof of the boat.

Fig.5 FRP Boat

Fig.6 Equipment set up inside the Boat

Software

- **Navisoft survey software**
- **Surfer software**
- **SESWIN for data acquisition in SES 2000**
- **I.S.E. 2.9.2 Post Processing Software**

DATA COLLECTION

The mobile station consists of the DGPS and its antenna, Echo sounder, Sub Bottom Profiler and the transducers, etc., is mounted on the FRP boat. The transducer of Sub Bottom Profiler is permanently fixed at the center of the boat. The traducer of Echo sounder is connected to the left side of the boat and is detachable. Proper connections are made between these equipment and the laptops for the data collection. The boat is sailed along the planned track with a speed of 3 to 4knots. The data from the Echo sounder and Sub Bottom Profiler is collected simultaneously through two laptops as shown in fig.7.

Fig.7 Data Collection set up inside the Boat

For IBS Survey, the laptop loaded with Navisoft survey software is used. Navisoft is used for the Planning and Presentation, data collection and the data processing. The Navisoft Survey Module is used to collect the depth data from the echo sounder which is linked with the position data. The data is collected at the required interval and logged as "PRD" format data for further analysis.

The system**SES-2000**(Sediment Echo Sounder) Sub Bottom Profiler is a parametric (non-linear) dual frequency echo sounder. The instrument simultaneously transmits two signals of slightly different high frequencies; their interaction creates a new low frequency signal. It has a large bandwidth and a short signal length, which allows good use in very shallow water and results a high (~15–20cm) vertical resolution at

acceptable sub-bottom penetration up to 10m or more. Some favourable near sub-bottom seismic and geological conditions permit to achieve a vertical resolution up to 10cm. Parametric (non-linear) sound generation allows designing acoustical systems with small transducer dimensions and narrow sound beams at low frequencies. An Innomar SES-2000 parametric transducer has an active area of 20 by 20cm and provides a beam width of less than four degrees (at 3dB), valid for all adjustable low frequencies between 5kHz and 15 kHz. The transmit directivity of the parametric sound beam does not show any significant side lobe characteristic, which reduces ambiguities during the interpretation of individual reflectors. Short transmit signals of single sinusoidal cycles without any ringing and high ping rates of up to 50pings per second are further advantages. They contribute to a high spatial resolution of this acoustical system and permit to apply it in a shallow basin. Innomar's software tool ISE provides near real-time processing of the collected SES data. The operation procedure can be tuned online. A value of the sound velocity in water is used to convert sound travel time to the depth. The depth values are screened online.

Works carried out during 2017:

1. Sedimentation Survey of Kanjirapuzha Reservoir Using IBS & Sub Bottom Profiler.

Sedimentation Division, of KERI conducts studies to compute the present capacity of reservoirs and other water bodies.

The main aim of conducting a bathymetric survey at Kanjirapuzha reservoir is to make a detailed study of the siltation and sedimentation in the reservoir.

- ***To quantify or determine the present capacity of Kanjirapuzha Reservoir using IBS.***
- ***To find the quantity of sediment and its distribution in the reservoir using Sub Bottom Profiler.***
- ***To compare the present result with the previous study result, for analyzing the chronological sedimentation behavior of the reservoir.***
- ***To Study the soil particle distribution from the various parts of the reservoirs.***

The work was started on 12/10/2017 and completed 31/10/2017.

KANJIRAPUZHA PROJECT

Salient Features

1.	Name	Kannjirapuzha
2.	Location Longitude Latitude	 76^{o} 32'E 10^{o} 59'N
3.	Year of starting	1961
4.	Year of commissioning	1980
5.	Type of Dam	Straight gravity Masonry dam with earthen saddle dams
6.	Length of Masonry Dam	231.6m
7.	Length of Earthen Dam	1896.4m
8.	Height of Masonry Dam	38m
9.	Height of earth dam	28m
10.	Full reservoir level	97.5m
11.	Dead storage level	77.42m
12.	Catchment area	$70km^2$
13.	Maximum storage	$70Mm^3$
14.	Dead storage	$1.557Mm^3$
15.	Water spread area	5.15Sq.km
16.	Purpose	Irrigation

Study area

The Kanjirapuzha Irrigation Project is one of the medium irrigation system implemented in Palakkad District. The project was partially commissioned in 1980.The aim of Kanjirapuzha Irrigation Project initially was to irrigate the second crop and also to supplement the rainfall dependent crops in the season between the south-west and north-east monsoon in December & January. The cultivation prior to the completion of the project was dependent entirely on rainfall which is heavy in the catchment area but unevenly distributed. All low lying lands that can retains some moisture could rise two crops, while the high level lands could rise only single crop. The seeds for the first crop, which coincide with south-west monsoon are laid in the month of May. After two or three down poresand as soon as this is harvested, the land is prepared for other crops like banana, Ginger Pulses and other vegetations.

The project comprises of a storage reservoir of 70million cubic meter capacity, by constructing an earth cum masonry dam of 2128m length across Kanjirapuzha River at Pulikkal in Kanjirapuzha Grama Panchayat. The Kanjirapuzha River is a tributary of Bharathapuzha. The catchment area of the river above the dam site is 70sq.km, which is entirely in Kerala state. Kanjirapuzha Reservoir with its catchment is shown in fig.8.

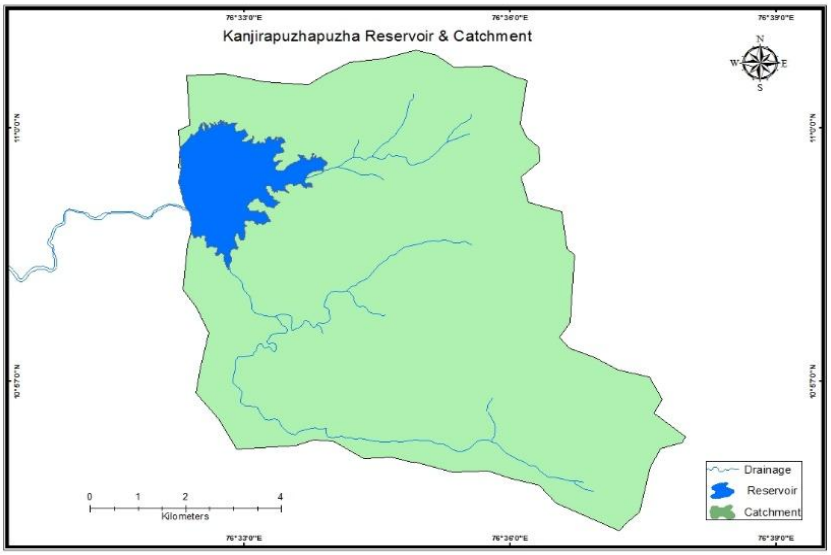


Fig.8 Kanjirapuzha Reservoir with catchment

Fig.9 View of Kanjirapuzha reservoir

Location

Kanjirapuzha Reservoir is constructed across the River Kanjirapuzha, in Mannarkkad, Palakkad District. The nearest town is Palakkad which is 46Km away from the dam site. The reservoir is located between 10^{o} 59'8.515''N latitude and 76^{o} 32'18.955''E longitude. Location details are shown in fig 10.

Fig.10 Location Map of Kanjirapuzha reservoir

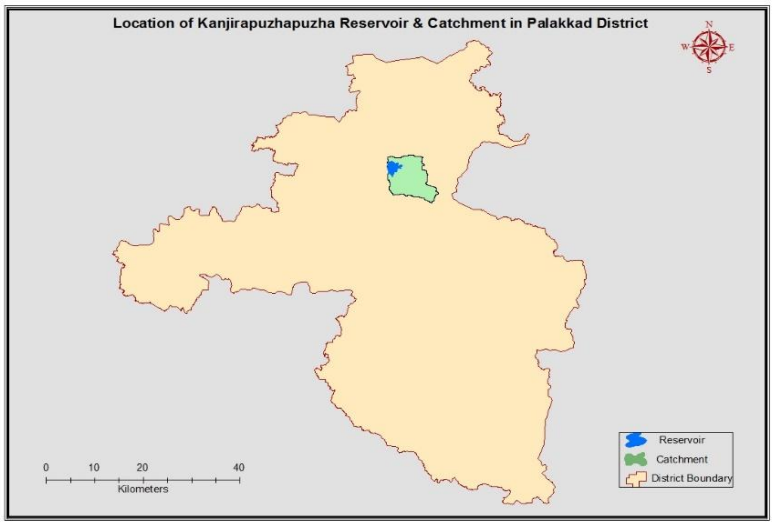


Fig.11 Location of Kanjirapuzha Reservoir in Palakkad District

The profiles show the depth of water at different locations along the track marked in the profile map of Kanjirapuzha Reservoir, and is shown in Fig.13 to Fig14.

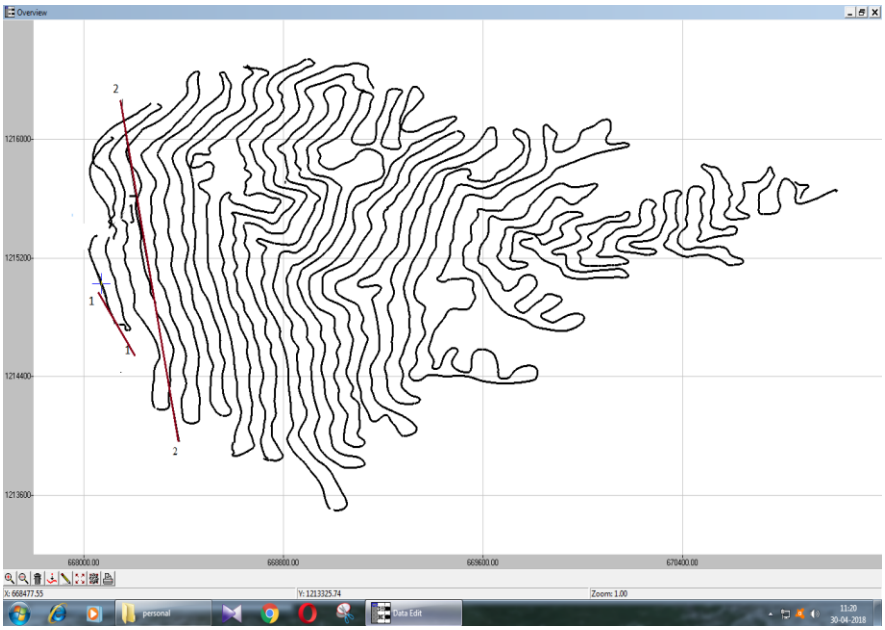


Fig.12 Plan of Kanjirapuzha Reservoir showing sections surveyed

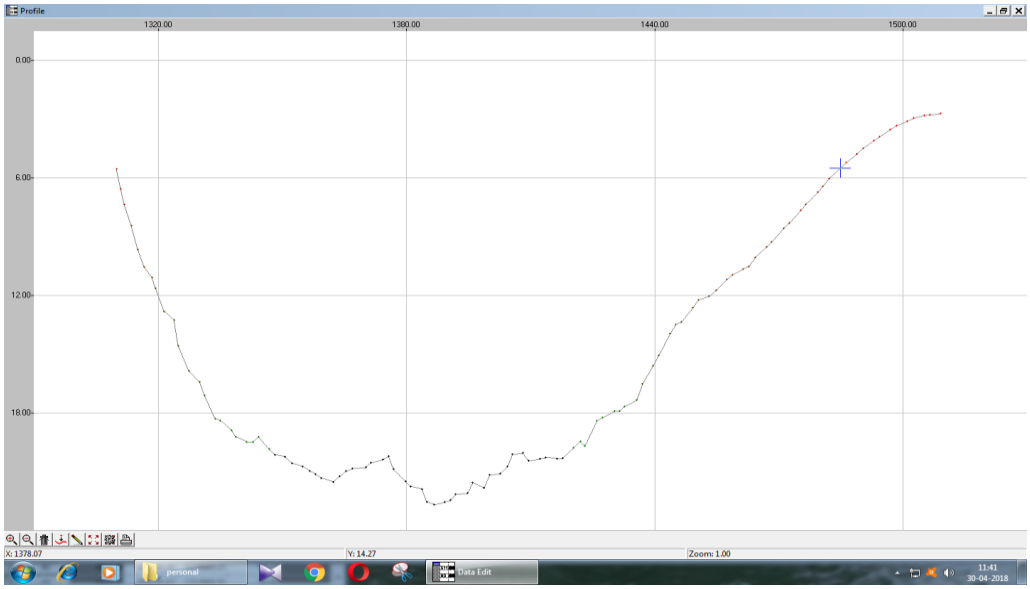


Fig.13 Profile 1-1 (E- 668144.20,N-1214751.06), (E -668136.92,N- 1214751.93)

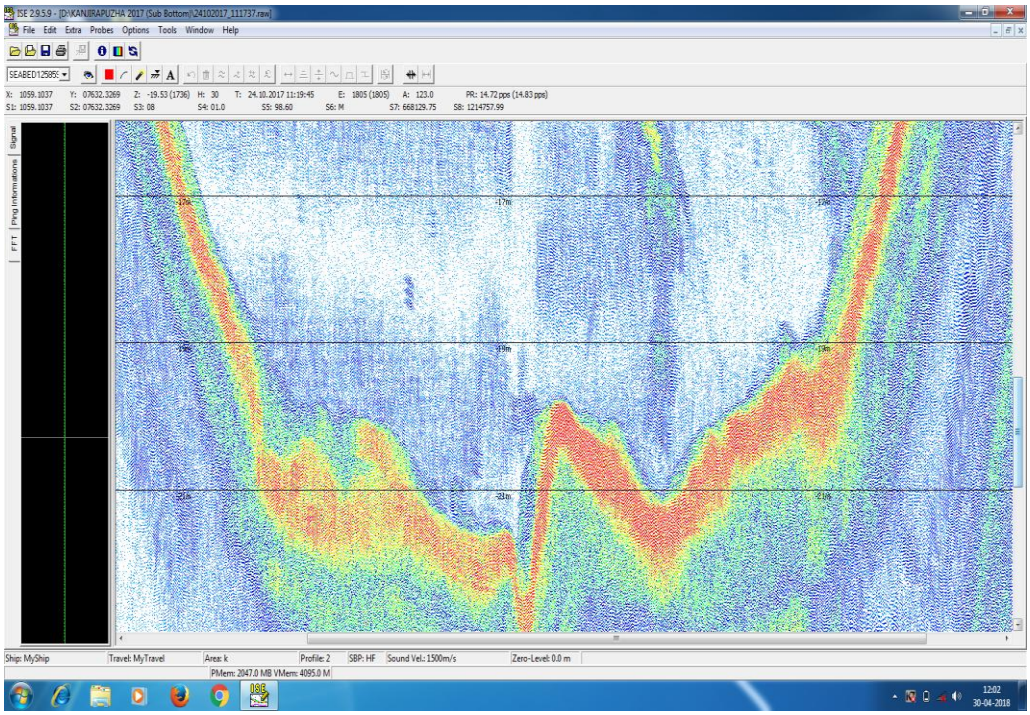


Fig.14 Sub Bottom Profile1-1
(E-668144.20, N- 1214751.06), (E- 668136.92,N- 1214751.93)

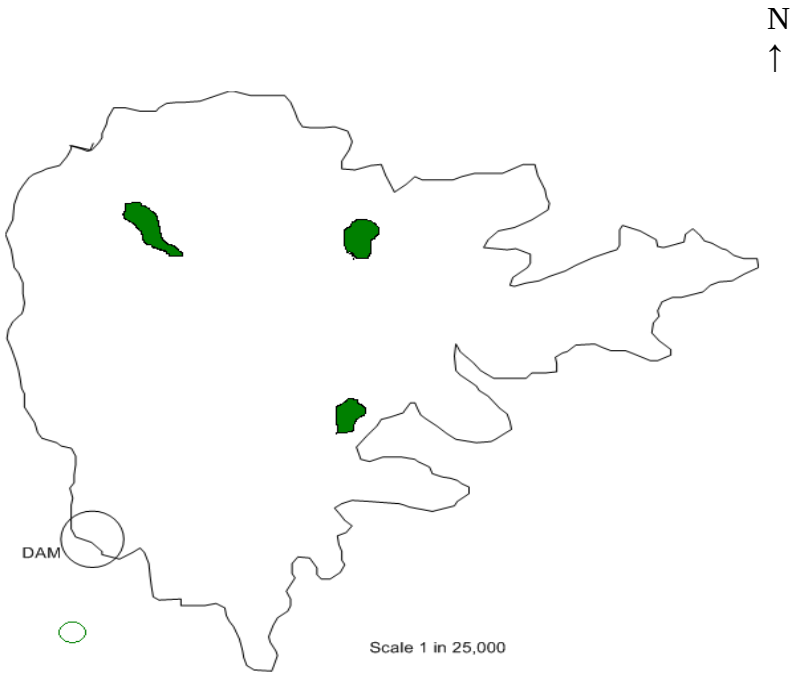


Fig.15 F.RL Map

Estimation of Capacity

The survey is carried out at the permissible maximum water level of 96.0m. The original water holding capacity at this level is 62.44 Mm^3. As per the current IBS study the volume at the same level is estimated as 49.16 $Mm^3$and the corresponding water spread area is 5.05Sq.km.Total capacity reduction of the reservoir is 13.28Mm^3in 37years, i.e., the reduction in capacity at the specified level is 21.27%. The capacity reduction is due to the sediment deposit.

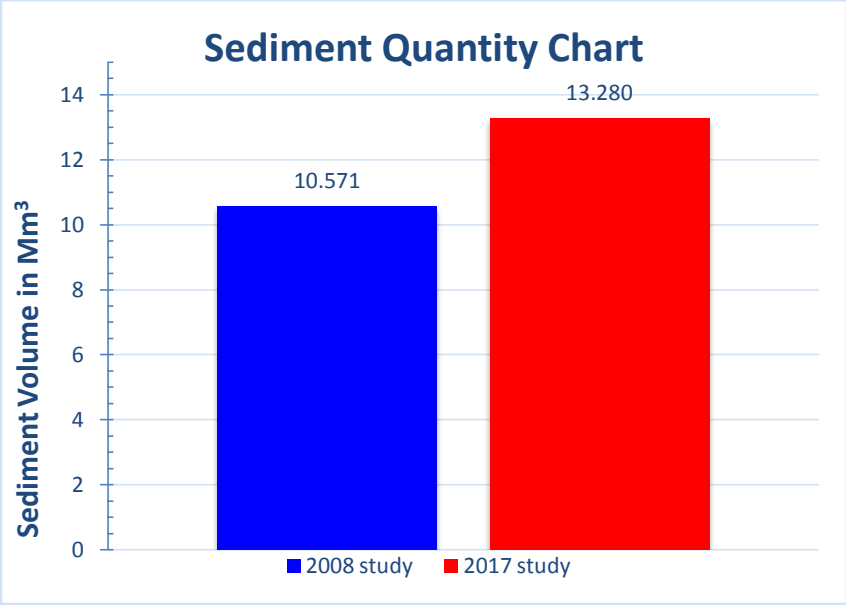


Fig.16 Increase in Sediment quantity

Table 1 shows the comparison in capacity of the reservoir between the two consecutive studies conducted in 2008 &2017.

Table 1 – Capacityreduction of the reservoir

Year of Study	Capacity	Reduction in Capacity w.r.t. Original Volume (62.44 Mm^3)	
		In Mm^3	In Percentage
2008	51.869	10.571	16.93
2017	49.160	13.280	21.27

The contour map of water spread area is shown in Fig 17 at an interval of 1m

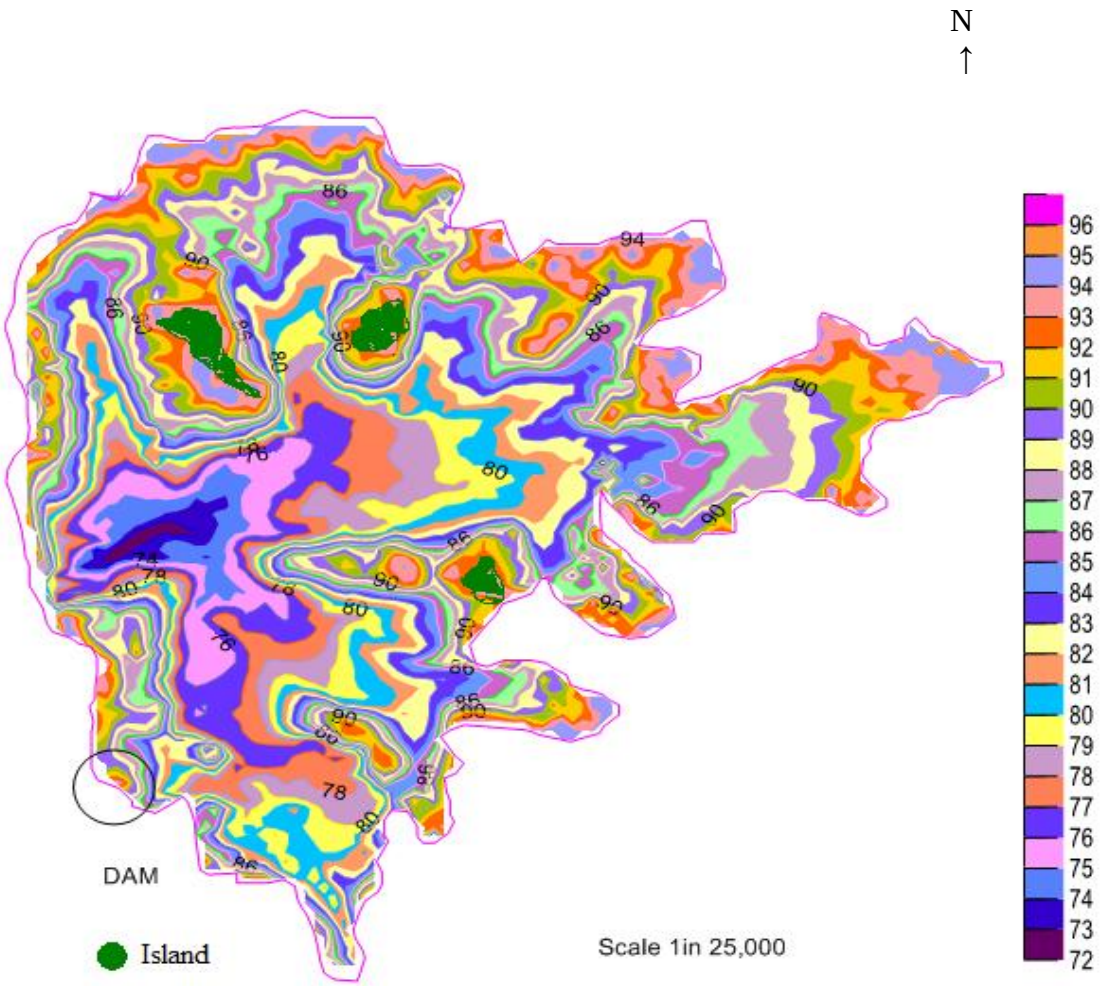


Fig.17 Contour Map based on IBS Survey

Capacity at Different Water Level

Reservoir volume at different water levels can be found out using the IBS data in SURFER software. The capacity reduction obtained from the IBS is comparable with the sediment volume calculated from the Sub Bottom Profiler. The present capacity at different level is compared with the original and IBS result in 2008 and is shown in Table 2.

Table-2 Reservoir capacity at different water levels.

Sl. No.	Water Level	Water Holding Capacity			Percentage Reduction in Capacity (IBS 2017)
		Original	IBS Survey 2008	IBS Survey 2017	
	m	M. Cub. m	M. Cub. m	M. Cub m	%
1	96	62.440	51.869	49.160	21.27
2	95	56.862	46.907	44.660	21.46
3	94	51.858	42.212	40.213	22.46
4	93	46.849	37.772	35.913	23.34
5	92	42.339	33.646	31.112	26.52
6	91	37.829	29.811	28.249	25.32
7	90	33.546	26.248	24.768	26.17
8	89	27.264	22.930	21.530	21.03
9	88	25.419	19.869	18.535	27.08
10	87	21.561	17.043	15.785	26.79
11	86	18.051	14.463	13.288	26.39
12	85	14.586	12.116	11.027	24.40
13	84	11.470	9.992	8.990	21.62
14	83	8.354	8.083	7.180	14.05
15	82	7.408	6.395	5.584	24.62
16	81	5.492	4.913	4.191	23.69
17	80	4.253	3.625	3.001	29.44
18	79	3.180	2.529	2.022	36.42
19	78	2.286	1.626	1.248	45.41
20*	**77.42**	**1.557**	**1.198**	**0.894**	**42.58**
21	77	1.350	0.934	0.683	49.41
22	76	0.718	0.450	0.323	55.01
23	75	0.394	0.157	0.125	68.27
24	74	0.182	0.026	0.040	78.02
25	73	0.182	0.026	0.014	92.31

***Dead Storage Level**

The original storage capacity curve is compared with the same obtained from the IBS surveys in 2008 and 2017 as shown in Fig.18.

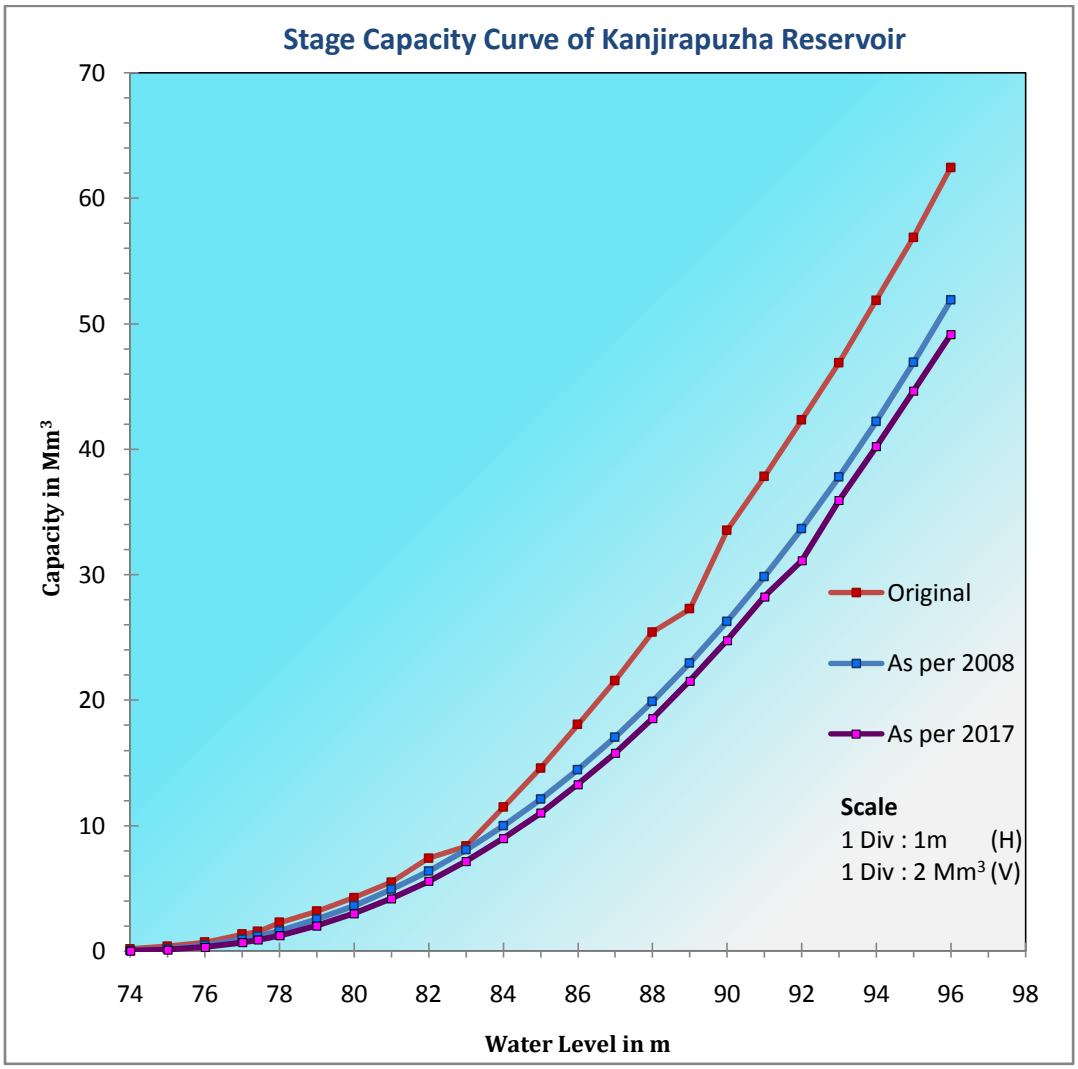


Fig.18 Water level v/s water holding capacity curve

Water Spread Area at Different Water Level

The present water spread area at different level is compared with the original and IBS result in 2008 and is shown in Table 3.Fig.19 shows its graphical representation

Table 3 Water spread area at different water levels.

Sl. No.	Water Level	Water Spread Area		
		Original	IBS Survey 2008	IBS Survey 2017
	m	Sq.km	Sq.km	Sq.km
1	96	5.15	5.2	5.05
2	95	4.9	4.8	4.47
3	94	4.74	4.57	4.27
4	93	4.36	4.29	4.01
5	92	4.09	3.98	3.70
6	91	3.87	3.7	3.50
7	90	3.64	3.44	3.30
8	89	3.41	3.19	3.07
9	88	3.09	2.95	2.85
10	87	2.87	2.71	2.60
11	86	2.65	2.46	2.36
12	85	2.35	2.24	2.13
13	84	2.14	2.01	1.91
14	83	1.92	1.8	1.69
15	82	1.69	1.58	1.48
16	81	1.44	1.39	1.29
17	80	1.29	1.19	1.08
18	79	1.07	1	0.87
19	78	0.88	0.8	0.67
20	77.42	0.750	0.700	0.54
21	77	0.64	0.58	0.45
22	76	0.45	0.38	0.26
23	75	0.33	0.21	0.13
24	74	0.17	0.056	0.05
25	73	0.17	0.056	0.012

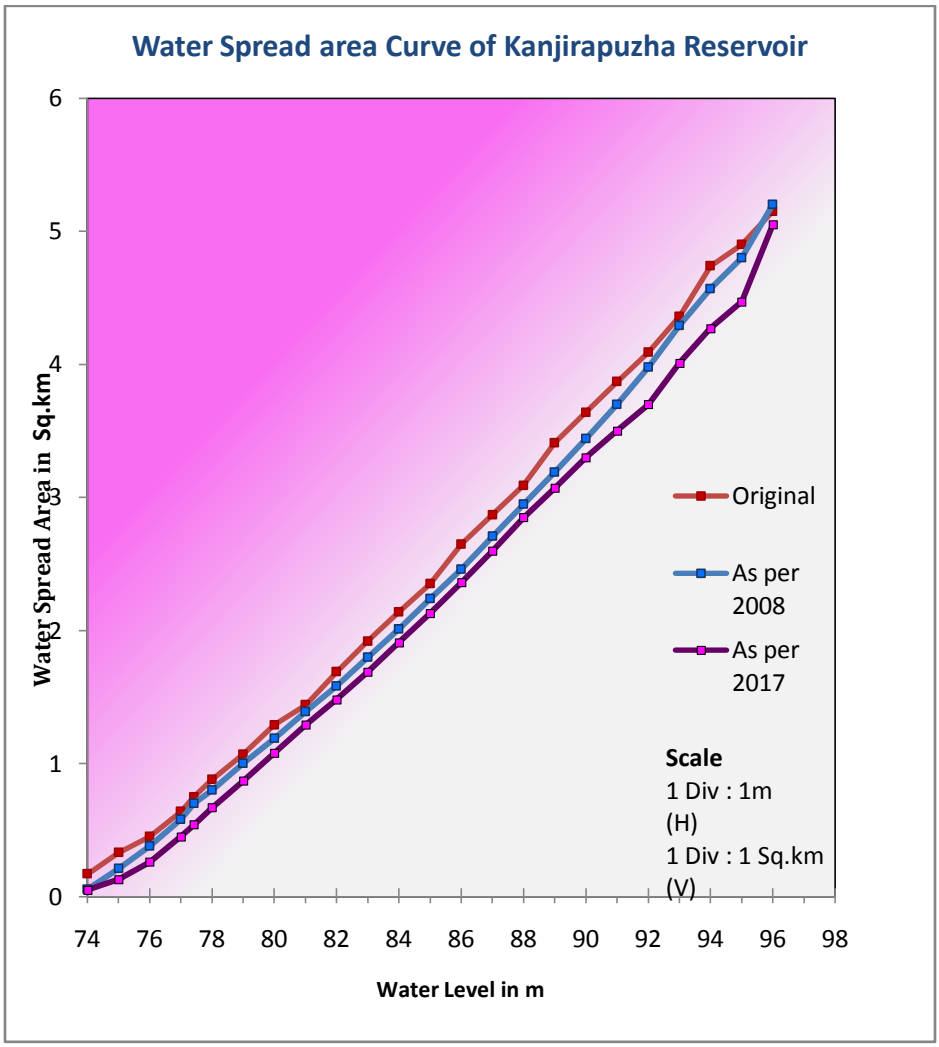


Fig.19 Water level v/s water spread area curve

Classification of soil

Soil Sample Collection

Disturbed soil samples were collected using grab type mud sampler (only surface soil) from 13locationsin the reservoir. The sample collection locations are shown in Fig.20**.** Undisturbed samples cannot be collected using this type of sampler. These soil samples were analyzed in Soil Mechanics and Foundations Division, KERI, Peechi.

Fig.20 Soil sample collection

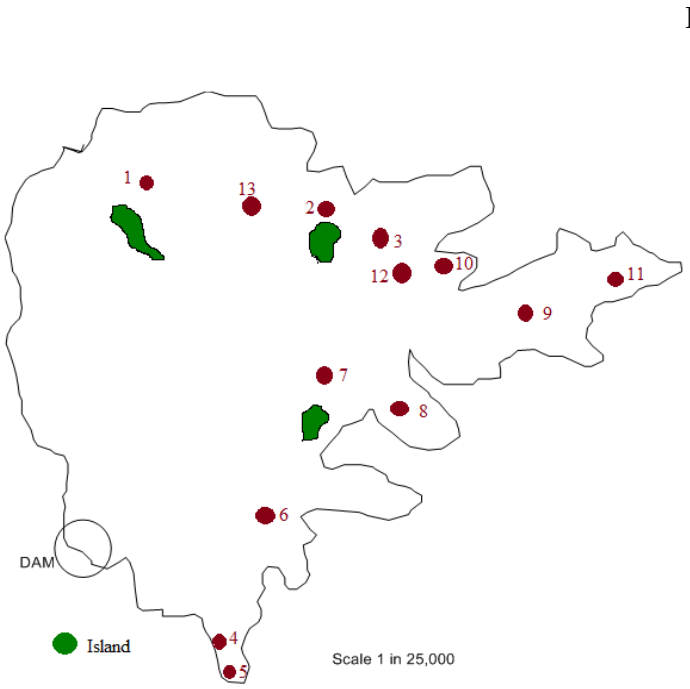


Fig.21 Location of Soil sample

Analysis of soil sample

In the sedimentation study conducted in 2008, 12 Nos. of disturbed soil samples were analyzed. In the present study 13 No of soil samples are analyzed. Since the samples for both the studies were collected from different locations, the average percentage of Clay, Silt, Sand and Gravel are almost same. The details are shown in the bar chart given in Fig.22

The result of soil sample analysis are shown in Table 4.

Sl. No.	Pit No. (Position)	Depth of Sample taken in m	Nature of sample	Soil texture	Colour	Specific gravity	Class	% of Various size of Soil Particle				Uniformity Coefficient
								Clay	Silt	Sand	Gravel	
1.	N-1215996 E- 668514	10.00	Disturbed	Siltysoil	Light Brown	2.09	SM-SC	18	32	49	1	-
2.	N-1215976 E- 669144	14.20	Disturbed	Ordinary soil	Light Buff	2.50	SM-SC	12	13	60	15	-
3.	N-1215871 E-669356	10.75	Disturbed	Ordinarysoil	Light brown	2.20	SM-SC	17	24	41	18	-
4.	N-1213693 E-668814	8.00	Disturbed	Sandy soil	Light Brown	2.39	SP	3	7	90	0	4.77
5.	N-1213576 E-668991	4. 00	Disturbed	Silty soil	Light Brown	1.99	SM-SC	8	36	56	0	38.57
6.	N-1214506 E-669102	16.00	Disturbed	Sandy soil	Light Brown	2.42	SM-SC	7	13	80	0	46.84
7.	N-1215122 E-669210	18. 00	Disturbed	Silty soil	Light Brown	2.03	SM-SC	10	28	62	0	52.75
8.	N-1214929 E-669712	13.00	Disturbed	Silty soil	Light Brown	2.18	MH	34	56	10	0	4.83
9.	N-1215388 E-670244	10.00	Disturbed	Silty soil	Light Brown	2.19	MH	20	36	44	0	24

10.	N-1215607 E-669830	12.00	Disturbed	Sandy soil	Light Brown	2.27	SW	6	6	88	0	17.36
11.	N-1215519 E-670717	5.00	Disturbed	Silty sand	Light Brown	2.06	SM-SC	6	20	73	1	34.92
12.	N -1215845 E-669564	10.00	Disturbed	Silty sand	Light Brown	2.04	SM-SC	11	38	51	0	17.41
13	N-1216237 E-669082	11.00	Disturbed	Sandy soil	Light Brown	2.31	SM-SC	15	32	51	2	25.63

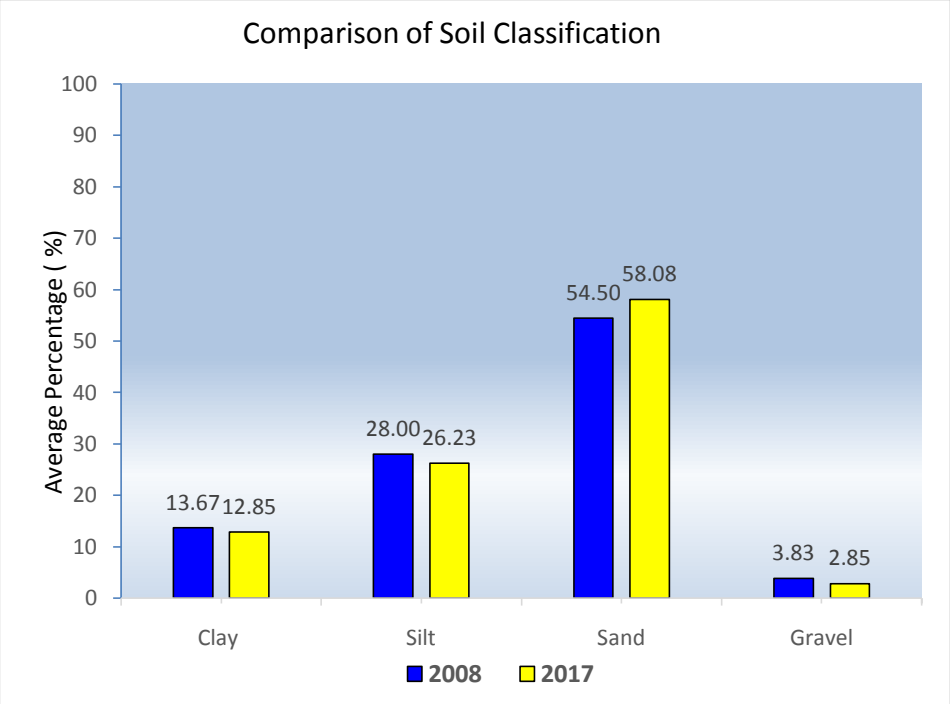


Fig.22 Comparison of Soil particle distribution as per two consecutive

Sedimentation Study

The percentages of soil particles are only indicative and not accurate. For accurate assessment of contents in the soil, core sample analysis has to be done.

RESULT AND DISCUSSION

The original capacity of Kanjirapuzha Reservoir at 96.0m level is 62.44Mm^3. The present capacity is 49.160 Mm^3.The capacity reduction of the reservoir is 13.28Mm^3in 37years at the same level.

- *As per the IBS **Survey 2008**, the Reservoir capacity was 51.869 Mm^3at permissible maximum water level of 96m and Capacity was reduced by 10.571 Mm^3 in 28years @ 0.375 Mm^3/per year.*
- *The average thickness of the sediment deposit corresponding to the original water spread area 5.15Sq.km was2.05m in 28years, the rate of deposition 7.3cm/Year.*
- *The original volume at dead storage level (77.42m) was 1.557Mm^3, volume reduced to 1.198Mm^3 in 28years. Reduction percentage is 23.05%.*
- *In the **present study**, the Reservoir capacity is 49.16Mm^3at the permissible maximum water level of 96m and Capacity is reduced by 2.709Mm^3 in 9years @ 0.301Mm^3/per year.*
- *The average thickness of the sediment deposit was 0.53m in 9years, the rate of deposition 5.8cm/Year.*
- *Volume at dead storage level is 0.894m^3, Percentage reduction in dead storage is 42.58% in 37years. Within the last 9 years dead storage capacity reduced by 19.53%.*

Sediment layer profile of the reservoir area at an interval of 75m is obtained from the Sub Bottom profiler.

During the first 28years of the dam life the capacity reduction rate was 0.60% per year. Within the next 9year, the reduction rate is 0.48% per year. It indicates that the rate of sedimentation is gradually decreasing.

The graphical representation of reduction and rate is shown in Fig.23

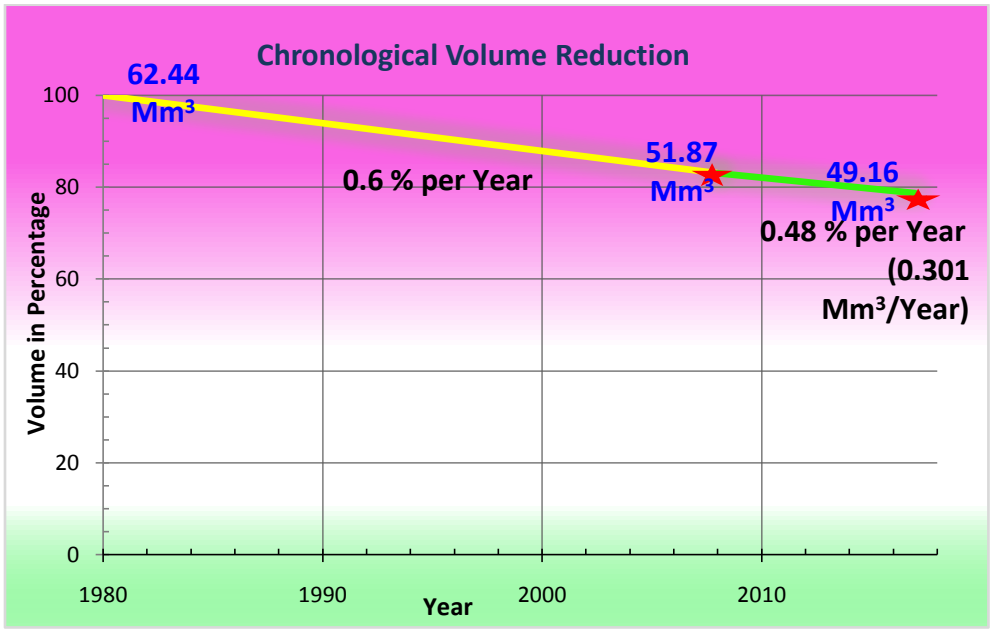


Fig.23 Chronological Volume Reduction

CONCLUSION

The Bathymetric survey of Kanjirapuzha Reservoir is conducted from 12th October, 2017 to 31st October, 2017.Initially this survey had been conducted in 2008,using IBS and the results were published. Now the survey is carried out using IBS and SubBottom profiler and the results are reported herein. Soil sample analysis is done and the results are also published.

5. Sedimentation Study of Pothundy Reservoir in Palakkad District Using Integrated Bathymetric System & Sub Bottom Profiler

- ***To quantify or determine the present capacity of Pothundy reservoir using IBS.***
- ***To find the quantity of sediment and its Distribution in the reservoir using Sub Bottom Profiler.***
- ***To compare the present result with the previous study result, for analyzing the chronological sedimentation behavior of the reservoir***
- ***To Study the soil particle distribution from the various parts of the reservoirs***

POTHUNDY PROJECT

Salient features

1.	Name	Pothundy
2.	Location Longitude Latitude	 76^{o} 37'33.392''E 10^{o} 32'41.003''N
3.	Year of starting	1958
4.	Year of completion	1971
5.	Type of Dam	Earth dam with Masonry Spillway
6.	Length of Dam	1680m
7.	Catchment area	30.82 Sq.km.
8.	Maximum storage	50.914 Mm^3
9.	Dead storage	7.023Mm^3
10.	Water spread area	4.14 Sq.km.
11.	Maximum water level	108.204 from MSL
12.	Bed level	81.93m
13.	Sill of canal	91.44m
14.	Purpose	Irrigation

About the Study Area

Location

The Pothundy reservoir is at Pothundy village of Chittur Taluk about 8 Km from Nenmara town along the Nenmara – Nelliyampathy road. The reservoir is located at 10^{o} 32'41.003''N Latitude and 76^{o} 37'33.392''E Longitude. The dam was constructed across Aayalurpuzha, a tributary of Gayathripuzha which in turn joins the Bharathapuzha, the longest river in Kerala. Ayalurpuzha is formed by the confluence of the two streams Padipuzha and Meenchadipuzha. Both are originated from the Nelliyampathi ranges. The location map of the area is shown in Fig.24 & 25.

Catchment

The catchment of the dam is a part of Nelliyampathy Hills with the Nelliyampathy Government Agricultural Farm on the top fringes and Pothundy dam site at the lowest reach. It covers 30.82Sq.km of steep and rocky hills by thick forest and vegetations. The steep and rocky nature of the catchment ensures good percentage of runoff. The Pothundy reservoir with its catchment is shown in Fig.25.

Fig.24 Location Map of Pothundy Reservoir

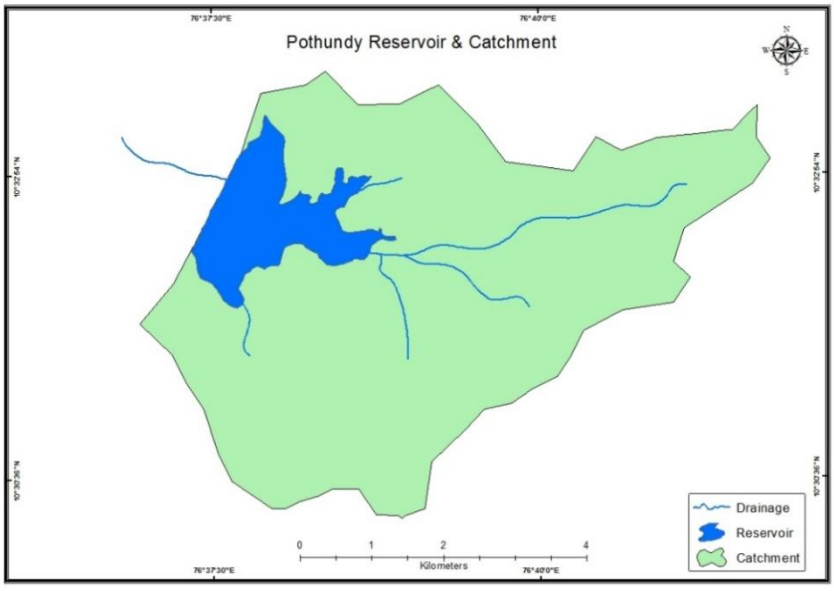


Fig.25 Location of Pothundy reservoir in Palakkad District

The water spread area is 4.14 Sq.km. The presence of number of big and small islands is considered as a unique feature of this catchment since the major portion of catchment is forest land with abundant growth of trees and plants. The erosion of soil and weathering of rocks are restricted which in turn helps to reduce the sedimentation loads coming into the reservoir.

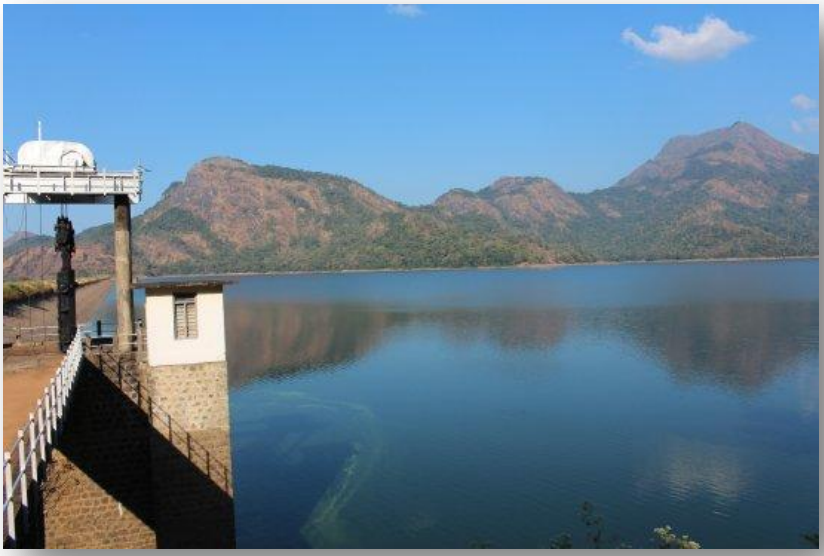


Fig.26 View of Pothundy reservoir

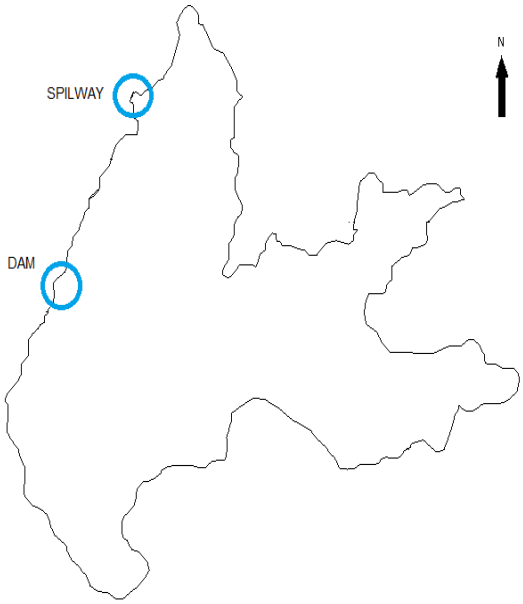


Fig.27 Water Spread Area Map of Pothundy Reservoir at WL 106.6m(surveyed portion)

Estimation of capacity

The survey is carried out at the water level of 106.6m. The original water holding capacity at this level is 45.859Mm^3. As per the current IBS study the volume at the same level is estimated as 43.238$Mm^3$and the corresponding water spread area is3.1Sq.km. Total capacity reduction of the reservoir at this level is 2.621Mm^3in 46year, i.e., the reduction in capacity at the specified level is 5.72%. The capacity reduction is due to the sediment deposit.

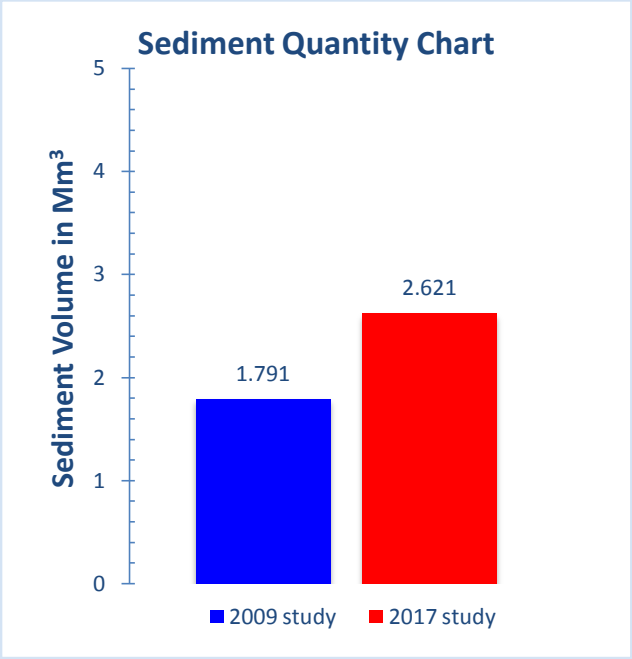


Fig.28 Increase in Sediment quantity

Capacity reduction of the reservoir at WL 106.6m

Table 5.1 shows the comparison in capacity of the reservoir at the water level of 106.6m between the two consecutive studies conducted in 2009 & 2017.

Table-5 Capacity reduction of the reservoir at WL 106.6m

Year of Study	Capacity	Reduction in Capacity w.r.t. Original Volume (45.859 Mm^3)	
		In Mm^3	In Percentage
2009	44.068	1.791	3.91
2017	43.238	2.621	5.72

The contour map of water spread area is shown in Fig. 29.

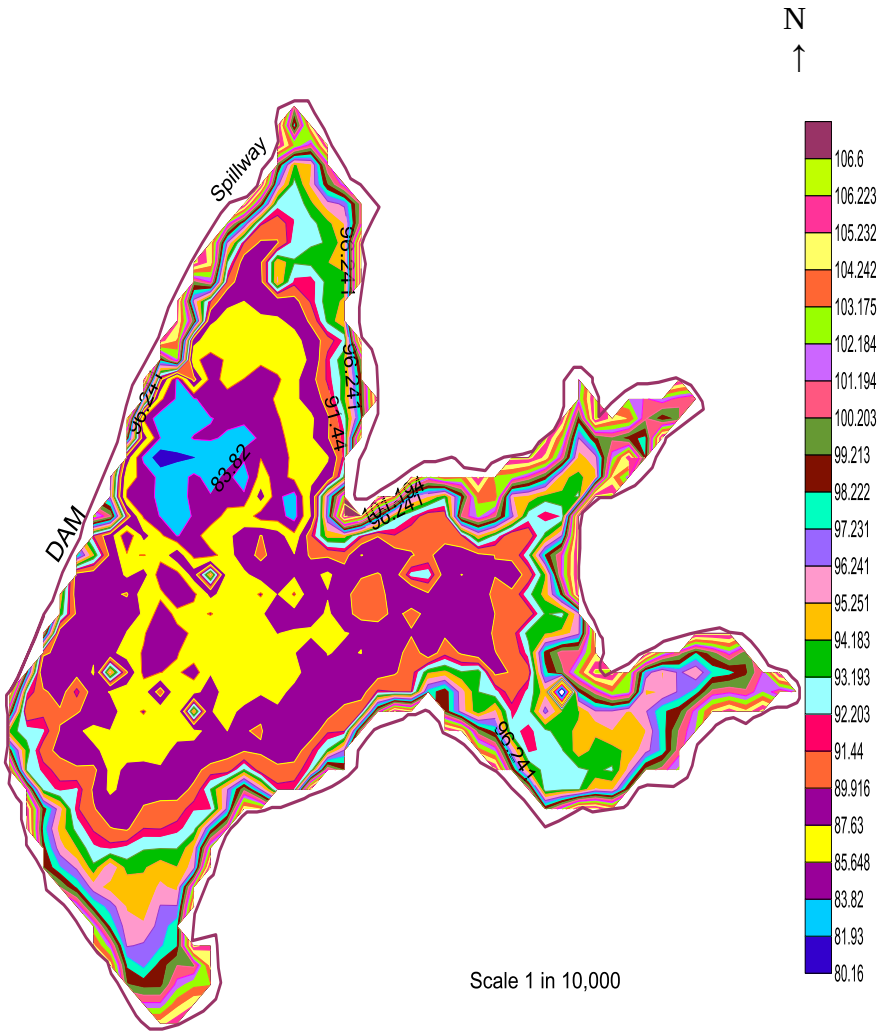


Fig.29 Contour Map based on IBS Survey

CAPACITY AT DIFFERENT WATER LEVEL

Reservoir volume at different water levels can be found out using the IBS data in Surfer software. The capacity reduction obtained from the IBS is comparable with the sediment volume calculated from the Sub Bottom Profiler. The present capacity at different level is compared with the original and IBS result in 2009 and is shown in Table 6.

Table-6 Reservoir capacity at different water levels.

Sl. No.	Water Level	Water Holding Capacity			Percentage Reduction in Capacity (IBS 2017)
		Original	IBS Survey 2009	IBS Survey 2017	
	m	M. Cub. m	M. Cub. m	M. Cub m	%
1	106.60	45.859	44.068	43.238	5.72
2	106.223	44.657	42.884	42.126	5.67
3	105.232	41.549	39.775	39.174	5.72
4	104.242	38.511	36.715	36.288	5.77
5	103.175	35.241	33.516	33.113	6.04
6	102.184	32.281	30.649	30.328	6.05
7	101.194	29.393	27.882	27.559	6.24
8	100.203	26.547	25.208	24.878	6.29
9	99.218	23.823	22.627	22.3	6.39
10	98.222	21.259	20.138	19.826	6.74
11	97.231	18.803	17.750	17.454	7.17
12	96.241	16.423	15.467	15.182	7.56
13	95.251	14.283	13.292	13.292	6.94
14	94.183	12.092	11.804	10.825	10.48
15	93.193	10.166	9.185	8.955	11.91
16	92.203	8.340	7.456	7.249	13.08
17	91.44*	7.023	6.234	6.033	14.1

***Dead Storage Level**

The original storage capacity curve is compared with the same obtained from the IBS surveys in 2009 and 2017 as shown in Fig.30.

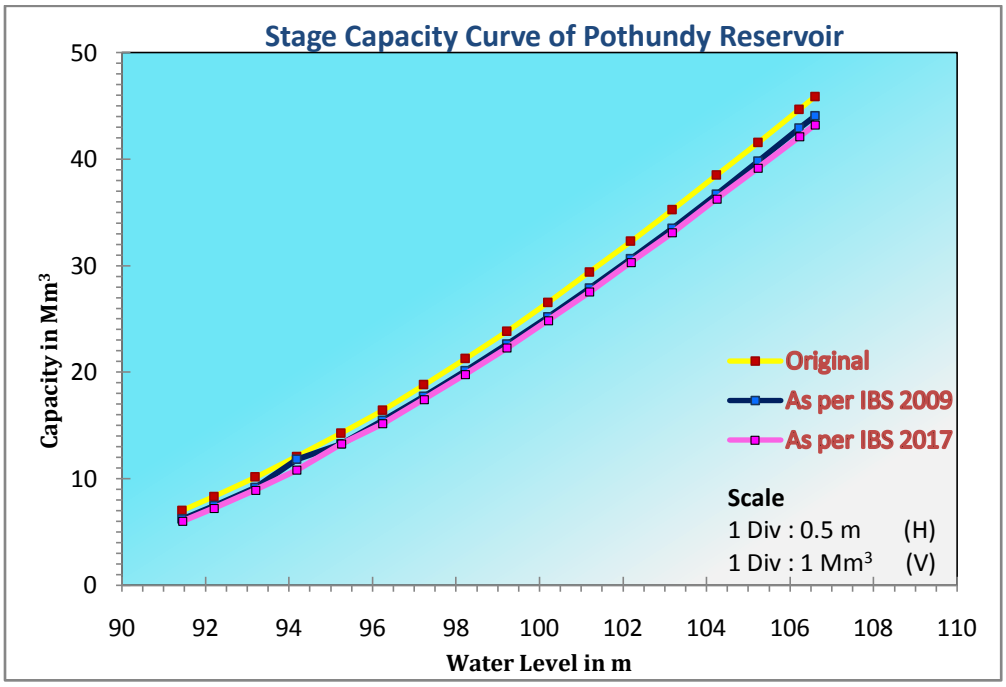


Fig.30 Water level v/s water holding capacity curve

WATER SPREAD AREA AT DIFFERENT WATER LEVEL

The present water spread area at different level is compared with the original and IBS result in 2009 and is shown in Table 7. Fig.31 shows its graphical representation

Table-7 Water spread area at different water levels.

Sl. No.	Water Level	Water Spread Area	
		IBS Survey 2009	IBS Survey 2017
	M	Sq.km	Sq.km
1	106.6	3.17	3.1
2	106.223	3.14	3.06
3	105.232	3.05	2.98
4	104.242	2.96	2.90
5	103.175	2.86	2.82
6	102.184	2.77	2.74
7	101.194	2.68	2.67
8	100.203	2.6	2.58
9	99.218	2.52	2.48
10	98.222	2.43	2.40
11	97.231	2.33	2.31

12	96.241	2.23	2.21
13	95.251	2.12	2.10
14	94.183	1.98	1.96
15	93.193	1.83	1.81
16	92.203	1.65	1.65
17	91.44	1.55	1.54

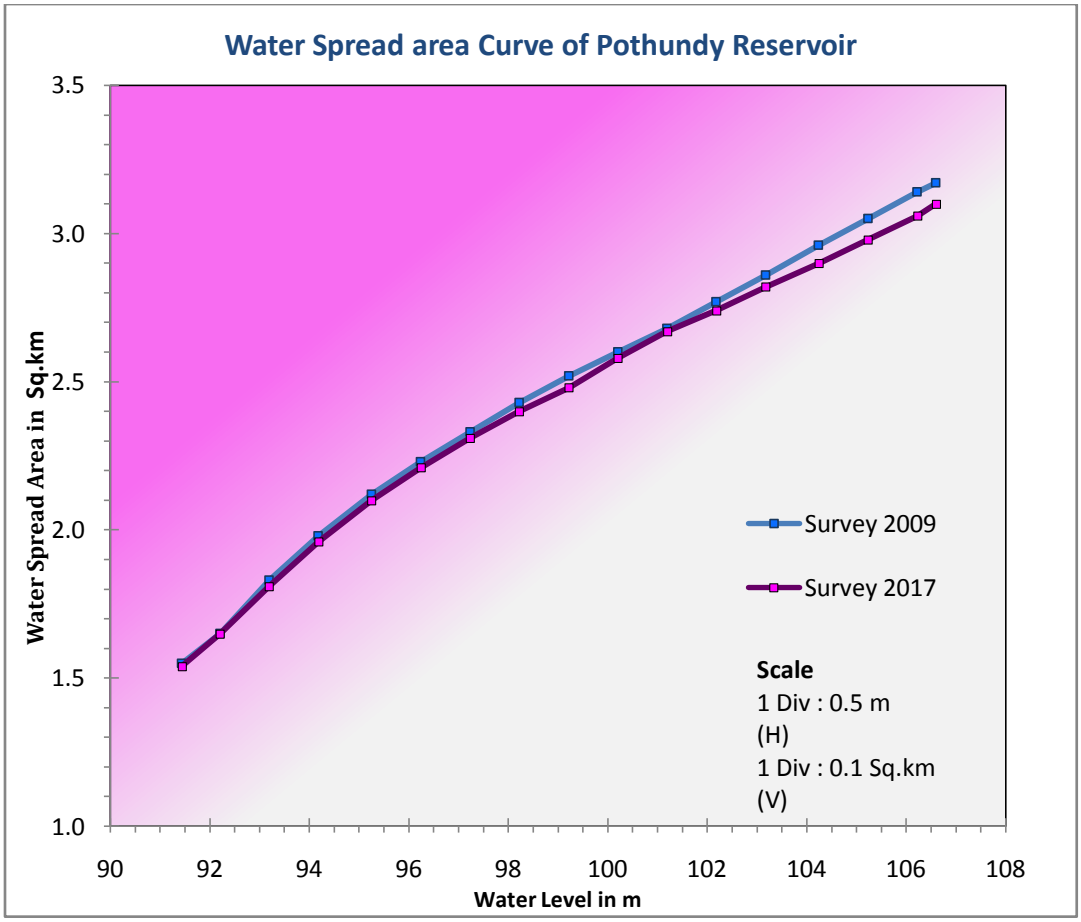


Fig.31 Water level v/s water spread area curve

CLASSIFICATION OF SOIL

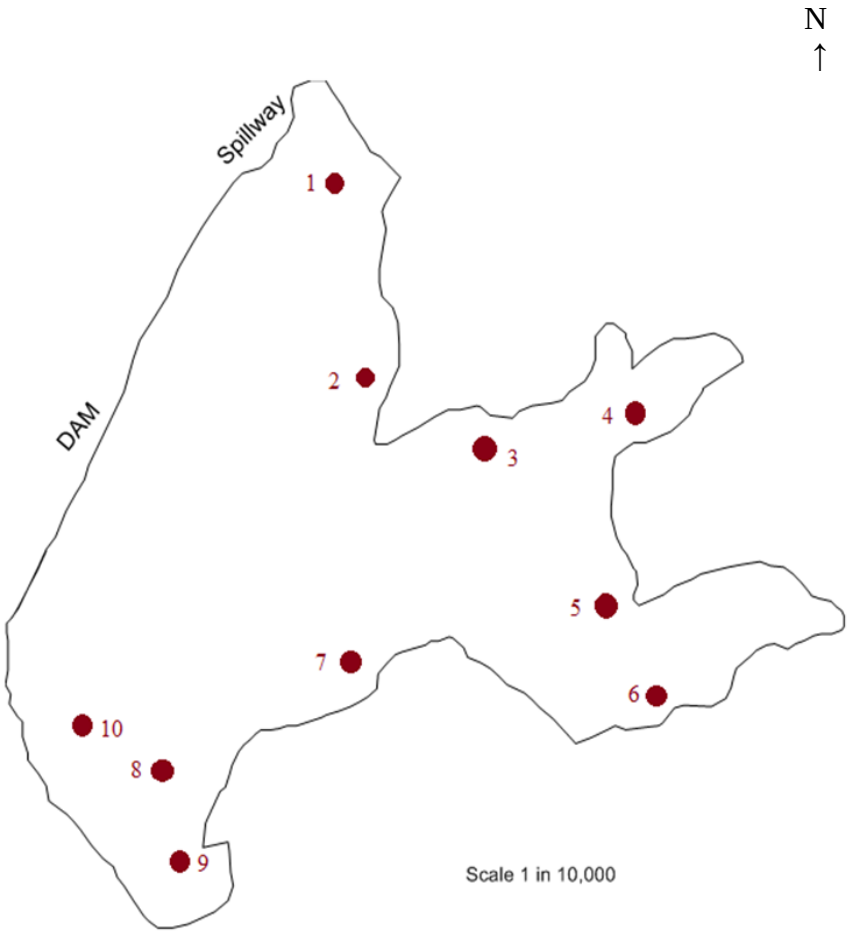


Fig.32 Location of Soil sample

ANALYSIS OF SOIL SAMPLE

In the sedimentation study conducted in 2009, 8Nos. of disturbed soil samples were analyzed. In the present study 10Nos. of soil samples are analyzed. The samples for both the studies were collected from different locations. By comparing the results of two studies, remarkable variations are observed in the percentage of Silt and Sand. The details are shown in the bar chart given in Fig.33.

Table-8 Soil Sample Analysis Result

Sl. No.	Sample (Position)	Depth of Sample taken in m	Nature of sample	Soil texture	Colour	Specific gravity	Class	% of Various size of Soil Particle				Uniformity Coefficient
								Clay	Silt	Sand	Gravel	
1.	N- 1166953 E- 678612	15.00	Disturbed	Silty soil	Slate Gray	2.12	SM	1	35	64	0	5.88
2.	N-1166398 E- 678678	18.00	Disturbed	Silty soil	Slate Gray	2.05	SM	3	40	57	0	14.47
3.	N-1166128 E-679042	15.50	Disturbed	Silty soil	Slate Gray	2.20	MI	11	65	24	0	38.15
4.	N-1166287 E-679697	10.50	Disturbed	Silty soil	Slate Gray	1.90	ML	8	62	30	0	18.02
5.	N-1165650 E-679460	9.50	Disturbed	Silty sand	Slate Gray	2.37	SM	1	26	72	1	19.92
6.	N-1165493 E-679729	12.00	Disturbed	Silty soil	Slate Gray	1.91	MI	14	59	27	0	2.93
7.	N-1165574 E-678744	17.00	Disturbed	Silty soil	Slate grey	1.72	MH	16	72	12	0	1.79
8.	N-1165081 E-678078	12.00	Disturbed	Silty soil	Slate grey	1.78	MH	16	70	14	0	2.33

9.	N-1164894 E-678063	11.50	Disturbed	Silty soil	Slate grey	1.84	MH	16	68	16	0	1.88
10.	N-1165396 E-677783	17.00	Disturbed	Silty soil	Slate grey	2.00	MI	12	45	43	0	5.95

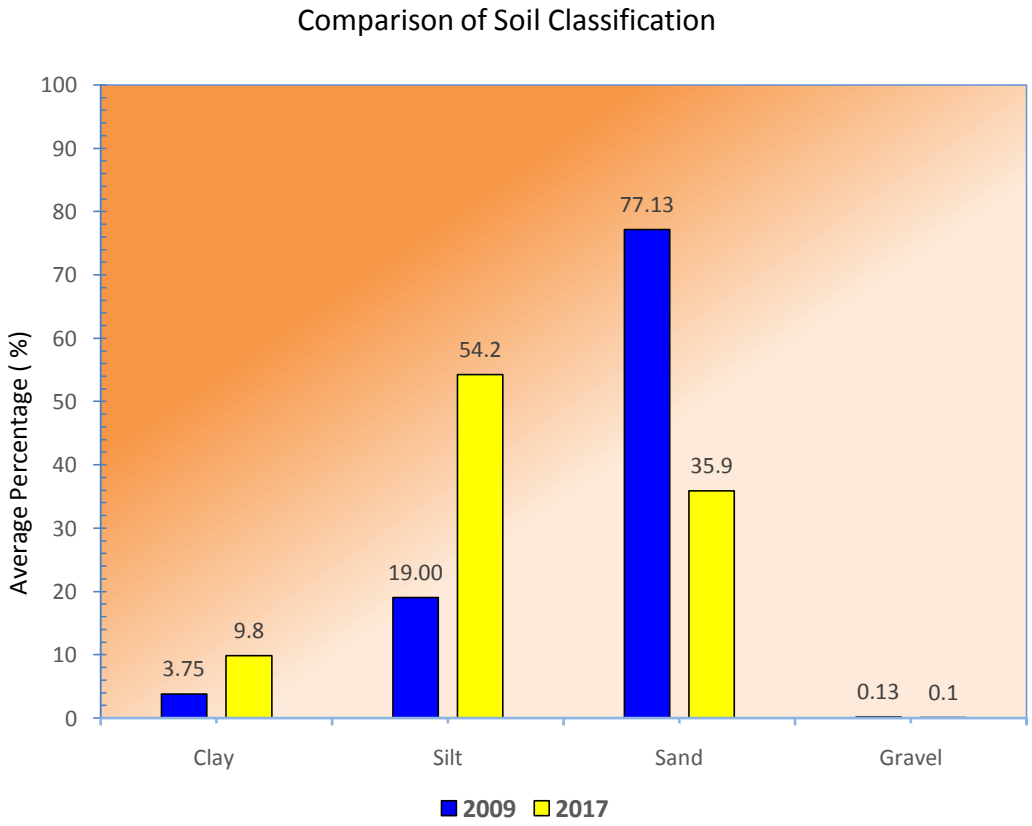


Fig.33 Comparison of Soil particle distribution as per two consecutive sedimentation studies

The percentages of soil particles are only indicative and not accurate. For accurate assessment of contents in the soil, core sample analysis must be done.

RESULT AND DISCUSSION

The original Capacity of Pothundy Reservoir at 106.6m level is 45.859Mm^3. The present capacity is 43.238Mm^3. The capacity reduction of the reservoir is 2.621Mm^3in 46years at the same level.

- *As per the IBS **Survey 2009**, the Reservoir capacity was 44.068 Mm^3at 106.6m and Capacity was reduced by 1.791 Mm^3 in 38 years @ 0.047 Mm^3/per year.*
- *The average thickness of the sediment deposit corresponding to the original water spread area 3.17Sq.km was 0.56m in 38 years, the rate of deposition 1.49 cm/Year.*
- *The original volume at dead storage level (91.44m) was 7.023 Mm^3, volume reduced to 6.234Mm^3 in 38years. Reduction percentage is 11.23 %.*
- *In the **present study**, the Reservoir capacity is 43.238 Mm^3at the water level of 106.6m and capacity is reduced by 0.83Mm^3 in 8years @ 0.104Mm^3/per year.*
- *The average thickness of the sediment deposit is **0.268m** in 8years, the rate of deposition 3.35cm/Year.*
- *Volume at dead storage level is 6.033Mm^3, Percentage reduction in dead storage is 14.10 % in 46years. Within the last 8years dead storage capacity reduced by 2.87%.*
- *Sediment layer profile of the reservoir area at an interval of 50m is obtained from the Sub Bottom profiler.*

During the first 38years of the dam life the capacity reduction rate was 0.10 % per Year. Within the next 8 year, the reduction rate is 0.23% per year. It indicates that the rate of sedimentation is increasing.

The graphical representation of reduction and rate is shown in Fig.34

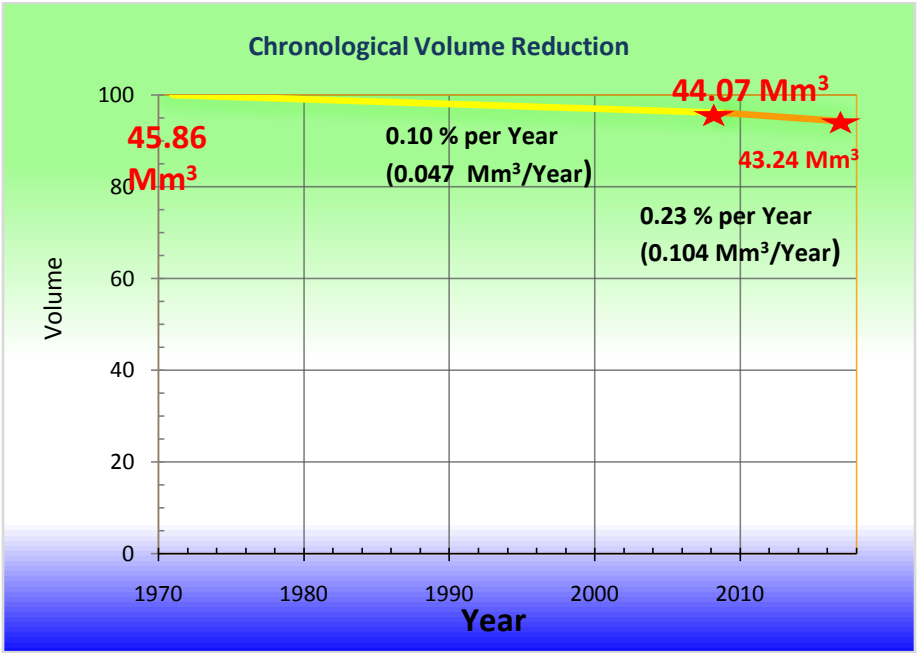


Fig.34 Chronological Volume Reduction

CONCLUSION

The Bathymetric survey of Pothundy Reservoir is conducted from 12th October, 2017 to 31st October, 2017.Initially this survey had been conducted in 2009, using IBS and the results were published. Now the survey is carried out using IBS and Sub Bottom profiler and the results are reported herein. Soil sample analysis is done and the results are also published.

4. Sedimentation Study of Chulliyar Reservoir in Palakkad District Using Integrated Bathymetric System & Sub Bottom Profiler

OBJECTIVES

- ***To quantify or determine the present capacity of Chulliyar Reservoir using IBS.***
- ***To find the quantity of sediment and its Distribution in the reservoir using Sub Bottom Profiler.***
- ***To compare the present result with the previous study result, for analyzing the chronological sedimentation behavior of the reservoir.***

CHULLIYAR PROJECT

Salient Features

1.	Name	Chulliyar
2.	Location Longitude Latitude	 76°45'59.993" E 10°35'35.524" N
3.	Year of starting	1961
4.	Year of Partially commissioning	1964
5.	Year of completion	1970
6.	Type of Dam	Masonry straight gravity dam
7.	Length of Masonry Dam	555 m (masonry dam)
8.	Length of Earthen Dam	1200 m (earth dam)
9.	Catchment area	29.78Sq.Km
10.	Maximum storage	13.733 Mm^3
11.	Dead storage	0.033 Mm^3
12.	Water spread area	1.65Sq.Km
13.	Maximum water level	154.08 from MSL
14.	Sill of canal	136.55 m
15.	Purpose	Irrigation

STUDY AREA

About the study area

Location

Chulliyar dam is located at 40km from district headquarters at Palakkad and 120km from Pollachi, one of South India's largest commercial markets. The reservoir is located at 10°35' 35.524"N latitude and 76°45' 59.993"E longitude. Chulliyar dam is the second stage of Gayathri scheme. This dam across Chulliyar River with canal system was completed in 1964 and was commissioned in 1966. About 1km below the Poonthoichalla anicut a stream called" Chulliyar "which starts from the Kollengod Hills, joins the main stream. The Chulliyar reservoir is constructed across the Chulliyar River at about 2km upstream of its confluence with Meenkara River. This project has made a tremendous impact on the agricultural scenario of the region. The location map of the area is shown in Fig.35.

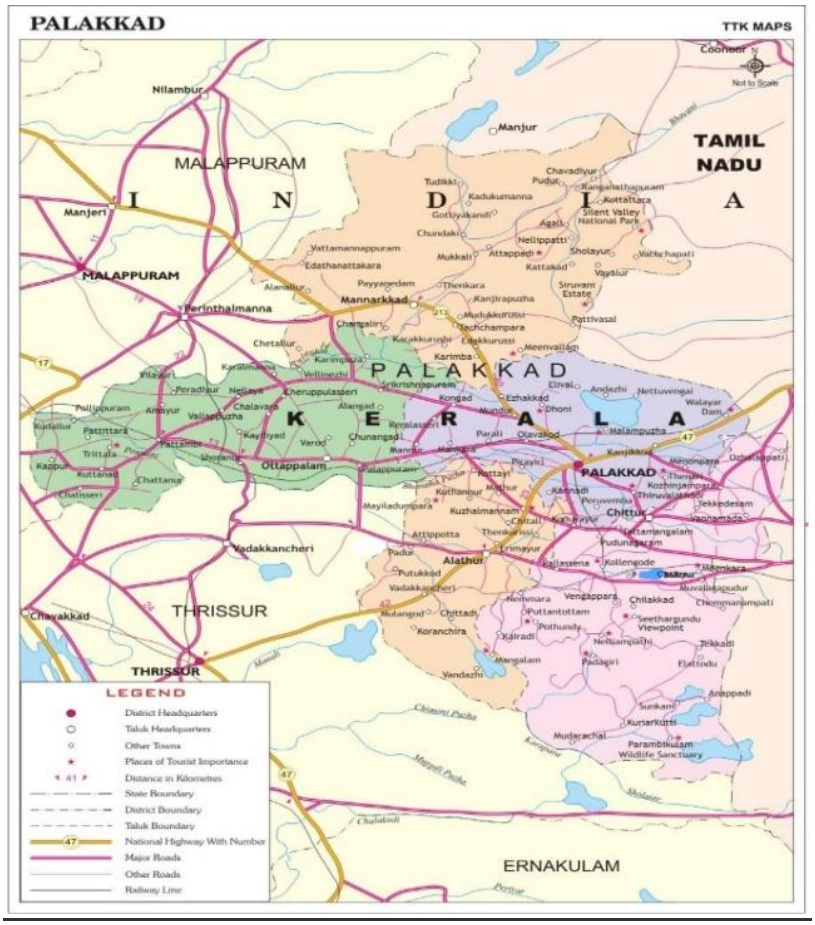


Fig.35 Location Map of Chulliyar Reservoir

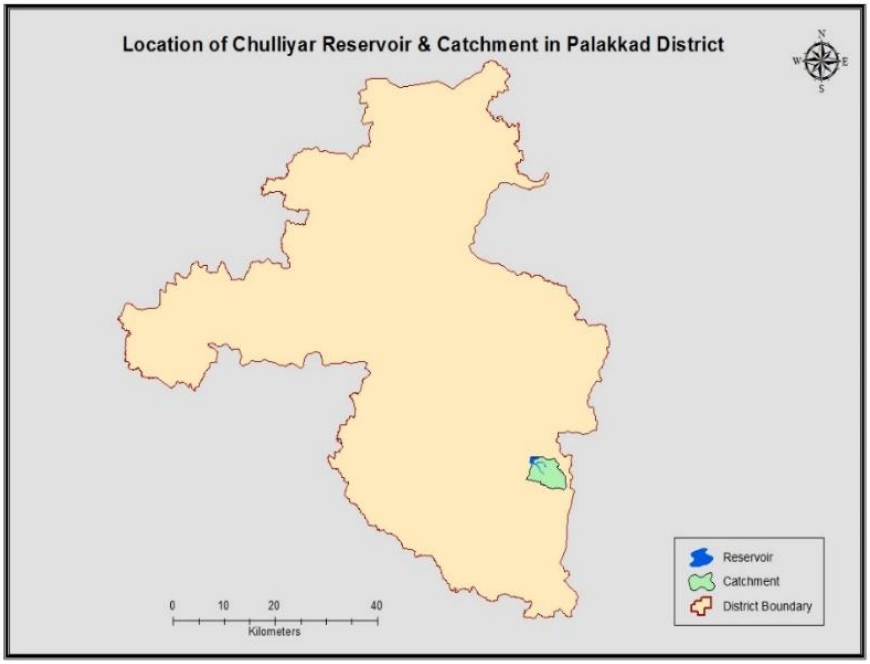


Fig.36 Location of Chulliyar reservoir in Palakkad District

CATCHMENT

The catchment area of river at the dam site is 29.78Sq.Km. The average slope varies from 2° to13°. Temperature plays a very important role in the development of soils in the catchment area. The soils developed under natural vegetation have been altered due to constant and dense farming activities. No thick forests are in the catchment except thorny bushes and Acacia forests seen in the catchment area. Coconut farming is also widely done in the catchment. The tract comprises of small hillocks and valleys, undulating with gentle slopes. There are several irrigation valleys and ridges. A major portion of the hill sides and dry areas has already been reclaimed and made fit for cultivation. The water spread area of the reservoir is 1.65 Sq.Km.

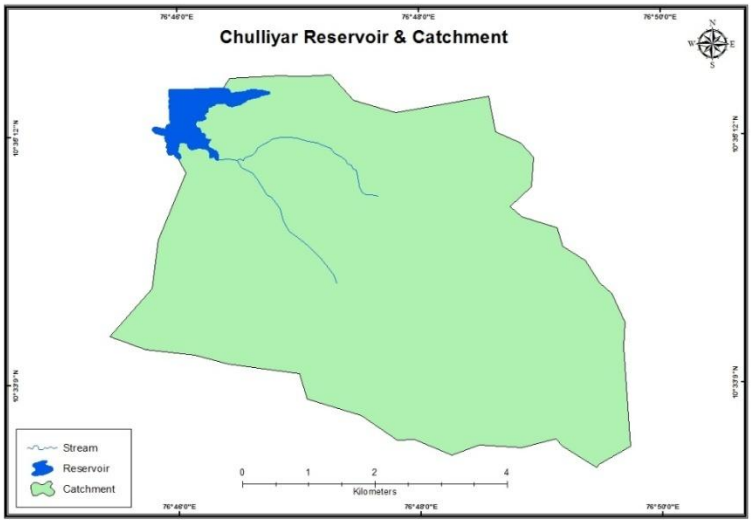


Fig.37 Chulliyar reservoir with catchment

Fig.38 View of Chulliyar reservoir

ESTIMATION OF CAPACITY

The survey is carried out at the water level of 147.37m. The original water holding capacity at this level is 4.589Mm^3. As per the current IBS study the volume at the same level is estimated as 3.449$Mm^3$and the corresponding water spread area is 0.96Sq.km. Total capacity reduction of the reservoir at this level is 1.14Mm^3 in 53years, i.e., the reduction in capacity at the specified level is 24.84%. The capacity reduction is due to sediment deposit.

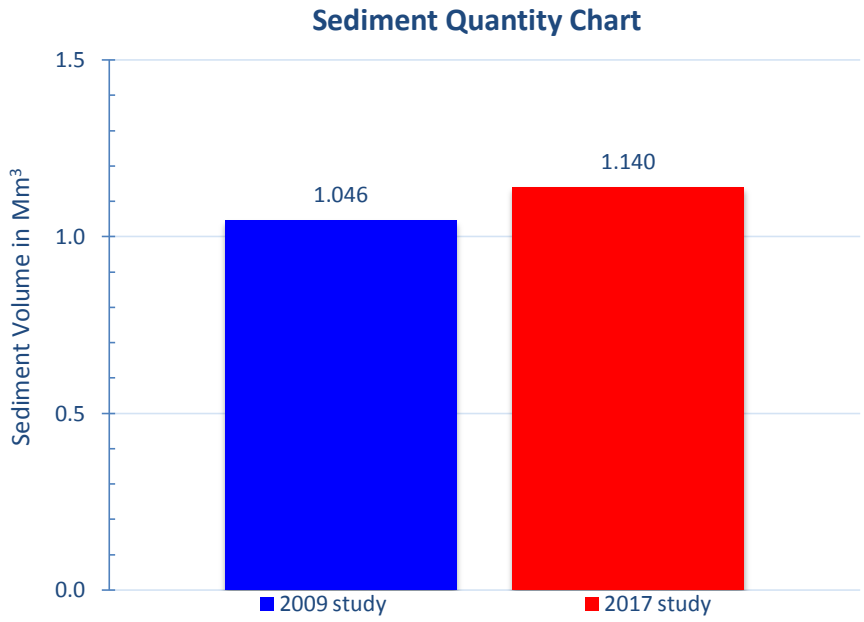


Fig.39 Increase in Sediment Volume

Table-9 Capacity reduction of the reservoir at WL 147.37m

Year of Study	Capacity	Reduction in Capacity w.r.t. Original Volume (4.589Mm^3)	
		in Mm^3	in Percentage
2009	3.543	1.046	22.79
2017	3.449	1.140	24.84

Table-9 shows the comparison in capacity of the reservoir at the water level of 147.37m between the two consecutive studies conducted in 2009& 2017. The contour map of water spread area is shown in Fig 40.

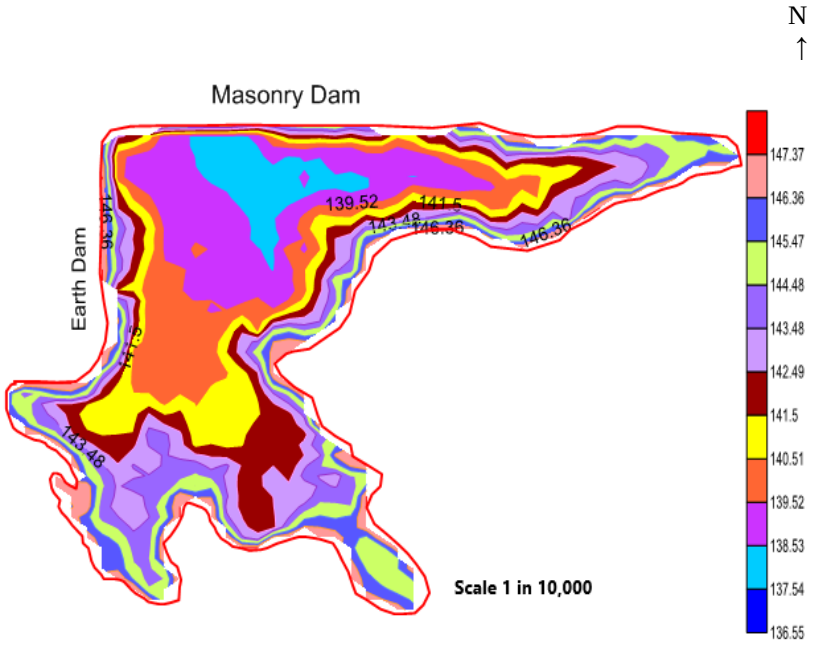


Fig.40 Contour Map based on IBS Survey

CAPACITY AT DIFFERENT WATER LEVEL

Reservoir volume at different water levels can be found out using the IBS data in Surfer software. The capacity reduction obtained from the IBS is comparable with the sediment volume calculated from the Sub Bottom Profiler. The present capacity at different level is compared with the original and IBS result in 2009 and is shown in Table 10.

Table-10 Reservoir capacity at different water levels.

Sl. No.	Water Level	Water Holding Capacity			Percentage Reduction in Capacity (IBS 2017)
		Original	IBS Survey 2009	IBS Survey 2017	
	m	M.Cub.m	M.Cub.m	M.Cub.m	%
1	147.37	4.589	3.543	3.449	24.84
2	146.46	3.833	2.787	2.779	27.50
3	145.47	3.106	2.102	2.092	32.65
4	144.48	2.397	1.544	1.505	37.21
5	143.48	1.902	1.089	1.021	46.32
6	142.49	1.443	0.726	0.640	55.65

7	141.5	1.059	0.444	0.356	66.38
8	140.51	0.740	0.235	0.162	78.11
9	139.52	0.486	0.092	0.053	89.09
10	138.53	0.288	0.014	0.019	93.40
11	137.54	0.139	0.002	0.016	88.49

The original storage capacity curve is compared with the same obtained from the IBS surveys in 2009 and 2017 is shown in Fig. 41.

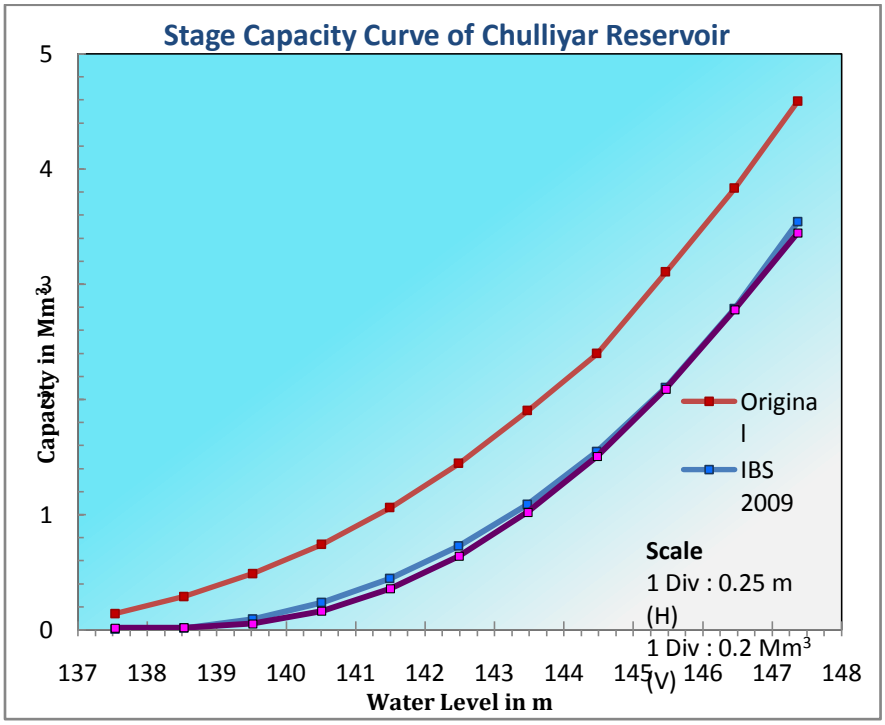


Fig.41 Water level v/s water holding capacity curve

Table-11 Water spread area at different water levels

Sl. No.	Water Level	Water Spread Area	
		IBS Survey 2009	IBS Survey 2017
	m	Sq.km	Sq.km
1	147.37	0.91	0.96
2	146.46	0.76	0.78
3	145.47	0.63	0.64
4	144.48	0.51	0.50
5	143.48	0.41	0.40
6	142.49	0.33	0.34

7	141.5	0.25	0.25
8	140.51	0.18	0.16
9	139.52	0.11	0.07
10	138.53	0.05	0.01
11	137.54	0.0009	0.01

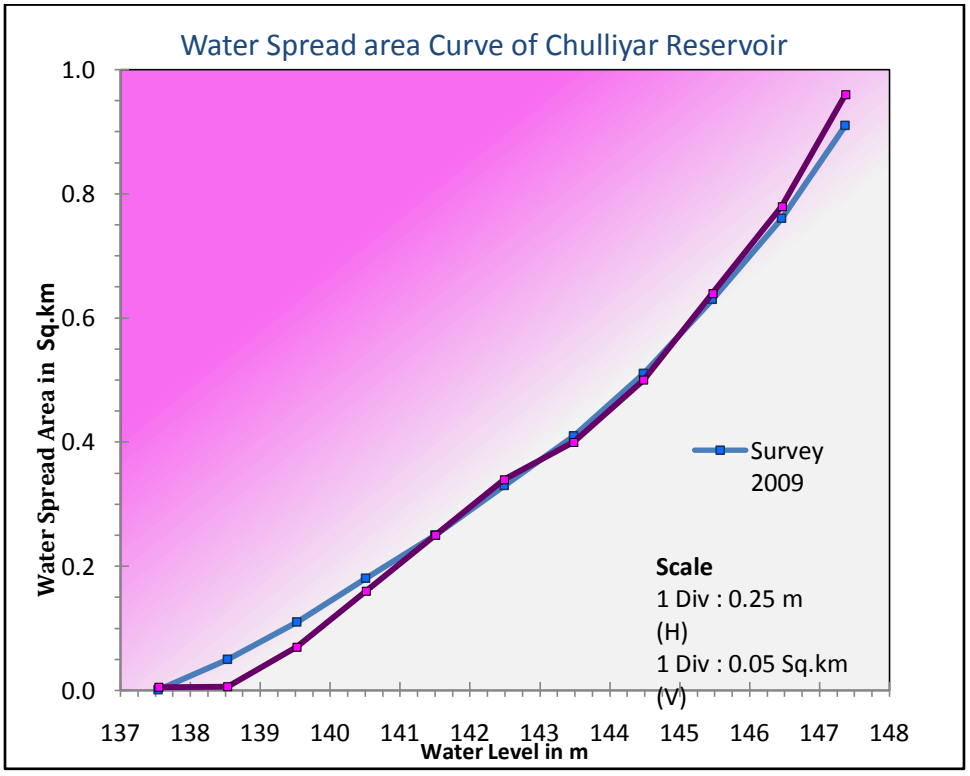


Fig.42 Water level v/s water spread area curve

Generally, the repeat study results of reservoirs shows the water spread area corresponding to each water level has been decreasing with time, if any other activities like silt removal, scouring etc., has not been carried out in the reservoir area.

But in case of Chulliyar reservoir, at higher levels it is observed that the water spread area is slightly greater than the previous study results. This is because of the silt removal desiltation carried out in the year 2012.

RESULT AND DISCUSSION

The original Capacity of Chulliyar Reservoir at 147.37m level is 4.589 Mm^3. The present capacity is 3.449 Mm^3. The capacity reduction of the reservoir is1.140 Mm^3in 53years at the same level.

- ***As per the IBS Survey 2009, the Reservoir capacity was 3.543 Mm^3at 147.37m and Capacity was reduced by 1.046 Mm^3 in 45 years @ 0.023 Mm^3/per year.***
- ***The water spread area obtained at the water level of 147.37m was 0.91 Sq.km. The average thickness of the sediment deposit corresponding to this water spread area was 1.15m in 45years i.e., the rate of deposition was 2.56cm/year.***
- ***The original volume at dead storage level (136.55m) was 0.033 Mm^3, volume reduced to 0.001 Mm^3 in 45 years. Reduction percentage is 96.97 %.***
- ***In the present study, the Reservoir capacity is 3.449Mm^3 at the water levelof147.37m and capacity is decreased by 0.094Mm^3in 8years. This volume incorporates the effect of desiltation conducted in the year 2012.***
- ***The average thickness of the sediment deposit is 0.103m in 8years, the rate of deposition cannot be specified as it may be influenced by the Desiltation.***
- ***Sediment layer profile of the reservoir area at an interval of 50 m is obtained from the Sub Bottom profiler.***

During the first 45years of the dam life the capacity reduction rate was 0.51 % per year. At the water level of 147.37m, the present capacity is 75.16% of the original capacity of the reservoir.

The graphical representation of reduction and rate is shown in Fig.43

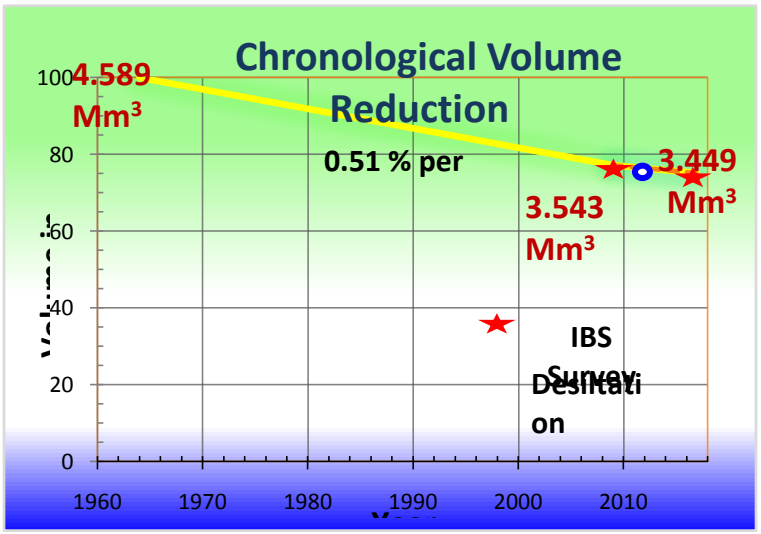


Fig.43 Chronological Volume Reduction

CONCLUSION

The Bathymetric survey of Chulliyar Reservoir is conducted from 12thDecember 2017 to 15stDecember 2017.Initially this survey had been conducted in 2009, using IBS and the results were published. Now the survey is carried out using IBS and Sub Bottom profiler and the results are reported herein.

6. Sedimentation Study of Kallada Reservoir in Kollam District Using Integrated Bathymetric System & Sub Bottom Profiler

OBJECTIVES

- ***To quantify or determine the present capacity of Kallada reservoir using IBS.***
- ***To find the quantity of sediment and its Distribution in the reservoir using Sub Bottom Profiler.***

KALLADA PROJECT

Salient features

1.	Name	Kallada(Parappar)
2.	Location Longitude Latitude	 77^{o} 04’12.149’’E 8^{o} 57’16.558’’N
3.	Year of starting	1972
4.	Year of Partially commissioning	24/05/1986
5.	Type of Dam	Masonry Straight gravity dam with spillway
6.	Length of Masonry Dam	335m
7.	Length of Spillway	42.0 m
8.	Maximum height above deepest foundation	85.35 m
9.	Top width of Dam	7.62m
10.	Full reservoir level	115.82m
11.	Maximum water level	116.77m
12.	Dead storage level	70.25m
13.	Catchment area	549 Sq.km
14.	Gross storage at F.R.L	504.92Mm^3
15.	Dead storage capacity	17.75Mm^3
16.	Water spread area at F R L	23.00Sq.km
17.	Purpose	Irrigation

Spillway

Type	:	Gated Ogee type
Type of crest gates and size	:	Radial 12.19m x 9.14
Number of Crest gates	:	3 Nos
Crest level	:	106.68m
Head over Crest	:	9.14m
Design discharge	:	2830 m^3/s

Auxiliary Spillway without control gates

Location	:	On right bank of Masonry Dam
Length	:	56.00m
Crest Level	:	116.73m
Design Discharge	:	698.0m^3/s
Type	:	Labyrinth Weir

Saddle Dam

Length	:	225.70 m
Maximum Height	:	12.51 m

Canal System

Right Bank Canal

Length	:	69.0 Km
Width at starting	:	4.65 m
Capacity	:	39.08 m^3/s
Cultivable Command Area	:	39530 Ha

Left Bank Canal

Length	:	56.0 Km
Width at starting	:	4.0 m
Capacity	:	22.00 m^3/s
Cultivable Command Area	:	22100 Ha

STUDY AREA

About the study area

Kallada River

The Kallada river is a west flowing river which originates from the Kulathupuzha ranges. It flows through Pathanapuram, Kunnathur, Kottarakkara and Kollam Taluks of Kollam District, Kerala State for about 80miles before it falls in to the Ashtamudi lake. The Project area lies between Latitudes $8^0$49' North and 9^0 17' North and Longitudes 77^0 16' East and 76^0 24' East. It covers portions of Thiruvanathapuram, Kollam and Alappuzha Districts. It is bounded by the Achenkoil River on the north, the backwaters on the west and the Ithikara River in the south.

The main tributaries of Kallada River are the Kulathupuzha, Senthuruni and Kazhuthurutti rivers. The Kulathupuzha River is formed by the confluence of the Pongumalai Aar, Sinikala Aar and the Sankalipalam Aar. The Kulathupuzha River flows in north – westerly direction till Moyala Mod where it turns and continues to flow in northern direction. It is joined by the Senthuruni at Kalangkunnu. The Senthuruni Aar originating from the Karimalai Kadakal and Alwarkurichi peaks flows in north western direction till it joins the Kulathupuzha Aar. The Kalthuruthy Aar joins the main river just above the Parappar. It is formed by several streams originating from the Periamuruthi Malai, Pillaiva Kovil Malai and Suvarnagiri Malai (+1600). It flows south – westerly direction first and then a westerly course up to Thenmalai, where it turns south and joins the main river at Parappar.

Kallada Reservoir

The location of the storage dam is at Parappar (Lattitude8^o 57'16.558'' North Longitude 77^o 04'12.149'' East). Here the three major tributaries of the river viz., Kulathupuzha, Senthuruni and Kazhuthurutti confluence to form the main Kallada River. The location map is shown in the Fig.44.

Fig.44 Location Map of Kallada reservoir

Kallada Irrigation Project is one of the largest irrigation projects in Kerala. The catchment area of reservoir having an extend of 549 Sq.km and the reservoir formed by the confluence of the three rivers and these rivers start from the Western Ghats with thick dense forest and wild life sanctuary. The boundary of which start from Aryankavu-Kottavasal to Ponmudi. The main component of the project comprises a straight gravity masonry dam at Parappar which has a storage capacity of 504.92 Mm^3 at FRL. The length of dam is 335metre and height from the deepest foundation is85.35metre.Kallada Reservoir with its Catchment is shown in Fig.45 & 46.

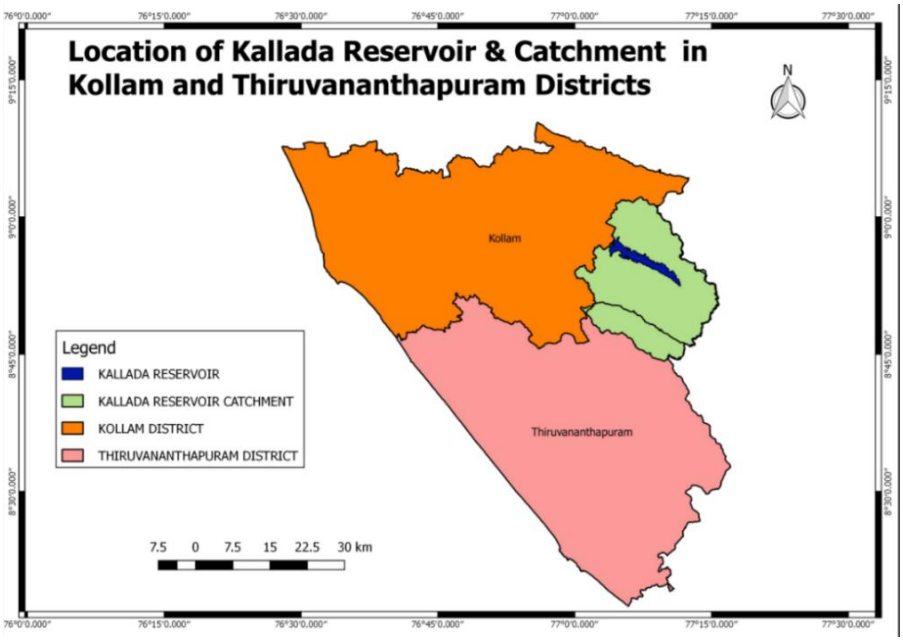


Fig.45 Location of Kallada reservoir in Districts

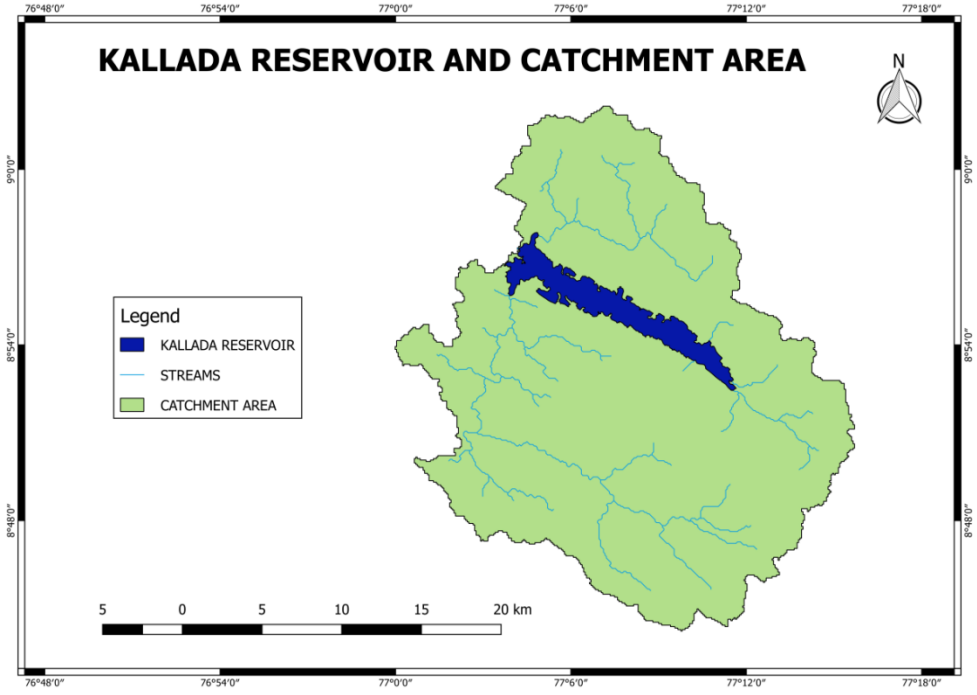


Fig.46 Kallada reservoir with Catchment

Fig.47 View of Kallada reservoir

15MW Hydro Electric Project is also working under this project. Pick up weir is located at 5Km downstream in Kallada River at Ottukal to divert the water to the main canals viz., Right bank canal and Left bank canal.

Right bank canal system has designed discharge of 39.08m^3/sec and a length of 69.00km. The Cultivable Command Area (CCA) of this canal network is 39530Ha.Left bank canal system has designed discharge of 22.00m^3/sec and a length of 56.00Km. The Cultivable Command Area (CCA) of this canal network is 22100 Ha.

ESTIMATION OF CAPACITY

The survey is carried out at the water level of 112.85m. The original water holding capacity at this level is 436.15Mm^3. As per the current IBS study the volume at the same level is estimated as 407.39$Mm^3$and the corresponding water spread area is 22.4Sq.km.Total capacity reduction of the reservoir is 28.76Mm^3in 32year, i.e., the reduction in capacity at the specified level is 6.59%. The capacity reduction is due to the sediment deposit.

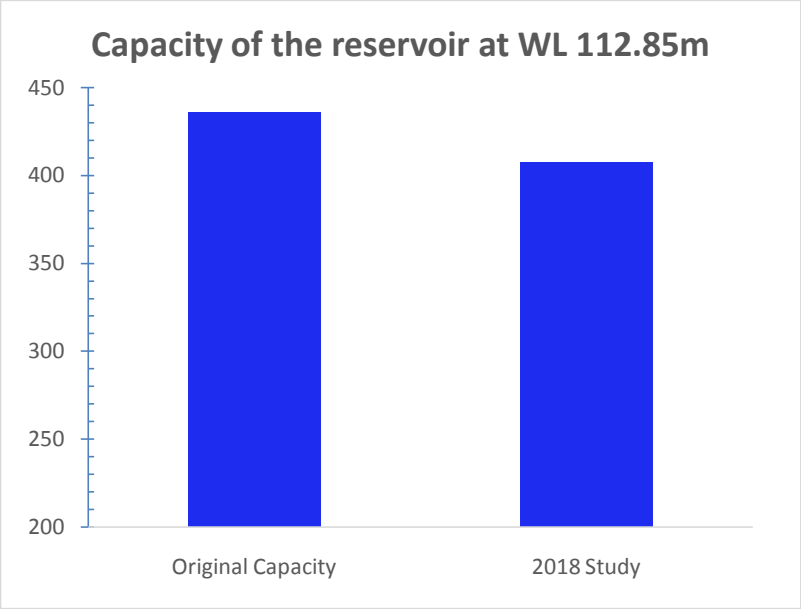


Fig.48 Comparison of Reservoir Capacity at Water Level 112.85m

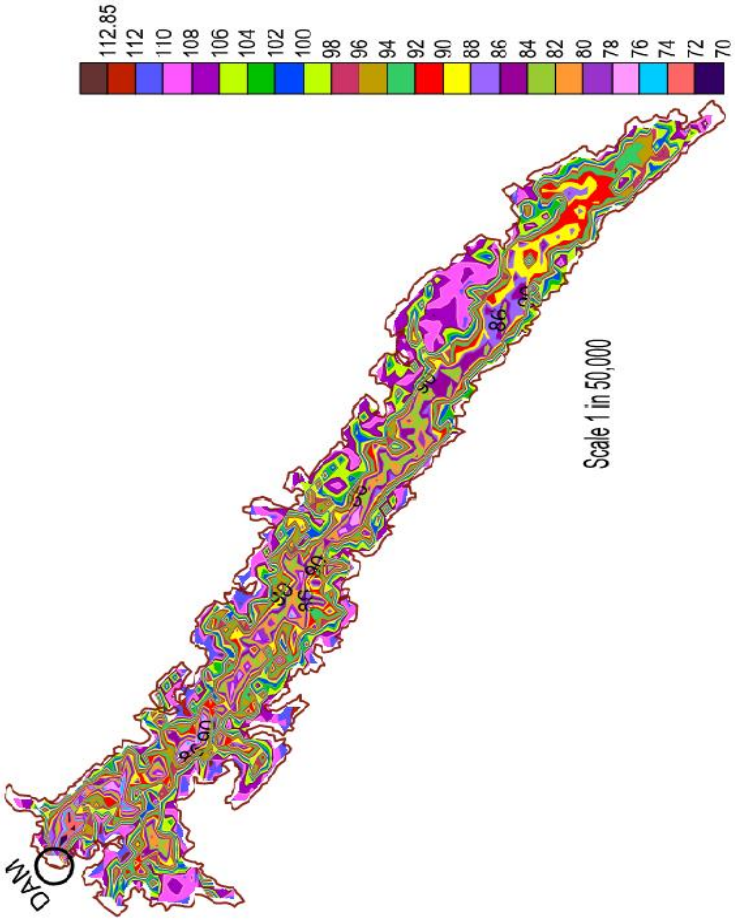


Fig.49 The contour map of water spread area at an interval of 2 m.

CAPACITY AT DIFFERENT WATER LEVEL

Reservoir volume at different water levels can be found out using the IBS data in Surfer software. The capacity reduction obtained from the IBS is comparable with the sediment volume calculated from the Sub Bottom Profiler. The present capacity at different level is compared with the original and IBS result in 2018 and is shown in Table 12.

Table-12 Reservoir capacity at different water levels.

Sl. No.	Water Level	Water Holding Capacity		Percentage Reduction in Capacity
		Original	IBS Survey 2018	
	(m)	(M. Cub. m)	(M. Cub m)	%
1	112.85	436.150	407.390	6.59
2	112	420.000	385.429	8.23
3	111	398.000	361.783	9.10
4	110	380.000	334.107	12.08
5	109	360.000	309.270	14.09
6	108	340.000	285.684	15.98
7	107	320.000	263.770	17.57
8	106	300.000	243.600	18.80
9	105	280.000	224.874	19.69
10	104	265.000	207.358	21.75
11	103	250.000	190.796	23.68
12	102	234.000	175.070	25.18
13	101	220.000	160.134	27.21
14	100	210.000	145.930	30.51
15	99	196.000	132.437	32.43
16	98	180.000	119.652	33.53
17	97	168.000	107.502	36.01
18	96	155.000	96.116	37.99
19	95	145.000	85.344	41.14
20	94	134.000	75.269	43.83
21	93	124.000	65.900	46.85
22	92	112.000	57.187	48.94
23	91	104.000	49.146	52.74
24	90	98.000	41.824	57.32
25	89	88.000	35.241	59.95
26	88	80.000	29.389	63.26
27	87	75.000	24.270	67.64
28	86	70.000	19.799	71.72
29	85	66.000	15.903	75.90
30	84	60.000	12.590	79.02

31	83	57.000	9.805	82.80
32	82	52.000	7.494	85.59
33	81	49.000	5.650	88.47
34	80	45.000	4.211	90.64
35	79	43.000	3.099	92.79
36	78	40.000	2.242	94.40
37	77	36.000	1.589	95.59
38	76	32.000	1.125	96.48
39	75	30.000	0.796	97.35
40	74	27.000	0.553	97.95
41	73	25.000	0.372	98.51
42	72	22.000	0.235	98.93
43	71	20.000	0.135	99.33
44	70.25*	17.75	0.086	99.52
45	70	17.000	0.075	99.56

***Dead Storage Level**

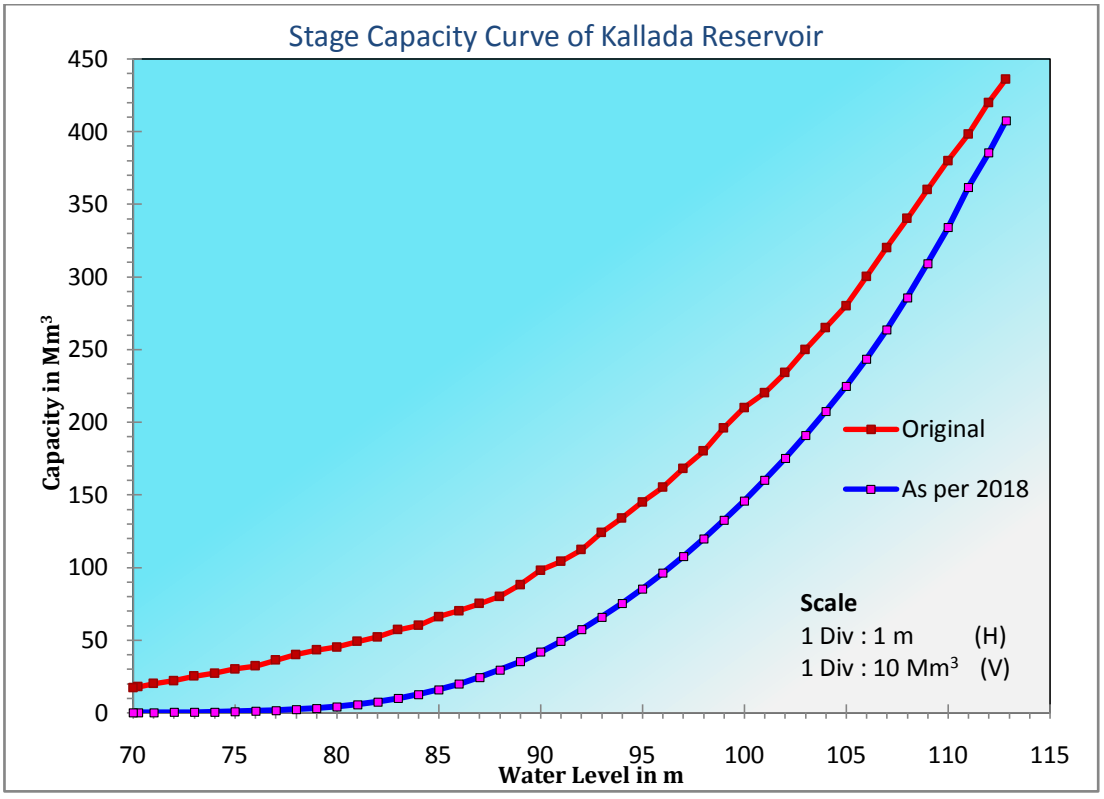


Fig.50 Water level v/s water holding capacity curve

The original storage capacity curve is compared with IBS survey in 2018 as shown in Fig.50

WATER SPREAD AREA AT DIFFERENT WATER LEVEL

The present water spread area at different level is shown in Table13. Fig.51 shows its graphical representation.

Table 13 Water spread area at different water levels.

Sl. No.	Water Level	Water Spread Area	Sl. No.	Water Level	Water Spread Area
		IBS Survey 2018			IBS Survey 2018
	(m)	(Sq. Km)			(Sq. Km)
1	112.85	22.40	23	91	7.37
2	112	22.30	24	90	6.62
3	111	22.18	25	89	5.89
4	110	22.00	26	88	5.15
5	109	21.40	27	87	4.44
6	108	20.30	28	86	3.84
7	107	19.18	29	85	3.27
8	106	18.08	30	84	2.74
9	105	17.14	31	83	2.24
10	104	16.34	32	82	1.77
11	103	15.58	33	81	1.35
12	102	14.83	34	80	1.04
13	101	14.12	35	79	0.79
14	100	13.44	36	78	0.59
15	99	12.76	37	77	0.42
16	98	12.09	38	76	0.28
17	97	11.44	39	75	0.21
18	96	10.78	40	74	0.15
19	95	10.10	41	73	0.12
20	94	9.40	42	72	0.08
21	93	8.71	43	71	0.04
22	92	8.07	44	70	0.01

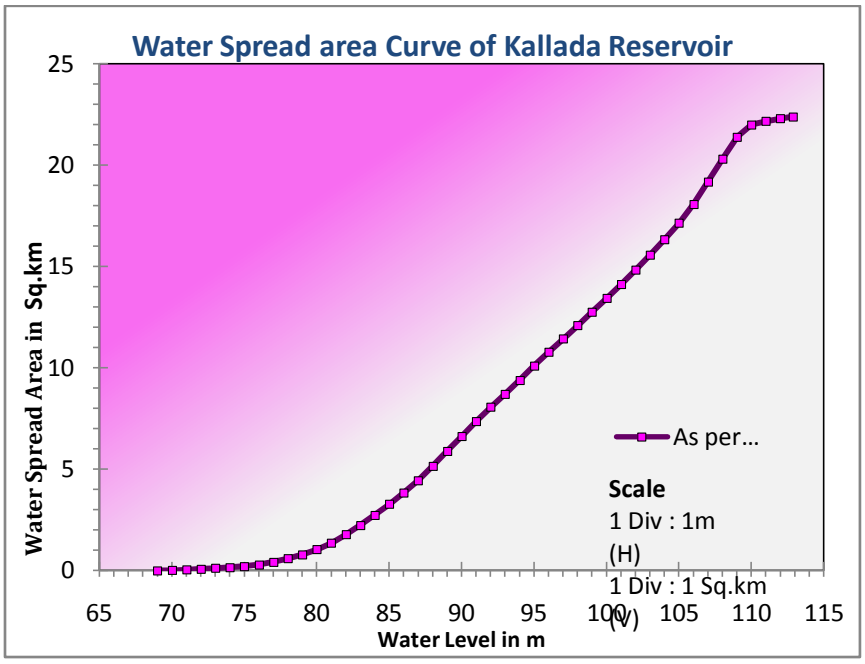


Fig.51 Water level v/s water spread area curve

RESULT AND DISCUSSION

The original Capacity of Kallada Reservoir at 112.85m level is 436.15 Mm^3.

- *As per the study, the Reservoir capacity is 407.390Mm^3at the water level of 112.85m and the capacity is reduced by 28.76 Mm^3 in 32 years @ 0.899 Mm^3/per year.*
- *The average thickness of the sediment deposit is1.28m in 32 years, the rate of deposition 4.0cm/Year.*
- *Volume at dead storage level is 0.086Mm^3, Percentage reduction in deadstorage is99.52% in 32 years.*
- *Sediment layer profile of the reservoir area at an interval of 100m is obtained from the Sub Bottom Profiler.*

The graphical representation of reduction in volume is shown in Fig.52

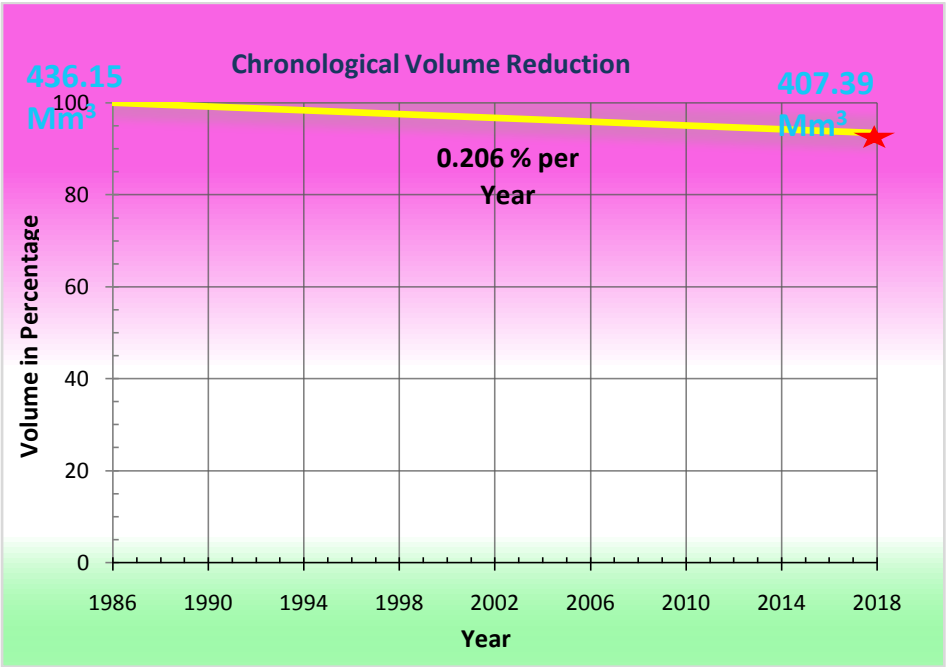


Fig.52 Chronological Volume Reduction

CONCLUSION

The Bathymetric survey of Kallada Reservoir is conducted from 1st January, 2018 to 24th March. 2018. The survey is carried out using IBS and Sub Bottom Profiler and the results are reported herein. Even though the survey was started at the FRL, it could not be completed at the same level due to waves. Since the survey was completed in the level of 112.85m, the volume is compared at this level only.

LIMITATIONS OF THE STUDY

- ***The IBS survey does not directly measure the silt in the reservoir. It helps to calculate the present storage capacity only which is compared with the original capacity and the reduction in capacity over a period is attributed to silt deposition.***
- ***The accuracy in the silt estimation by this method is fully dependent on the accuracy of the original capacity table. The comparison of results of two or more surveys will give correct sedimentation pattern and rate of siltation. Hence it is recommended that sedimentation survey of all reservoirs may be conducted at an interval of five years.***
- ***In Sub Bottom Profiler, the sediment layer thickness is calculated from the reflection of Ultrasound waves. Presence of an object or hard thin layer above the sediment deposit may lead to error in sediment depth calculation.***

D. CONSTRUCTION MATERIALS DIVISION

D.1 Introduction

Construction Material Division is one of the sub units of Kerala Engineering Research Institute (KERI) basically engaged in material testing. Testing of construction materials is an essential part for ensuring quality in construction. In addition to the testing of Irrigation department works, other Government agencies and Private agencies such as Indian Railways, Cochin Shipyard, P.W.D., C.P.W.D., Cap India construction etc., are utilizing the facilities of lab for ensuring quality construction. The Construction Materials Laboratory continued to contribute healthy revenue every year to the Government through various tests conducted for clients. The Lab is also functioning as a training centre of the Irrigation Department and providing training programmes and refresher courses for the benefit of department engineers. The training facility extends to other department engineers also. In addition, the Lab is on the process of accreditation from NABL which will boost up the status of the Lab and likely to increase the revenue to Government.

Construction materials division of KERI deals with testing of construction materials such as cement, aggregates, steel, tiles, bricks, rock, concrete etc., and design of concrete mixes. Also research activities are conducting at this division as and when required. The essentials tests for getting the physical properties of above materials are carrying out at this lab. During the year 2017-18, tests were conducted for 1009 samples of concrete cubes, 102 samples of steel rods, 102 samples of aggregates, 69 samples of rock core, 102 samples of solid blocks, 60 samples of paver blocks, 41 samples of cement, 44 samples of bricks, 8 samples of tiles in this laboratory.

Modernizing the lab will come true through with the addition of modern instruments which is a must for any Material Testing Lab. The modern equipments for ascertaining the strength of concrete structures using Non Destructive Techniques were available and will help to solve the practical problems arising in the field and creating awareness among the engineering fraternity. The lab is equipped with basic NDT instruments like Pile Integrity Test, Rebound hammer, Rebar locator, Ultra sonic pulse velocity

meter & Core cutter. These non destructive tests are being conducted to check the strength and deformation characteristics of the existing structures.

Two Hundred and seventy seven test reports were shaped from this division during the Financial year 2017-2018 earning a revenue of Rs.12,29,782 /- (Rupees Twelve lakh twenty nine thousand seven hundred and eighty two only). These materials were brought by various government as well as private entities.

D.2 Tests conducted

Details of tests conducted during the year 2017-2018 are given in Appendix-III

Field work conducted during the year 2017

1. Concrete core sample collection at MavelikkaraKuttanad package – Flood control work of T. A. Canal North – Unnippalam Box culvert – Onattukara

2. Pile Integrity Test (14 no piles) - Constructing Culvert in Kareethodu across Mannarkara road in Division No.47 & 48 of Kochi Corporation.

3. Kuttiyadi Dam Site core collection

E. SOIL MECHANICS AND FOUNDATIONS DIVISION

E.1 Introduction

Soil, the most unpredictable of all engineering materials also happens to be the all important material in civil engineering because all structures need to be founded on earth. In addition to being the founding medium, soil is also used as a material of construction. As in the case of other materials, properties of soil cannot be generalized since basically soil is a combination of different constituents having different properties. Therefore the study of the technical and structural aspects of soil is all important.

Major difficulties encountered in foundation work are due to the nature of soil. The investigation for any foundation engineering problem may range from a simple examination of soil to a detailed study of the soil and ground water by means of bore holes and laboratory tests on the materials encountered. The extent of the work depends on importance and foundation arrangement of structures, the complexity of the soil conditions and already available information of existing foundations on similar type of soils.

The physical characteristics of soils can be investigated by means of laboratory tests on samples taken from boreholes or trial pits. Results from lab tests can be used to derive important parameters in the design of substructure. The results of shear strength tests can be used to calculate the ultimate bearing capacity. Soil parameters so obtained by means of investigations can be utilized to design safe structures.

Soil Mechanics Laboratory under K.E.R.I. is fully equipped to determine the index as well as the engineering properties of soil samples and the engineers in charge are trained to provide recommendations if all necessary structural details are given. It covers Soil Mechanics, Soil Dynamics, and Ground improvement Techniques. The soil mechanics laboratory undertakes work from Government agency and private agencies.

Analysis of engineering problems such as bearing capacity computations, settlement analysis, stability analysis of slopes etc., are taken up by this Division. Instrumentation and analysis of seepage data from various Irrigation Projects are also taken up.

The work is spread out into the following stages.

E.1.1 PRE-CONSTRUCTION STAGE

During investigation, the soil samples are collected and tested in the laboratory, for finding out index properties and engineering properties like MDD, OMC/FMC, Permeability, Shear parameters, Consolidation and Swelling characteristics and relevant parameters are furnished to design the proposed structures. The laboratory is assisted by the Instrumentation Division which is equipped with field testing equipment for boring to collect undisturbed soil samples. Field tests like Plate Bearing Test, Standard Penetration Test, and Dynamic Cone Penetration Test to assess the in-situ characteristics of sub-soil are also being carried out.

E.1.2 POST CONSTRUCTION STAGE

Measurement of seepage through earth dam, inspection and investigations of causes of slips and breaches of canal and dam embankments are taken up and remedial measures are suggested.

All the tests on soil samples received from various projects of Irrigation Department, Roads and Buildings, Panchayat Raj, Public Health, Kerala State Electricity Board, Housing Board and Non-Government bodies are being tested as per the codes of Bureau of Indian Standards.

E.2 Infrastructure

The important equipments available in the laboratory are

i) Direct Shear Test apparatus (for both large & small boxes)
ii) Tri-axial Shear Apparatus
iii) Consolidation Apparatus
iv) Uni-axial testing Apparatus
v) Constant head permeability test apparatus
vi) Variable head permeability test apparatus
vii) Laboratory CBR test apparatus
viii) Field CBR test apparatus
ix) Fully Automatic consolidation Apparatus
x) Fully automatic Tri-axial shear apparatus
xi) Fully automatic Direct shear apparatus

E.3 Field Investigation

1) Construction of Regulator across Bharathappuzha at Koottakkadavu in Anakkara Panchayathu, Palakkadu - Pile Integrity Test Conducted

2) Fundamental Study– Conducting Geo physical study with Engineering Tomography of Rigid Dams–Tomographic study conducted at Kanhirappuzha Dam.

E.4 Fundamental Studies

One fundamental study, "Conducting a study on co-relation between grain size distribution/specific gravity, OMC and CBR value" has been proposed and data for the study were collected. Analysis is to be conducted. Due to another important works, studies could not be continued.

E.5 Laboratory Investigation

The list of works carried out in the lab during the current year is given in Appendix- IV.

E.6 Ongoing Works

1 Pambar basin Scheme - Reconstruction of Pattisseri Dam and Canal System under Chengalar scheme - Testing of earth Samples.

2 Qualitative analysis of sediments from Mangalam Reservoir.

3 Soil investigation for the construction of Regulator cum Bridge across Ummenchira at Chekkupalam Pinarayi Grama Panchayath in Kannur District.

F. INSTRUMENTATION DIVISION

F.1 Introduction

Instrumentation Division acts as the mobile unit of Soil Mechanics Division and conducts various field tests. The foundation is the lowest part of a structure. It transmits the load to the soil below. The extent of exploration depends on the importance of the structure, the complexity of the soil conditions and the budget available for exploration. A detail soil exploration programme involves deep boring, field tests and laboratory tests for determination of different properties of soils required for the design of any structure.Site investigation is essential for judging soil suitability for proposed engineering work and preparing adequate design. It also helps for selecting suitable and economic construction materials as well as methods. Site exploration reveals reliable information about soil and ground water which will help the Engineer for an intelligent planning.

Bore hole drilling – Making Bore holes is commonly used method for field investigations and they are executed by various devices ranging from simple hand operated augers to drilling machines.

1) Instrumentation division is in possession of two rotary type calyx type drilling machines. These machines are used for drilling in soil, soft rock and hard rocks for a depth of 50m to 60m. Standard Penetration Tests (SPT) are also conducted during the process of drilling. Disturbed and undisturbed samples are also collected during the course of drilling. Drilling in rocks are carried out by using diamond core bit. The

samples collected are transferred to Soil Mechanics & Foundations Division for carrying out various tests in soil for finding the engineering properties.

2) In-situ vane shear test apparatus – In-situ vane shear test apparatus instrument is used for conducting in-situ vane shear tests to determine the shear characteristics of the soil.

3) Permeability tests – Instrumentation division also in possessions of screw pumps and other related accessories for conducting field permeability tests of hard rock strata. Permeability tests has not yet been carried out by this division.

Soil samples are taken from sites on request and are transferred to Soil Mechanics and Foundations Division for testing. The following field tests are conducted by this division.

1. Standard Penetration Test.
2. Dynamic Cone Penetration Test.
3. Collection of disturbed and undisturbed soil samples by hand auger and machine boring.
4. In situ Vane Shear test

F.2 Activities of the division during the current year

This Division took part in the following work.

F.2.1. Construction of Regulator across Ummanchira River at Chekku Palam in PinarayiGrama Panchayath in Kannur District

The above investigation work has been taken as per the instructions of the Chief Engineer, IDRB, Thiruvananthapuram, Order No.IIS-INV-DB1/240/2017-IDRB Dated:22/06/2017.The site is at The Investigation work was carried out from 28/01/2018 to 11/03/2018.Investigation was carried out for 6points along the line of the proposed regulator and two points along the u/s and d/s of the regulator Administrative sanction (AS) was for an amount of Rs.8,65,000/-. Technical Sanction (TS) was for an amount of Rs.6,50,000/- and the expended amount for the work was Rs.4,51,205/.

F.2.2. Construction of Regulator at Parapram across Anjarakkandy River in PinarayiGrama Panchayath in Kannur District

The above investigation work has been taken as per the Site available for the construction of pump house is very close to river. Total investigations were carried in 15Nos. of Bore holes. The Investigation work was carried out from 25/08/2017 to 30/11/2017. Total amount expended for the works is Rs.4,23,865/-. FS was amount of Rs.12,00,000/-. AS for amount Rs.7,51,466/-. TS was for Rs.4,26,466/-.

F.2.3. Construction of Floating platform for carrying Investigation worksin Kannur.

The above works was carried for carrying out the investigation works of Parapram and Ummenchira as the departmental pontoons was engaged in works in Pathanamthittha and new boats with platform were to be engaged for carrying out the investigation works. AS for amount Rs.7,51,466/-. TS was for an amount of Rs.1,30,000/- and expended amount is Rs 1,29,629/-

F.2.4. Construction of Regulator across Manimala River on downstream side of intake well of RWSS to Nedungunnam&Kangazha at Kulathoormoozhy, Kottangal Panchayat in Ranni Constituency.

The above investigation work has been taken as per the instructions of the Chief Engineer, IDRB, Thiruvananthapuram. Order No.IIS-INV-DB1/240/2017-IDRB Dated:22/06/2017. Seven (7) bore holes were drilled during the period from 27/10/2017 to 11/12/17. Total Amount Expended is Rs.2,11,657/-. AS & TS was for an amount of Rs.2,15,610/-

F.2.5. Construction of a Regulator across Manimala River at Pullukuthy on the downstream side of intake well of CRWSS to Mallappally, Anikkadu &Kottangal (Part) Panchayat Phase 1.

The above investigation work has been taken as per the instructions of the Chief Engineer, IDRB, Thiruvananthapuram Order No.IIS-INV-DB1/240/2017-IDRB Dated:22/06/2017. The above investigation work has been taken as per the Site available for the construction of pump house is very close to river. The Investigation

work was carried out from to 09/08/17 to 27/12/2017. AS and TS was for an amount of Rs.2,14,741/-. Amount expended for this works is 2,13,947/-.

F.2.6. Construction of regulator cum bridge across Neyyar River at Mavillakadavu downstream of KWA pump house to prevent salinity intrusion.

The above investigation work has been taken as per the instructions of the Chief Engineer, IDRB, Thiruvananthapuram Order No.IIS-INV-DB1/240/2017-IDRB Dated:22/06/2017. Five (5) points along the stream and two on u/s and d/s of the proposed regulator. The investigation work was carried from 22/01/2018 to 17/02/2018. AS & TS was for an amount of Rs.2,07,897/-. Total Amount Expended is Rs.2,07,558/-.

F.2.7. Construction of regulator across Manimala River on the downstream side of Paduthode Bridge for the benefit of RWSS to Puramattam &Ezhumattoor.

The above investigation work has been taken as per the instructions of the Chief Engineer, IDRB, Thiruvananthapuram Order No.IIS-INV-DB1/240/2017-IDRB Dated:22/06/2017. Five numbers (5 Nos.) of boreholes were drilled along the cross section of the regulator and two numbers along the u/s and d/s of the regulator. The Investigation work was carried out from 28/07/2017 to 26/10/2017. AS and TS was for an amount of Rs.2,44,880/-. Amount expended for this works is Rs.2,42,854/-.

F.2.8. Investigation for proposed dam at Nerimangalam Farm of Agriculture Department.

Soil Investigation for the proposed dam at Nerimangalam Farm was carried as per the letter from the Assistant Executive Engineer, Agriculture Engineering Department, Ernakulam District. Investigation work was started on 23/04/2017 and completed on 09/05/2017. Eleven numbers (11 Nos.) of bore holes were drilled along the axis of the proposed dam and its peripheral area. AS and TS was for an amount of Rs.5,40,000/- and Rs.3,90,000/-. Total amount expended for both topographic work and investigation work was Rs.2,71,216/-. Working cost for Investigation woks was 1,46,256/-.

F.2.9 De-siltation of Mangalam Dam – QualitativeAnalysis of Sediments

From the sedimentation studies carried out by KERI, it was revealed that most of the reservoir got silted up beyond the Dead storage level. This fact prompted the Government to initiate the desilting of reservoir and the **Standard Operation Procedure (SOP)** was promulgated by the Government Vide G.O. (MS) No.79/2017/WRD dated, Thiruvananthapuram, 26/09/2017 for De-siltation of reservoirs. Chulliar and Mangalam reservoirs were selected as pilot projects for Desilting.

As per SOP, the water spread area of the reservoir is to be divided into grids of size 50mx 50m and samples should be extracted from the center of each Grid. KERI was entrusted the work qualitative analysis of sediments form Chulliar and Mangalam Reservoirs. Since the facility for extraction of sediment samples under water is not available with the KERI. Hence KERI had sought help from other agencies and NCESS expressed their willingness to extract samples and NCESS was entrusted with the work of sample extraction using gravity corer from under water and adopting other ground sampling methods from areas having no water. A Memorandum of Understanding (MoU) was also signed between Investigation Design and Research Board, Thiruvananthapuram on behalf of Irrigation Department, Kerala and the Director, NCESS, Thiruvananthapuram, on 13/12/2017 vide MoU No.01/INV-DB3/9/2017-IDRB Dated, 13/12/2017. As per SOP, total reservoir area was initially divided into several zones of size 200m x 200m and these zones were further divided into grids of size 50m x 50m. The zones were numbered from 1 to 93.

1180core samples were to be collected from the water spread area by considering Full Reservoir Level (FRL). Though as per higher level decision, it was decided that the extraction of core samples limited to the water spread area corresponding the water level 1m below the FRL. Reduced water spread area leads to change in total number of core samples to be extracted and hence core samples number changed to 1105 from 1180. Total 1105core samples were collected from the reservoir. Out of 1105core samples, 394 core samples have been tested by NCESS. Remaining core samples were tested in the Soil Mechanics and Foundations Division, KERI. The total number of core

samples to be collected from the water spread area was 1260 by considering FRL. But as per the decision taken in Technical Committee Meeting, it was decided that the extraction of core samples to be limited to water spread area, corresponding to the water level 1m below the FRL. Reduced water spread area led to change in total number of core samples to be extracted and hence core samples number changed to 1105. NCESS collected 1180samples from areas where they considered accumulation of sediments is more likely to occur. FRL level of Mangalam Dam 77.88m. Sample collection started on 20/02/2018 and continued till 02/05/2018. Of the 1105core samples collected, 380core samples have been tested by NCESS, remaining 725core samples were tested by Soil Mechanics & Foundations Division, KERI. Sample extraction work was by NCESS under the supervision of officials from Instrumentation, CM & FE, KERI; first set of samples received at Soil Mechanics Division on 12thMarch, 2018 and the analysis of sediments completed in 2ndweek of May, 2018. As per order No.d2-1206 dated:12/02/2018 recording of items of works connected with the sample collection from reservoir site, conveying the samples to SM Laboratory, KERI and conveyance of officers for supervision of works and preparation of bills was entrusted to Instrumentation Division KERI. AS for the works for an amount of Rs.1,86,00,000/- in which for the works of Mangalam Dam was Rs.1,45,00,000/-. TS was for an amount of Rs.1,41,50,000/-.

F.3. Infrastructure

The important equipments available in the Division are

- Equipments for hand auguring.
- In-situ Vane shear test apparatus

Boring work in right abutment in Paduthode site

Boring work in stream in Paduthode

Boring work in stream middle portion Paduthode

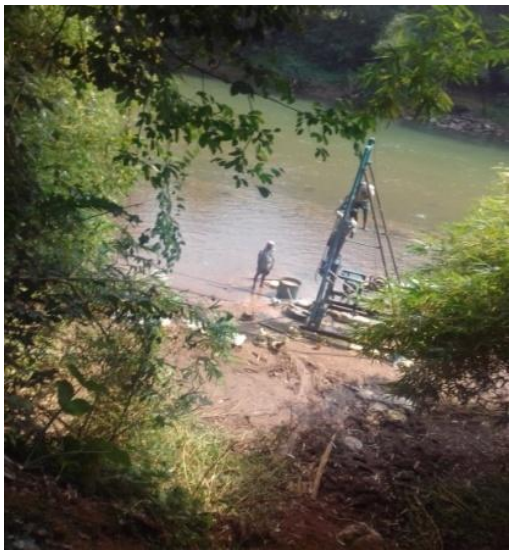
Water level risen in stream in Paduthode

Boring works in Pullukuthy site

Boring works in stream portion Pullukuthy site

Boring in stream –Paraparam

Boring in stream –Paraparam



Boring in stream –Kulathoormozhy site

Boring in stream –Mavillakadavu site

Gravity core sampling of sediments at Mangalam Dam

G. PUBLICATIONS WING

G.1 Introduction

Publications Wing was acting as the information bureau of the Kerala Engineering Research institute. This wing provides necessary technical information to all other divisions through its technical library containing around 10000 (ten thousand) books and a number of latest periodicals. This wing conducts seminars and training programmes for the benefit of staff of the Institute. Also, the wing conducts Trainings and Refresher courses for the staff of the Irrigation Department. Publications Division was deployed with effect from 31/01/2017 and the activities are now being taken up under Instrumentation Division.

G.2 Activities of the Wing

During the financial year 2017-18 the main areas of work attended by this wing are:

- Maintenance and development of Library.
- Editing and publishing of Annual Report 2016-17.
- Conducting Seminars for the benefit of the technical hands and staff in the institute.
- Conducting Refresher courses for the Engineers and technical staff of the department.
- Routine works of Publications Wing.

G.3 Library Service

This Wing has an excellent technical library attached to it. Latest publications on topics of interest to research workers are being regularly added. The library is being used by many technical persons in different Government Departments and also by a number of students from different Engineering Colleges and Polytechnics. Books are issued to officers attached to KERI using Library software. The card system is also being maintained. However, facilities are extended to Engineers working in various Departments and Institutions for referring the books.

The books are arranged in different shelves according to the subjects

G.3.1 Library Books

26 books were purchased to the library during this financial year.

G.3.2 Periodicals

A total of 10numbers of Indian periodicals were subscribed by this Wing. The following journals were purchased by subscription during the year.

G.3.2.1. Indian Periodicals

1. Indian Concrete Journal
2. Electronics for You
3. The Bridge &Structural Engineer
4. Indian Journal of Power & River Valley Development
5. Civil Engineering and Construction Review
6. Master builder
7. Down to earth
8. Indian Geo Technical Journal
9. Indian Journal of Geosynthetics and Ground Improvement.
10. ISRM India Journal.

G.4 Publication of Annual reports

Annual Reports for 2017-18 was published and copies were sent to important institutions and personnel.

G.7 Seminar Programme

Sl. No.	Title of paper	Name of speaker	Date
1	Research Methodology in Civil Engineering.	Dr. Santhosh Kumar.P.T,Assistant Executive Engineer,Cauveri Sub Division,Sulthan Batheri.	25/09/2017

G.8 Training and Refresher courses for Engineers and Technical Staff of Department

G.8.1 Refresher course on "Quality tests for Construction materials"

The refresher course was conducted at KERI on 23rd January, 2018 for the Overseers of Irrigation Department. Eighty-five (85) Delegates participated in the Programme. The classes were taken by Er. Siji T.V., Assistant Director, Construction Materials Division, KERI, Peechi.

G.8.2 Refresher course on "Quality tests for construction materials"

The refresher course was conducted at KERI on 31st January 2018 for the Overseers of Irrigation Department. Forty-six 46 Delegates participated in the Programme. The classes were taken by Er. Siji T.V, Assistant Director, CM Division, KERI, Peechi.

H. COASTAL ENGINEERING FIELD STUDIES, THRISSUR

H.1 Introduction

The Coastal Engineering Field Studies was formed in 1973 and is engaged in the collection of data and field studies on Coastal Erosion along the Kerala Coast. The coast of Kerala extending 576km in the south west coast of India, is Characterized by a narrow longitudinal barrier strip of low-lying land, sand-witched between the Arabian Sea and a continuous chain of lagoons and back waters with connection to sea at several points. This strip is formed of alluvial deposits. In considerable stretches, the space between the sea and the back waters is very narrow and even less than a few hundred meters at many places. Any break in this narrow strip would expose the back water to the fury of the waves and could endanger the entire disappearance of the barrier beaches.

The coastal zone has the maximum concentration of population and is even many times the State average at several places. Many of the foreign exchange earning industries, residential localities, a number of district headquarters, good number of ports, fishing harbours and extensively cultivated land also exist along this narrow coastal zone.

The coastline of Kerala is subjected to severe erosion in a major portion of its length during the monsoons, when the sea becomes rough due to consistent attack of waves. The coastline is sometimes subject to tidal overflow also, when adjoining low lying lands get submerged. Erosion is very severe in the coastal areas during the south west monsoon period. During the worst monsoon period, the highest waves average 2.3metres and wave periods range from 9 to 12sec and they come mostly from west. Storm tides occur all along the coast during the monsoon season. During the monsoon, the high waves coupled with storm surges, cause overflow and flooding of the low lying backshore lands all along the coast, resulting in considerable loss of property, destruction of private and Government buildings, communications, dislocation of life of lakhs of population and disruption of other activities affecting economy. The influence of saline water through mouth of rivers also affects agriculture and industry.

New CP stones have been planted throughout the Kerala coast except about 25km length of north extreme end at Manjeswaram. The GPS Co-ordinates of all CP stones have been recorded.

All aspects of the coastal erosion problems of the State, the necessity for immediate protection of vulnerable stretches, efforts made in collection of coastal data for long periods in conducting studies and in getting expert advice from all over the world and achievements made so far in tacking the erosion problem.

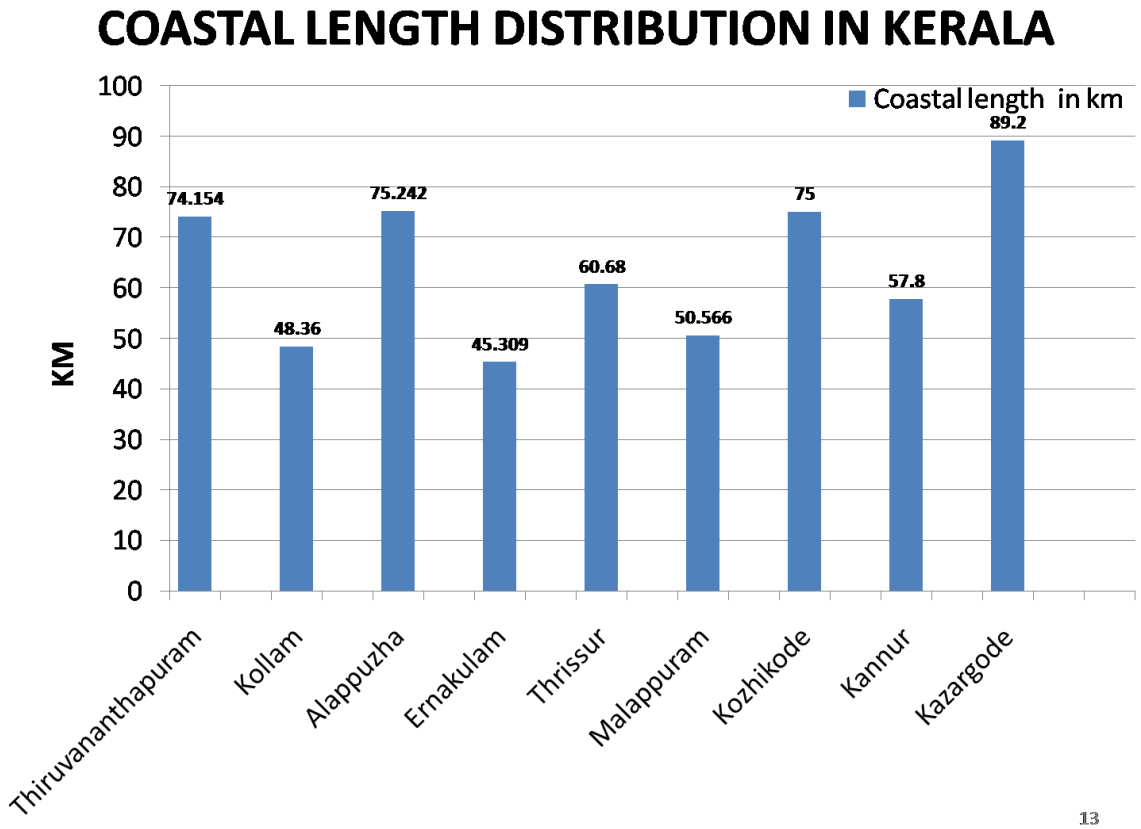
Many experts who visited this State, to study the behavior of the coast and also for periodical evaluation of the performance of completed sea walls, were all of the same opinion that the sea wall damage, mostly due to improper maintenance is as important as the construction of sea wall.

For proper construction and to understand the performance of the sea wall during and after construction, proper monitoring is necessary. This requires consideration of the field staff with the staff engaged in coastal erosion studies. Whenever a new sea wall is to be constructed, the research staff must be informed of the different stages of construction, starting from alignment of the sea wall forming filter, core, armour layers,

etc., so that the performance of it during construction and after construction can be watched.

The field staff also must keep a date-war record of construction details starting from alignment, excavation, putting filter, forming core, armour layer, etc., as per lines and level. The distance and levels of stones in front of sea wall also must be watched regularly with the progress of construction of sea wall. All chainages of sea wall must be made with reference to the Km/CP stone available at site.

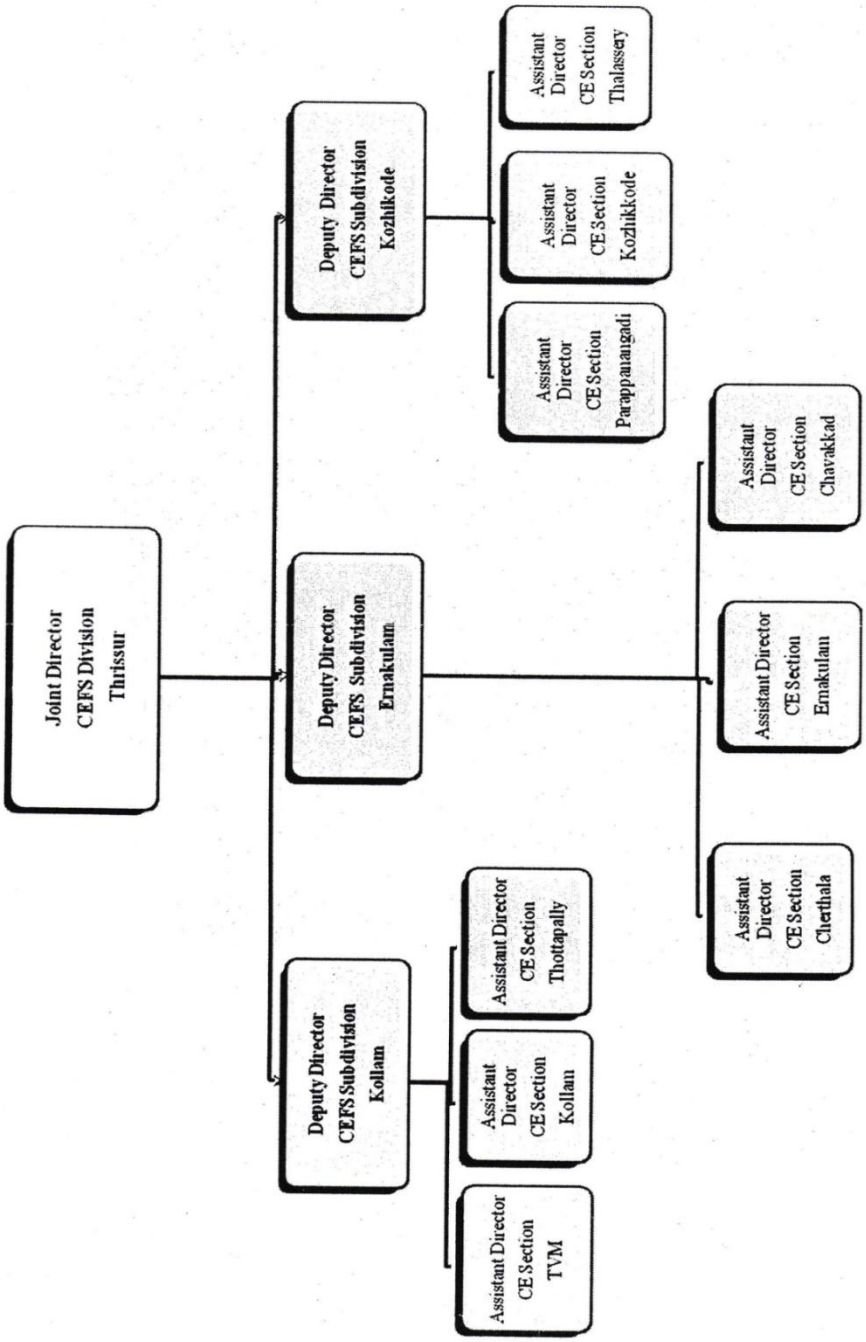
The concerned Assistant Engineers must give all relevant details to the concerned Assistant Directors in charge of Coastal Erosion Studies from time to time, as per the above guideline and also keep a copy of the same for reference.



13

ORGANISATIONAL SET UP

Name of Sub Divisions and Sections Under Coastal Engineering Field Studies Division, Thrissur



H.2General Arrangements and field studies

For the detailed study of the characteristics and behavior of the beach, the 576km of the Kerala coast is divided into three regions viz., Southern region, Central region and Northern region. Each of these regions is under the control of the Deputy Directors and further sub divided into the control of Assistant Directors. The three regions come under the Coastal Engineering Field Studies, headed by the Joint Director who works under the guidance of the Director, Fundamental and Applied Research, Kerala Engineering Research Institute, Peechi.

The extent of natural formation of beach, the position of protective dunes, the details of lagoons, inlets i.e., azhis are observed. Assessment of variation in tides and winds, movements of waves, littoral drift etc., are made. Also the general study of the important structures in the coast, natural bed slope and depth of water as far as possible up to the depth of closure of sea are also carried out, (which are to be examined in detail before any protection work is taken up). Thus the programme of study can be summarized as, Investigation of present conditions of sea coast by means of surveys and observations. Investigation of past history of coast from the available maps and records.

The specific factors for which specific data are being collected and obtained are as follows:

1. Shore History
2. Shoreline and shore depth changes
3. Accretion and erosion
4. Type of protection works installed and their effectiveness.
5. The direction, amount and character of littoral drift that produced the problem conditions.
6. Material characteristics composing the littoral zone.
7. Forces pertinent to the littoral zones
   a) Waves
   b) Currents
   c) Tides
8. Effects of mud banks
9. Effects of inlets

H.2.1 Sub Items of Study

1. Fixing and maintaining Control Point stones, K.M.stones and Alignment stones.

   a) Connecting levels of Control points.

   b) Maintenance of existing Control Point stones, K.M.stones and Alignment stones.

   c) Planting new and replanting missing CP Stones, KM stones, Alignment stones and Bench mark stones

2. Study of shoreline and shore depth changes

   a)Taking cross section profiles

3. Physical Surveys

   a) Topographic surveys
   b) Periodical measurements of shorelines
   c) Photograph

4. Study of littoral drift
5. Study of beach samples
6. Studies on wind, wave and tides
7. Studies on coastal protection works
8. Mud banks studies
9. Alignment fixation of new seawall
10. Other Studies

    a)Simultaneous Observations and daily observations

H.3 Details of Works

H.3.1 Planting of New Control Point Stones, Alignment Stones, Kilometer Stones and Benchmark Stones along the Sea Coast

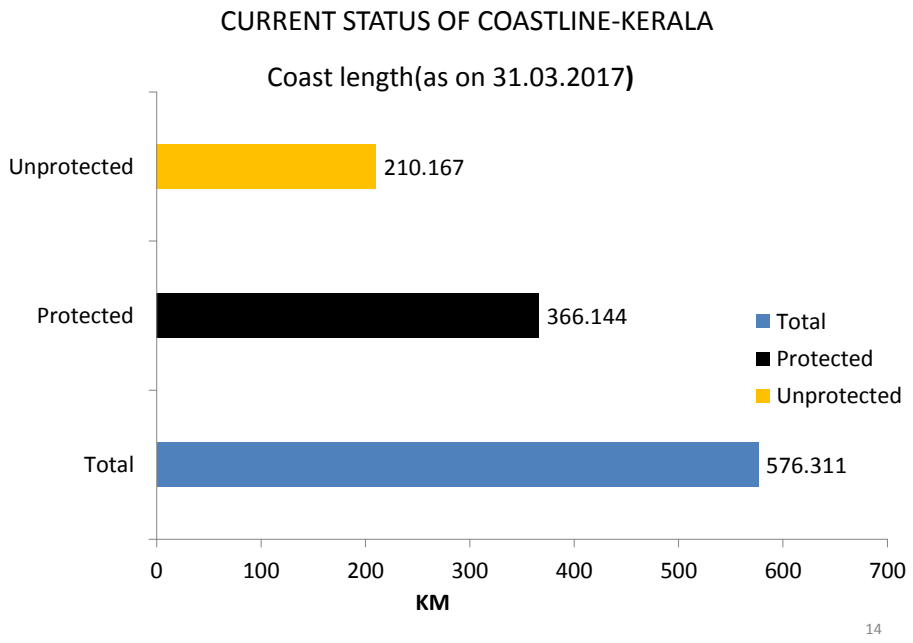
Control Point Stones and Alignment Stones are the most important reference points for all the collection of data and for carrying out the protection works. In most area, levels are also established on those stones. The regions are referred by the Control Point stones. The references in certain reaches are made on BLS i.e., Base Line Stones. Shore line measurements, fixing of levels, topographic survey and similar important factors are based on these stones. Similarly, K.M. Stones are established to ear mark each region. BM stones are planted along the shore as permanent level marks. The levels on Control Point Stones are further checked on the basis of the B.M. stones.

Many of the Control point stones and alignment stones are seen missing and damaged due to various reasons.

The work of planting new CP stones, alignment stones, KM stones and BM stones along the sea coast under the jurisdiction of Thalassery for a length of 25km is not executed. The above works have not been executed in this work since no fund is allotted.

H.3.2 Investigation Works

Field studies and collection of data on coastal erosion have been conducted on all sections under this Division. All Kerala level, Coastal status is updated and Presentation was done at the Ministry Level. A copy of the same was sent to all the Divisions to construct the protection works at the priority basis.



H.4. Programme of Study

In coastal environment, waves, tides, currents and winds are the important parameters which need to be considered for any development. It is very much essential to understand the physics of these process. Coastal erosion is the wearing away of land by the action of waves, current and wind. Coastal erosion is accompanied with landward recession of the sea shore and loss of land area. It is a common problem faced in almost

all coastal areas. Only the magnitude and nature of erosion changes from place to place. Along the most part of Kerala Coast, the erosion observed is seasonal in nature, that is, beach gets eroded during monsoon and regains its original profile during fair weather season. However, at some places erosion is of permanent nature.

H.4.1 Simultaneous Wave Observations

Simultaneous wave observations are being conducted at 18 specified location along Kerala Coast on all new moon days to understand characteristics of wind, wave and tide details such as width of back shore, fore shore, slope of fore shore, composition of beach materials, characteristics of littoral drifts, shore history and they are recorded on standardized format.

H.4.1.1Study of Littoral drift

Littoral transport is the movement of sediments in the near shore zone by waves and currents. This transport of suspend and bed load particles are both in parallel to the sea shore and perpendicular to sea shore. This transport of suspended materials is called littoral drift. It has been ascertained from the past studies that the dominant direction of littoral drift in Kerala coast is from north to south. However the directions, an annual quantity of net and gross quantity are important in developing shore protection arrangements. Now only the direction of drift is being studied at selected at points along the shore.

H.4.1.2 Study of Wind and Waves

Winds are the natural generators of wave and their study is necessary. An understanding of the nature of the tidal phenomenon is necessary for the study of coastal behaviors. The top level of the coastal protection structures depend on the tidal level and their data must be collected.

Wave causes sand to move along the coast as well as on to or off a beach. Due to refraction, wave energy is concentrated in certain reaches of the coast where erosion became naturally severe. Hence the design of coastal protection structures primarily depends on wave characteristics and since these studies are essential.(Predominant direction of waves is from west or north west).

H.4.2 Dates and places of observations

In order to have more detailed idea of the behavior of factors affecting the shore line changes, three consecutive points are taken for reference. At a particular study reach five readings are taken in all three points at definite timing. Nearly 20 to 25km apart straight reaches without much external disturbances are selected for taking these simultaneous observations. The places of observations with timing and CP Nos. are listed below. The dates in the year 2017 are shown in Appendix V.

H.4.3 Study of Mud banks

Mud banks, a phenomenon peculiar to the coast of Kerala are those in shore region where wave energy is dissipated completely as a result of the colloidal mud suspension mud bank protect the coast immediately near it, but causes erosion in the down-drift side due to diffraction of waves.

Many rivers in Kerala exhibit a continuous migrating tendency. Such migration influences the beach characteristics in the adjacent areas considerably.

H.4.4 Periodical measurement of shore line changes:

Periodical surveys are taken to determine the shore line changes of the coast. The offset measurement of the shore line with respect to Control point and Alignment stones are taken every month and recorded. It provides very important data to understand the shore line fluctuation of the coast.

H.4.5 Collection and Study of beach samples

Pre-monsoon (May) and post-monsoon beach samples are collected from specified places for testing grain size distribution and specific gravity since the erosion and accretion of coast depends up on the nature of beach material to a certain extent. Also for natural nourishment materials can be supplemented to the beach and thereby the erosion can be reduced. Beach samples are important variables determining the beach characteristics. Study of beach materials, characteristics and sources is essential for the evolution of a long term shore protection plan.

H.4.6 Report on Coastal damages and Taking photographs

The details of damages at various places in the coastal beaches have been collected from time to time and photographs are taken to understand the details of erosion, coastal damages occurred during monsoon and drastic changes in the shore line.

H.4.7 Cyclone Ockhi and its Impact on Coastal Area:

In the wake of cyclone Ockhi, heavy coastal damages were reported from entire coastal area of Kerala especially in Thiruvananthapuram district. The wave height was 2-3m above than the normal. As a result, heavy erosion to sea coast and extensive damages to houses were reported from many places. The most affected locations are Panathura, Poonthura, Beemappally, Valiyathura, Sanghumukham, Poothura and Anchuthengu of Thiruvananthapuram District, Thanni, Eravipuram, Alappad and Cheriyazheekkal in Kollam District and Thurayilkadavu, Arattupuzha, Thrikkunnapuzha, Panoor, Kumarakodi, Pallana, Purakkadu, Ambalappuzha and Valanjavazhi of Alappuzha District. The damages caused by Ockhi had been timely reported to the higher office with photographs.

H.4.8 Taking cross section profile of the beach

Cross section profiles taken using leveling instrument and leveling staff (Taken up to wading depth of waters).

H.4.9 Alignment fixation of sea walls:

The Joint Director inspected the sites for fixing alignment of sea wall (construction and reformation) with the concerned Irrigation officials, Deputy Director and Assistant Director of the Coastal Sub Division & Sections concerned, and approved the alignments of sea walls along Kerala Coast, considering the last 5year shore line measurements and the alignment of the sea.

Alignment approval has been given to the following works by the Joint Director, Coastal Engineering Field studies, Thrissur during the year 2017.

Sl.No.	Name of sub Division	Alignment approved during 2017	Essentiality certificate issued during 2017
1	CE SubDivision, Kozhikode	1 No	1 No
2	CE SubDivision, Kollam	Nil	Nil
3	CE SubDivision, Ernakulam	1 No	Nil

H.5 Performance of the Division in the year 2017

Within the limitations of availability of funds, availability of field staff and modern instrument, this division has taken up all the possible studies in the year 2017. The performance can be summarized as follows.

Types of works

1.	Topographic survey conducted for Determining beach profiles	Nil
2.	Periodical measurement of shoreline changes	4321.308 Km
3.	Simultaneous observations	211 Set
4.	Soil sample collected	42 Set.
5.	Cross section profiles	Nil
6.	Levels connected	Nil
7.	C.P Stones planted	Nil
8.	Alignment stones planted	Nil
9.	Kilometer stones planted	Nil
10.	Bench mark stones plant	Nil
11.	Alignment fixed by Joint Director	1No.
12.	Details of damages at various places in the Coastal beaches collected (separately attached - Statement No.3)	72 Nos.
13.	Mud bank study	Nil

H.6 Sub Division-wise Coastal studies performance are as follows:

Sl. No.	Coastal studies	Sub Division		
		Kollam	Ernakulam	Kozhikode
1.	Topographic survey conducted	Nil	Nil	Nil
2.	Periodical measurement of shoreline changes	1488.00 Km	1119.468 Km	1716.00 Km
3.	Simultaneous observations	60 Set.	72 Set	84 Nos.
4.	Taking photograph	45Nos	22 Nos.	79 Nos.
5.	Soil sample collected	20 Set	12 Set	14 Set
6.	Cross section profiles	Nil	Nil	Nil
7.	Levels connected	Nil	Nil	Nil
8.	C.P Stones planted	Nil	Nil	Nil
9.	Alignment stones planted	Nil	Nil	Nil
10.	Kilometer stones planted	Nil	Nil	Nil
11.	Bench mark stones planted	Nil	Nil	Nil
12.	Guard stones planted	Nil	Nil	Nil
13.	Details of damages at various places in the Coastal beaches collected	Nos.	Nos.	Nos.
14.	Study of Mud bank	Nil	Nil	Nil

The coastal data of Periodical measurements which backs to 1990 has been digitized and the digitization of available data of sled survey.

IX. BOTTLENECK FACING

Coastal Engineering Field Studies is the one and only institution entrusted with the collection of coastal field data and field studies connected with the erosion of the entire sea coast of Kerala, the functions assigned to which are vital & essential. But at present CEFS is provided with bare minimum facilities. The office building of CEFS, Thrissur is in a pathetic condition and it is a Herculean task to protect the valuable records of collected data. Similarly, it is very cumbersome to consolidate and process the valuable

data collected for the last so many years manually and are being deteriorated. However, the staff of Coastal Engineering Field Studies took great effort to digitize available maximum data for the past 25 years.

The Chairman, Coastal Protection and Development Advisory Committee (CPDAC) had advised the Chief Secretaries of all Coastal States to create a separate department for dealing with the Coastal Engineering works of the respective states vide Lr.No.4(5)/2000CED dated:09/06/2000 to organize a coordinated program of collection, compilation, evaluation and publication of coastal data. Hence this wing is to be made permanent.

The staff strength of the wing is insufficient even for the routine performance. The CEFS Division is not having the posts of PA/TA., DA. The only two posts of clerks were declared as supernumerary. Only an Assistant Director is available in Parappanangadi section for the last ten years for meeting all the activities.

Coastal Engineering Section, Thalassery coming under the control of Deputy Director, Kozhikode Sub division extends from Mahe to Manjesweram with a length of 148km. At present only 90km is under study reach. No study is being conducted in the remaining 58km (excluding Naval Academy and Bakel Fort). Assistant Director of each section is collecting field data and doing survey works for an average length of about 60km with the assistance of 2 Draftsman/Overseer.

As far as Kerala Coast is concerned, the sea is turbulent, especially during monsoon and coastal erosion is a common phenomenon along the sea coast for which continuous field study in all aspects is essential. But it is regretted to state that the budget provision, which was around 100lakh during the nineteen nineties, has got reduced considerably in the recent years to 5lakh bringing the survey works to almost stand still. At present the wing is collecting data on shoreline measurements, simultaneous observation, preparation of coastal damage reports with photographs and collecting soil samples only. Training programs on Coastal Engineering and allied subjects to update and train the technical personnel of the department regarding the latest development in this field is essential. No training has been conducted under this wing due to lack of

funds. The study wing now follows old conventional method of observations like visual observations, tape measurements etc. High derivative modern instruments are now available in this field.

The driver post for the Jeep under CEFS Division and Kollam remains vacant for a long time and it adversely affects the momentum of work schedule. The availability of vehicles is helpful in carrying out our studies as coastal areas are not easily accessible everywhere and private vehicles are reluctant for a trip to these remote areas with pathetic road conditions.

X. SUGGESTIONS/RECOMMENDATIONS

Sufficient fund has to be made available in time for conducting the entire study of coastal erosion. The coastal length coming under the jurisdiction of Thalassery section is 148km,and for studying the entire reach an additional section is to be formed.

The location of new International Port at Vizhinjam is between CP45 and 55.The construction authority has formed artificial shore and road by using materials drilled from the sea and breakwater construction is in progress. This area needs some specific studies for shoreline characteristics before and after the construction of Vizhinjam Port. Here due to terrain of land CP Stones have not been planted.

Some of the CP stones have been swallowed by the sea waves and some got destroyed by the weathering actions. As the new CP stones have not been planted for the continuous stretch, that profile could not be adopted for aligning sea walls etc. Hence CP stone planting and its timely maintenance is essential.

For getting the sufficient staff strength and for their maximum efficiency this wing is to be made permanent, considering the importance of this Division. Sufficient fund should be allocated for the training of technical staff and for procuring the modern scientific equipments for the collection of coastal data.

5. FINANCE

In the budget for the financial year 2017-18 an outlay of Rs.85 Lakh (Rupees Eighty Five lakh only) had been allotted under the Head of Account '4701-80-800-99-Development of KERI Stage II'. The proposal for the amount was grouped under three heads viz., Routine activities, modernization and revamping. The details of sanctioned amount and expenditure are given below. From the routine works carried out in the laboratories an amount of Rs.14,30,580/- (Rupees fourteen lakh thirty thousand five hundred and eighty only) has been collected as test charges and the amount was remitted in the treasury.

Details of sanctioned Amount and Expenditure

Sl. No.	Divisions	A.S. Amount
I	**Joint Director, C.M.&F.E., KERI, Peechi.**	
1	Construction Materials Division	13.12 lakh
2	Soil Mechanics and Foundations Division	10 lakh
3	Instrumentation Division	13 lakh
	Total amount received	**36,12,000/-**
	Expenditure	**17,67,746 /-**
II	**Joint Director, Hydraulic Research, KERI, Peechi.**	
1	Coastal Engineering Division	17,60000
2	Hydraulics Division	17,98,822
3	Sedimentation Division	18,00,000
	Total amount received	**53,58,822/-**
	Expenditure	**34,60,661/-**

Details of Expenditure statement for the year 2017 -18 had been allotted under the **Head of Account '4700-80-005-99-02-00-V "Investigation of Major Irrigation Schemes** " . The details of sanctioned amount and expenditure are given below.

KIIFB WORKS

Sl no.	Name of work	division	A.S Amount	Expenditure
I	**Joint Director, C.M.&F.E., KERI, Peechi**			
1	Investigation works for construction of Regulator across various river	Instrumentation Division	21,14,594/-	18,91,744/-
2	Desiltation of Mangalam dam: Qualitative analysis of sediments	Instrumentation Division	1,41,50,000/-	10,50,000/-
II	**Joint Director, Hydraulic Research, KERI, Peechi.**			
1	Investigation works for construction of Regulator across various river by using smart station.	Coastal Engineering Division	10,35000/-	7,66,411/-
2	Desiltation of Chulliyar dam: Qualitative analysis of sediments	Hydraulics Division	41,00000/-	3,45,402/-

Details of Expenditure statement for the year 2017 -18 had been allotted under the **Head of Account '2701-01-101-98-00-18-V "Maintenance of Peechi Schemes" .** The details of sanctioned amount and expenditure are given below.

Sl no.	Name of work	division	A.S Amount	Expenditure
I	**Joint Director, Hydraulic Research , KERI, Peechi**			
1	Renovation work of Kerala Model Building	Hydraulics Division	5,50,000/-	3,41,439/-

6. SUMMARY

In the annual report for the current financial year a general introduction about the institute, organization set up, division wise functioning of the institute, implementation of modernization scheme and details regarding budget allotment and expenditure have been explained in detail.

The bottlenecks or hindrance in the development of the institute as a full-fledged research organization are

- ***Insufficient number of technical personnel.***
- ***Lack of well qualified engineers.***
- ***Lack of up-gradation of technical knowledge of engineers through training.***
- ***Insufficient number of projects/underutilizations of the facilities available at the institute.***
- ***In the case of Field studies division, sufficient fund has to be made available in time for conducting the study of coastal erosion and high derivative modern equipments has to be made available.***
- ***The building of CEFS, Thrissur which is in a dilapidated condition has to be modified.***

All these require intervention from the part of the Government and it is hoped that the up gradation of the personnel of the institute will be taken up as a continuation of the modernization scheme.

Appendix – I

Vacancy Position as on 31/03/2017, KERI, Peechi

Sl. No	Designation	Sanctioned Strength					No of Posts Vacant					Remarks
		O/oDirector	CM&FE	Hydraulic Research	CEFS	Total	O/o Director	CM& FE	Hydraulic Research	CEFS	Total	
1	Director	1	-	-	-	1	-	-	-	-	-	
2	Joint Director	-	1	1	1	3	-	-	-	-	-	
3	Deputy Director	-	3	3	3	9	-	-	-	-	-	
4	Assistant Director	1	6	7	10	24	-	-	-	1	1	
5	Divisional Accountant	-	-	1	-	1	-		1	-	1	
6	Junior Superintendent	-	1	1	-	2	-	-	-	-	-	
7	Fair Copy Superintendent	-	-	1	-	1	-	-	-	-	-	
8	Selection Grade Typist/ UD Typist	-	2	1	1	4	-	1	-	-	1	
9	Research Assistant	1	8	7	9	25	-	-	-	-	-	
10	2nd Grade Overseer	1	4	4	12	21	-	1	-	4	5	
11	3rd Grade Overseer	-	3	2	-	5	-	-	1	-	1	
12	Scientific Assistant	-	1	1	-	2	-	1	1	-	2	
13	Tracer	-	-	1	-	1	-	-	-	-	-	
14	Blue Printer	-	-	1	-	1	-	-	1	-	1	
15	Driver	-	1	1	3	4	-	-	-	-	-	
16	Boat Driver	-	-	1	-	1	-	-	1	-	1	
17	Lab Attender	-	1	1	-	2	-	1	1	-	2	
18	Modeler	-	-	1	-	1	-	-	1	-	1	
19	Mason	-	-	1	-	1	-	-	1	-	1	
20	Worker Grade I/II	-	9	8	-	14	-	7	8	-	15	
21	Head Clerk	-	-	-	1	1	-	-	-	-	-	
22	UD Clerk	2	1	-	4	7	-	-	-	-	-	
23	Senior clerk	-	1	4	-	4	-	-	-	-	-	
24	LD Clerk	2	7	3	7	19	-	1	-	1	2	1 No. Deployed to MP
25	LD Typist	1	-	1	1	3	-	-	-	-	-	
26	Typist Clerk	-	1	1	-	4	-	1	-	-	1	
27	Office Attendant	2	6	3	13	24	-	-	-	5	5	
28	Part Time Sweeper	-	4	2	3	8	-	-	1	-	1	
29	Lab Assistant	-	2	-	-	2	-	2	-	-	2	
30	Information Assistant	-	1	-	-	1	-	1	-	-	1	
31	Assistant Surgeon	-	1	-	-	1	-	-	-	-	-	Deployed with effect from 31/01/2017
32	Pharmacist	-	1	-	-	1	-	-	-	-	-	
33	JPHN	-	1	-	-	1	-	-	-	-	-	
34	Hospital Attendant Gr.II	-	1	-	-	1	-	-	-	-	-	
35	Nursing Assistant	-	1	-	-	1	-	-	-	-	-	

Appendix – II

An abstract of the Weather data collected from Automatic Weather Station for the period from April 2016 to March 2017 is given below

Abstract of the weather data from April 2017 to March 2018

STATION: K.E.R.I,PEECHI

Latitude- 10^o 31' 30" N Longitude- 76^o 21'59" E MSL- +96.03 M.

Sl. No	Weather Elements	Range of the weather data
1.	Atmospheric pressure	Data from April, 2017 to February, 2018 not recorded due to sensor complaint. Maximum Atmospheric Pressure observed was 1004 milli bars in March-2018 and Minimum Atmospheric Pressure was 1000 milli bars in March - 2018.
2.	Temperature	The maximum temperature was 39.2^{o}C in March - 2018 and the minimum temperature was 20.0^{o}C in January - 2018
3.	Relative Humidity	Maximum relative humidity recorded was 100% in all the months and minimum relative humidity was 14.17% in March – 2018
4.	Precipitation	Annual rainfall was 2568.20mm and the maximum rainfall was 126.4mm in June-2017 and minimum rainfall 0.20mm in May & July, 2017.
5.	Wind-Direction	The main wind directions observed were from South East and North East directions.
6.	Wind Speed	Maximum daily mean wind speed was 9.1km/hr. in December, 2017 and minimum daily mean wind speed was 0.10 km/hr. in August and September, 2017.
7.	Global Radiation	Maximum Global Radiation was 1317.3watts/m^2 in June, 2017 and minimum of 465watt/m^2 in June, 2017.
8.	Evaporation	Maximum Evaporation was 8 mm in February & March, 2018 and minimum of 3.2 mm inSeptember, 2017.
9.	Sunshine Recorder	The maximum duration of bright sunshine was 9.3 Hours in March - 2018

Appendix – III

List of tests conducted in the CM laboratory

D.3 Routine Tests Conducted (January 2017 to December2017)

1 Compressive strength of Bricks supplied by the Assistant Engineer Chimmony Dam Project Sn. No 2. Echippara. Thrissur.

2 Testing of Cement Samples supplied by NALIN Agencies, Cement stockiest, Muringoor.

3 Compressive strength of concrete cubes supplied by the Assistant Engineer Quality control Sn, Thrissur.

4 Compressive strength test of concrete cubes supplied by The Assistant Engineer, HW section, Peechi.

5 Tension Test for steel rods upto 25 mm dia supplied by the Assistant Engineer Head works Section, Peechi.

6 Compressive strength test of concrete cubes supplied by M/s HPCL, Kozhikode.

7 Compressive strength test of concrete solid blocks supplied by M/s Bharathi cement corporation.

8 MIX Design for AEE, Irrigation Sub Division, Piravam.

9 Compressive strength test of concrete cubes supplied by Govt Hospital, Ghandigram, Koratty. HRDI

10 Testing Steel rods, cement, M sand & coarse aggregate from Chimony dam project Echippara

11 Compressive strength test of concrete cubes supplied by Assistant Engineer, Quality control Sn Thrissur for the construction of RCB at Attapilly across Kurumali River.

12 Compressive strength test of concrete cubes supplied by Assistant Engineer, Quality control Sn Thrissur for the construction of RCB at Attapilly across Kurumali River.

13 Compressive strength test of concrete cubes supplied by Assistant Engineer, Quality control SnThrissur for the construction of RCB at Attapilly across Kurumali River.

14 Compressive strength test of concrete cubes supplied by Assistant Engineer, Quality control Sn. Thrissur for the construction Nadathra Lift Irrigation Scheme

15 Tension Test for Steel rods supplied by the Assistant Engineer Quality control Sn Thrissur for the construction of RCB at Attapilly across Kurumali River

16 Compressive strength test of concrete cubes supplied by HPCL, Kozhikode

17 Testing M20 cement cubes for the reconstruction of damaged culvert at km3/000 of Kodungallur Shornur road

18 Compressive strength of concrete cubes supplied by Assistant Engineer PWD Road sn., Thrissur for the reconstruction of damaged culvert and drain in Edakunny road.

19 Testing compressive strength of concrete cubes by AE, PWD Road Sn Valappad

20 Testing compressive strength of concrete cubes by AE Quality control Sn Thrissur for the work of construction of RCB at Attappilly across Kurumali River.

21 Testing of steel bars supplied by AE Quality control Sn., Thrissur for the work of construction of RCB at Attappilly across Kurumali river.

22 Testing of steel bars supplied by AE, Sn No.I, Chimony Dam Project.

23 Testing compressive strength of concrete cubes by AE Quality control Sn Palakkad.

24 Testing compressive strength of concrete cubes by AE PWD Road Sn, Cherpu, Valappad

25 Testing of solid blocks by NCC for LULU Thrissur

26 Testing of tiles supplied by Mrs Syamala K.P, Sastha petrol pump, Puthur, Thrissur

27 Concrete Mix Design including determination of materials Properties supplied by the Assistant Engineer, PWD Building Sn No 1, Thrissur.

28 Concrete Mix Design by The Assistant Engineer, PWD Building Sn, Wadakanchery

29 Mix design by the project Manager Mahindra holidays7 Resorts India Ltd Chavara, kollam

30 Testing of tiles by Senior section Engineer(works), Ernakulam

31 MIX Design for AEE, Irrigation sub Dn, Piravam for the work of Check dam cum bridge across kothamangalam river.

32 Mix Design by Senior section Engineer Southern Railway, Thrissur,

33 Testing compressive strength of concrete cubes by AE, PWD Building Sn Chalakudy Govt: skin hospital HRDI ,Koratty, Ghandigram.

34 MIX Design by Southern Railway Kollam.

35 MIX Design M30 P.M Club Mahindra

36 Flexural strength& Tensile strength of Tiles supplied
The student NCERC Mechancial Pampady.

37 Test on steel rods by Phoenix Infra Build, Mahindra Holidays & Resorts, Thrissur.

38 Testing Fine aggregates supplied by Phoenix Infra Build, Mahindra Holidays & Resorts, Wayand.

39 Testing Coarse aggregates supplied by M/s Sterlin Holidays &Resorts, Wayand.

40 Testing compressive strength of concrete cubes by AE Quality control SnThrissur

41 Testing compressive strength of concrete cubes by AE Quality control SnThrissur

42 Testing of steel bars supplied by AE Sn No2 Chimony Dam project Echippara

43 Testing of Tiles supplied by Mrs. Syamala K. P Sastha Petrol Pump, Puthur, Thrissur

44 Testing of solid blocks supplied by the Secretary, Adaat Grama Panchayath,

45 Compressive strength of paving blocks supplied by Fins Engineers and Contractors.

46 Compressive strength of concrete cubes by Hindustan Petroleum corporation, Kozhikkode

47 Compressive strength of paving Tiles supplied by Assistant Engineer Irrigation Sn Aluva.

48 Compressive strength of paving Tiles supplied by Assistant Engineer Irrigation Sn Aluva.

49 Testing of Granular sub base and wet mix Macadam supplied by Assistant Engineer, PWD Road Sn, Thrissur

50 Water absorption test for Hydrophobic Plastering Mortar-"IZONIL" Supplied by CEO, Prasanth Menon P,Octagreen, Nanoproducts, Elamakkara (P.O).Kochi

51 Compressive strength of paving Tiles supplied by Assistant Engineer, LSGD Sn Nadathara for Ayyappankavu Heavenly Garden, Nadathara Panchayath

52 Compressive strength of paving Blocks supplied by Assistant Ex: Engineer TC Sub Dn, KSEB, Madakkathara.

53 MIX Design by Assistant Engineer, Thrithala

54 Testing compressive strength of concrete cubes by AE PWD (Jerin)

55 Testing compressive strength of c concrete cubes by AE Harbour Engineering Sub Dn, Chettuva, Kodungaloor

56 Testing compressive strength of concrete cubes by AE Head works Sn Peechi for DRIP Building for Dam Model Display for Peechi Irrigation Project.

57 MIX Design by Assistant Executive Engineer, MVIP Sub DnNo :8Vazhakulam, Kaloorkad.

58 Testing compressive strength of solid blocks and concrete cubes supplied by the Assistant Engineer, P.W.D. buildings section, Iringalakkuda.

59 Testing compressive strength of concrete cubes by the Assistant Engineer, Quality Control section, Thrissur.

60 Testing of cement, broken stone, steel bars & M sand supplied by Assistant Engineer, Walayar Dam Sn

61 Testing compressive strength of concrete cubes by AE Head works Sn, Peechi.

62 Testing compressive strength of concrete cubes by Assistant Engineer QC SnThrissur

63 Compressive strength & Water absorption tests of paving Tiles supplied by Sri.George baby, MD, SCORIPIO

64 Testing compressive strength of concrete cubes by assistant Engineer PWD Building sn, Chalakudy

65 Testing compressive strength of concrete cubes & concrete Cylindrical cube supplied by Sri VipinVijyan, MCE, Desamangalam, Thrissur.

66 Testing tensile strength of steel supplied by Assistant Engineer, IQC, Thrissur & Compressive strength of concrete cubes

67 Testing tensile strength of steel supplied by Assistant Engineer, PWD Building Sn for the work of construction of class room

68 Gradation test for wet mix Macadam for urgent restoration works to Kannara Moorkanikkara road supplied by Assistant Engineer PWD Road sn Thrissur.

69 -do-

70 Tension test of steel supplied by Senior Section Engineer, Southern railway, Thrissur226

71 Testing of coarse aggregate and M sand supplied by Assistant Engineer PWD Building Sn, Kodungllur.

72 Testing tensile strength of steel supplied by AEE, Engineering sub Dn Vellanikkara.

73 Testing compressive strength of concrete cubes by The Project Manager, Salim Associates, Guruvayoor

74 Testing compressive strength of concrete cubes by Ceecon firm

75 Testing of aggregates by AE road section Kodakara

76 Testing compressive strength of concrete cubes by Salim Associates Nandanam Heaven Padukkad

77 Testing of steel rods & Aggregates supplied by Assistant engineer, MI SnThrithala

78 Sieve analysis of fine aggregates collected from RCB across Bharathapuzha at Chenganamkunnu

79 Testing of concrete cubes supplied by Assistant Engineer, PWd Road sn, Valappad for the construction of Thonikavu Kanjirachivadu road in Thanniym Panchayath

80 Testing compressive strength of concrete cubes for RCB at Attappilly across Kurumali river.

81 Testing compressive strength of concrete cubes by AE Chimmony Dam Sn No III, Echippara.

82 Testing compressive strength of concrete cubes by AE TC Section, KSEB, Chalakudy.

83 Testing tensile strength of steel supplied by AE, PWD, Building Sn. -2, Ayyanthole.

84 Testing compressive strength of concrete cubes by Mr. Shanu S, NCC Ltd for the work of lulu hotel & convention centre

85 Testing compressive strength of concrete cubes by AE PWD Building section Irinjalakkuda

86 Testing compressive strength of concrete cubes by Senior Sn Engineer Southern Railway Thrissur

87 Testing of paver blocks supplied by AEE Engineering sub Dn Vellanikkara

88 Testing compressive strength of concrete cubes supplied by CDP Sn Echippara for constructing RCB at Attappilly

89 Testing compressive strength of concrete cubes supplied by Assistant Engineer, QC sn Irrgn Dept Palakkad.

90 Compressive strength and water absorption test of solid blocks supplied by Mr. Shanu S, NCC Ltd for the work of lulu hotel& convention centre.

91 Testing compressive strength of concrete cubes supplied by Assistant Engineer, QC sn Thrissur Irrgn Dept for the construction of sluice cum tractor crossing at Chelapuzha and Kutichirakaithodu, Eyyal

92 Testing of solid Blocks supplied by Saleesh K. M Quality Surveyor, Kottapuram road, Punkunnam, Thrissur for M/S Mahindra Holidays and resorts, India ltd

93 Testing tensile strength of steel supplied by AE, Minor Irrigation Sn, Thirurangadi

94 Testing compressive strength of concrete cubes supplied by Assistant Ex Engineer, Engineering sub division, Vellanikkara

95 Mix design for AEE KYIP Peruvannamuzhi

96 Testing of coarse aggregates by AE Head works section PEECHI

97 Concrete mix design by AE PWD building Sn Thrissur

98 Testing of cement by AE KPIP SN no4/3 Kanjirapuzha

99 Gradation test for 36mm metal supplied by Assistant Engineer, QC Sn, Thrissur

100 Gradation test for 36mm metal supplied by Assistant Engineer, head works Sn, Peechi.

101 Testing tensile strength of steel rods supplied by AEE, Engineering sub division, Vellanikkara

102 Testing tensile strength of steel rods supplied by AEE, Engineering sub division, Vellanikkara

103 Testing tensile strength of steel rods supplied by AEE, Engineering sub division, Vellanikkara

104 Testing of coarse aggregate Sand Steel rods and angles supplied by Power Grid Corporation of India Ltd, Kozhikode

105 Testing compressive strength of concrete cubes supplied by Assistant Engineer, Head works Sn, Peechi.

106 Tests on cement concrete paving tiles supplied by Senior Section Engineer, Southern railway, Kayamkulam.

107 Testing compressive strength of concrete cubes & Tensile strength of steel rods supplied by Assistant Engineer, CDP Sn No II, Echippara.

108 Testing compressive strength of concrete cubes supplied by Assistant Engineer, PWD Building Sn, Wadakacherry.

109 Testing of Aggregates by Power Grid corporation of India, Madakathara.

110 Testing compressive strength of concrete cubes supplied by Assistant Engineer, Chalakkudy Ghandigram, Koratty,

111 Testing of steel rods and solid blocks supplied by Assistant Engineer, PWD Building Sn, Chalakkudy.

112 Testing of solid blocks by Assistant Engineer, Kanjirapuzha irrigation Project.

113 Testing compressive strength of concrete cubes supplied by Assistant Engineer, PWD Building Sn., Irinjalakuda for Aloor Primary Health Centre

114 Compressive strength of Paver Blocks supplied by The Registrar, KFRI, Peechi.

115 Testing compressive strength of concrete cubes supplied by Assistant Engineer, Irrigation Quality control Sn, Thrissur.

116 Testing compressive strength of concrete cubes supplied by Assistant Engineer, Head works Sn Peechi for Peechi Project.

117 Testing of solid blocks by Assistant Engineer, Kanjirapuzha irrigation Project.

118 Mix design by Power Grid Corporation of India

119 Testing of coarse & Fine aggregates by Hilite Mall at Thrissur

120 Testing compressive strength of concrete cubes supplied by Assistant Engineer, PWD Building Irinjalakuda for Aloor primary Health Centre

121 Testing of cement & Fine aggregates by Hilite Mall at Thrissur

122 Testing of cement, Aggregates by Central Ware housing Corporation, Thrissur

123 Mix design by Assistant Engineer, Thrithala

124 Testing compressive strength of concrete cubes supplied by Assistant Engineer, Attappilly RCB, Chimmony Dam Project.

125 Mix design by power Grid Kozhikode &Testing of 40 mm Metal

126 Flexural strength of concrete Beams by Central Warehousing Corporation.

127 Flexural strength of concrete Beams by Central Warehousing Corporation.

128 Testing compressive strength of concrete cubes supplied CEO, Power grid corporation, Pathanamthitta

129 Testing coarse aggregates supplied by AGM, Power grid corporation, Pathanamthitta

130 Testing coarse aggregates supplied by AGM, Power grid corporation, Pathanamthitta

131 Testing Fine aggregates supplied by AGM, Power grid corporation, Pathanamthitta

132 Testing coarse aggregates supplied by AGM, Power grid corporation, Pathanamthitta

133 Testing compressive strength of concrete cubes supplied by AGM, Power grid corporation, Kochi

134 Testing Coarse aggregates supplied by AGM, Power grid corporation, Kochi

135 Testing Fine aggregates supplied by AGM, Power grid corporation, Kochi

136 Testing compressive strength of concrete cubes supplied by AGM, Power grid Corporation, Kochi

137 Testing compressive strength of concrete cubes supplied by AGM, Power grid Corporation, Kochi

138 Testing compressive strength of concrete cubes supplied by AGM, Power grid corporation, Kochi

139 Testing compressive strength of concrete cubes supplied by AGM, Power grid Corporation, Kochi

140 Testing Coarse aggregates supplied by AGM, Power grid corporation, Kochi

141 Testing Fine aggregates supplied by AGM, Power grid corporation, Kochi

142 Testing compressive strength of concrete cubes supplied by AGM, Power grid corporation, Kochi

143 Testing compressive strength of concrete cubes supplied by AGM, Power grid Corporation, Kochi(21Nos.)

144 Testing Tensile strength, % Elongation&Bend,Rebend test of steel supplied by AGM, Power grid Corporation, Kochi

145 Testing of cement supplied by AGM, Power grid Corporation, Kochi

146 Testing of cement supplied by AGM, Power grid Corporation, Pathanamthitta

147 Testing compressive strength of concrete cubes supplied CEO Power grid corporation, Pathanamthitta (18 Nos)

148 Testing compressive strength of concrete cubes supplied CEO Power grid corporation, Pathanamthitta (24 Nos)

149 Testing compressive strength of concrete cubes supplied CEO Power grid corporation, Pathanamthitta (18 Nos)

150 Testing compressive strength of concrete cubes from Assistant Engineer, CDP Sn.2, Echippara,for RCB work at Attappilly across Kurumali river (30Nos.)

151 Testing tensile Strength of steel rods supplied by Assistant Ex: Engineer, IIP sub Division No :3, Malayatoor.

152 Testing compressive strength of concrete cubes supplied by AGM, Power grid corporation, Kochi

153 Testing compressive strength of concrete cubes supplied CEO Power grid corporation, Pathanamthitta (18 Nos)

154 Testing of cement supplied CEO Power grid corporation, Pathanamthitta.

155 Testing of aggregates, Sand and solid blocks supplied by Assistant Engineer, PWD, Building Sn, Irinjalakuda.

156 Testing compressive strength of concrete cubes supplied by the Assistant Engineer, Quality control Sn, Thrissur.

157 Testing compressive strength of concrete cubes supplied by the Power grid corporationPathanamthitta& Kochi

158 Testing compressive strength of Paver blocks by BSNL Veterinary College, Mannuthy.

159 Testing of cement & steel test by Power grid corporation Malappuram District.

160 Testing compressive strength of concrete cubes supplied by the Power Gid corporation, HVDC, Thrissur.

161 Testing compressive strength of concrete cubes supplied by Engineer, KFRI, Peechi.

162 Testing compressive strength of Paver Blocks supplied by the Engineer, KFRI, Peechi.

163 Sieve analysis of fine aggregates by the Assistant Engineer, TC Sn, Pudukkad.

164 Testing compressive strength of concrete cubes supplied by the Power grid corporation of India, Kozhikode.

165 Testing of cement supplied by Managing Partner, Vishraam Builders, Thrissur

166 Testing of cement & Aggregates supplied by the Junior Engineer Power grid corporation of India, Kozhikode(cement 2 bags, & Aggregates)

167 Testing compressive strength of concrete cubes & Aggregates supplied CEO Power grid corporation, Pathanamthitta

168 Testing compressive strength of concrete cubes supplied by the Assistant Engineer, Head Works Section, Peechi.

169 Testing compressive strength of concrete cubes supplied by the Assistant Engineer, Quality control Sn, peechi.

170 Testing compressive strength of concrete cubes supplied by the Power grid corporation , Kozhikode

171 Testing compressive strength of concrete cubes supplied by the Assistant Engineer, Chimmoni Dam Sn, Echippara.

172 Testing of aggregates, Crushing value, Flakiness index Suppl1ied by

173 Compressive strength, Water absorption &Efflorescence of bricks supplied by Power Grid corporation, HVDC, Thrissur.

174 Testing compressive strength of concrete cubes supplied by the Power grid corporation of India, Kochi

175 Tensile Strength of steel rods supplied by Quality control section, Thrissur.

176 Compressive strength & Water absorption test for solid blocks supplied by Phoenix Infrabuild

177 Testing compressive strength of concrete cubes & Testing of cement supplied by Power grid corporation of India, Malappuram.

178 Tensile strength of steel rods supplied by Hilite mall at Thrissur.

179 Compressive strength of concrete cubes supplied by Ceecon, RMC Ltd, Padukkad

180 Testing compressive strength of concrete cubes & Tensile Strength of steel rods supplied The Assistant Engineer, Poomangalam Grama panchayath

181 Testing compressive strength of concrete cubes & Testing of cement supplied by Power grid corporation of India, Kochi. & Pathanamthitta

182 Compressive strength of concrete cubes supplied by The Assistant Engineer, PWD, Building Sn, Chalakudy.

183 Compressive strength of concrete cubes supplied by Power grid corporation, Kozhikode.

184 Compressive strength of concrete cubes supplied by KFRI, Peechi.

185 Testing PPC, Bharathi Cement by the dealers

186 Compressive strength of concrete cubes supplied by The Assistant Engineer, PWD, Road Sn, Kodungallur .

187 Testing of Aggregates by CEECon, RMC Pvt Ltd Pudukkad, Thrissur.

188 Compressive strength of concrete cubes 7 testing of Aggregates supplied by Power grid corporation, HVDC, Thrissur.

189 Testing of Aggregates, Cement & Concrete cubes Supplied by Power Grid Corporation, Pallikkara, Kochi.

190 Testing of Aggregates, Cement & Concrete cubes Supplied by Power Grid Corporation, Pathanamthitta (24 Cubes)

191 Testing of Aggregates by power Grid Corportion, Kochi.

192 Testing compressive strength of concrete cubes supplied by the Assistant Engineer, Quality control Sn, Irrigation Department, Palakkad.

193 Testing compressive strength of concrete cubes supplied by Power grid corporation of India, Kozhikode

194 Testing compressive strength of concrete cubes supplied by Power grid corporation of India, Kozhikode

195 Testing cement by Power Grid Corporation, Pathanamthitta

196 Testing of Aggregates by KEC International Ltd

197 Testing compressive strength of concrete cubes supplied by Power grid corporation of India, Kozhikode

198 Testing compressive strength of concrete cubes supplied by Power grid corporation of India, Kozhikode

199 Compressive strength of concrete cubes supplied by Power grid corporation, HVDC, Thrissur.

200 Compressive strength of concrete cubes supplied by Power grid corporation, HVDC, Thrissur.

201 Testing compressive strength of concrete cubes supplied by the Assistant Engineer, Quality control Sn, Irrigation Department Thrissur.

202 Compressive strength of concrete cubes supplied by the Assistant Engineer, Chimmoni Dam snEchippara..

203 Compressive strength of concrete cubes supplied by the Registrar, KFRI. Peechi.

204 Compressive strength of concrete cubes supplied by Power grid corporation, HVDC, Thrissur.

205 Compressive strength of concrete cubes supplied by Power grid corporation, Kozhikode

206 Compressive strength of concrete cubes supplied by the Registrar, KFRI. Peechi.

207 Compressive strength of concrete cubes supplied by the Registrar, KFRI. Peechi.

208 Compressive strength of concrete cubes supplied by M/S Global Builders, Chalakudy.

209 Mix design by (M25, M30 & M35) for Thrissur Builders Builders private Ltd

210 Mix Design by Southern Railway, Ernakulam (M25)

211 Mix Design (M25) & testing of steel rod 8mm dia for the Section Engineer, Southern Railway, Thrissur

212 Testing Compressive strength of Bricks and Water absorption by Phoenix Infrabuild.

213 Compressive strength of concrete cubes supplied by the The Assistant Engineer, PWD, Road Section, Kodungallur

214 Testing Compressive strength of Concrete Cubes supplied by The Project Manager, Nirmithi Kendra, Ayyanthole, Thrissur.

215 Compressive strength of Paver Blocks supplied M/s Kunduparambil Tiles, Mannampetta, Thrissur.

216 MIX DESIGN by Saleesh K M Quantity surveyor PHOENIX- INFRABUILD

217 Mix design by KFRI, Peechi

218 Compressive strength of concrete cubes supplied by Power grid corporation, Kozhikode.

219 Tesing of core rock samples supplied by Assistant engineer, M.I Sn, Thathamangalam. (13 bore Samples)

220 Tesing of core rock samples supplied by Assistant Engineer, M.I Sn, Thathamangalam. (10 Bore samples)

221 Testing of rock Core samples supplied by M/S Sediment soil, Palarivattam, Kochi.

222 Compressive strength of concrete cubes supplied by the Power Grid Corporation, Kozhikode

223 Mix Design by Assistant Engineer, M.I Sn, Thrithala

224 Compressive strength of concrete cubes supplied by the Power Grid Corporation, Kozhikode

225 Compressive strength of concrete cubes supplied by the K.F.R.I, Peechi.

226 Compressive strength of concrete cubes supplied by Assistant Engineer. PWD Road Sn, Chalakudy.

227 Compressive strength of concrete cubes supplied by the Power Grid Corporation, Kozhikode

228 Testing or rock core samples by A.E., M.I Section, Pattambi.

229 Compressive strength of concrete cubes supplied by the Assistant Engineer, Irrigation Quality control Sn, Thrissur.

230 Compressive strength of concrete cubes supplied by the Power Grid Corporation, Kozhikode

231 Compressive strength of Paver Blocks supplied by Kunduparambil Tiles, Mannampetta, P.O Varakkara.

232 Compressive strength of concrete cubes supplied by K.F.R.I, Peechi.

233 Compressive strength of concrete cubes supplied by the Power Grid Corporation, Kozhikode

234 Compressive strength of concrete cubes supplied by K.F.R.I, Peechi

235 Compressive strength of concrete cubes supplied by The Assistant Engineer,KPIP Sn Kanjirapuzha

236 Compressive strength of concrete cubes supplied by K.F.R.I, Peechi

237 Compressive strength of concrete cubes supplied by Ceecon Ready Mix Concrete Private Ltd, Pudukkad.

238 Compressive strength of concrete cubes supplied by Ceecon Ready Mix concrete, PVT Ltd, Pudukkad.

239 Testing of Cement & Aggregates supplied by Power Grid Corporation, Kochi & Pathanamthitta.

240 Compressive strength of Cement & Steel supplied by the Power Grid Corporation, Kozhikode

241 Compressive strength of concrete cubes supplied by the Assistant Engineer T. C Section, Pudukkad.

242 Compressive strength of concrete cubes supplied by the Assistant Engineer, KPIP Sn Kanjirapuzha

243 Compressive strength of concrete cubes supplied by Assistant Engineer, PWD, Road Sn, Kodungallur.

244 Compressive strength of concrete cubes supplied by Assistant Engineer. PWD Road Sn, Kodungallur

245 Compressive strength of concrete cubes supplied by Assistant Engineer. T.C Sn, Pudukkad.

246 Compressive strength of concrete cubes supplied by Engineer. KFRI, Peechi.

247 Compressive strength & W/A of Bricks supplied by Engineer Power Grid corporation, Kozhikode.

248 Compressive strength of paver Blocks supplied by Kundaparambil Tiles work. Mannapetta, Varakkara.

249 Compressive strength of concrete cubes supplied by Engineer Power Grid Corporation, Kozhikode

250 Compressive strength of concrete cubes supplied by Assistant Engineer Irrigation Quality Control Section, Palakkad

251 Compressive strength of concrete cubes supplied by Assistant Engineer Irrigation Quality Control Section, Thrissur

Appendix – IV

List of tests conducted in the SM Laboratory

E.5 Laboratory Investigation

Soil samples analysis for undisturbed and disturbed samples were tested for the following works:-

E.5.1. Engineering Structure Studies for setting up of an integrated Port Cum Ship Building Centre at Azhikkal Port in Kannur District - Testing of Sub soil samples.

E.5.2. Testing of soil sample for determining the properties of soil sample – M-tech thesis of Sri. Muraleedharan. M. A.

E.5.3. Testing of construction materials for construction of pathway in switchyard at Power grid, Kozhikode Sub-station.

E.5.4. An augmentation scheme to Painoor Kayal Lift Irrigation Project in Edathuruthy Panchayat of Kaipamangalam Constitutency

E.5.5. Laboratory Analysis of soil samples taken from Demolition site atThiruvathra in Chavakkadu Municipality. Thrissur

E.5.6. B.Tech Project work of Engineering students, Jawaharlal Collecge of Engineering and Technology.

E.5.7. Renewal of Chirakkal Chira, in Chirakkal Panchayath, Kannur District .

E.5.8 Investigation for small dam at Neriamangalam Farm of Agriculture Department in Ernakulam District.

E.5.9. Construction of canal bridge at Kurinjikkal Puthurkkara in Thrissur District.

E.5.10. Investigation of Kolarayar in Pathanamthitta District.

E.5.11. Investigation work for the construction Retaining wall on the bank of T. S. canal - Jalakelikendram to Kachikadavu

E.5.12. Investigation of Varattar, Pathanamthitta.

E.5.13. Investigation of Kolarayar in Pathanamthitta District

E.5.14. En Uru Project in Wayanadu District - Testing of Soil Samples from the Project site at Lakkidi in Wayandu District.

E.5.15. Construction of Bay Extension at 400/220 KV Substation, Kozhikkode.Testing of Construction Materials.

E.5.16. DRIP - Dam Rehabilitation and Improvement Project - Rehabilitation and Improvement of basic facilities of Walayar Irrigation project. Testing of Soil Samples

E.5.17. Construction of Bay Extension at 400/220 KV Substation, Kozhikkode. Testing of Construction Materials.

E.5.18. Construction of regulator across Manimala River on the downstream side of Paduthode Bridge for the benefit of RWSS to puramattom & Ezhumattor

E.5.19. Construction of regulator across Manimala River at Pullukuthy on the downstream side of intake well of CRWSS to Mallappally, Anikkadu and Kottangal (part I) Panchayath Phase I.

E.5.20. Soil investigation at the proposed site for Kizhuppillikkara Lift irrigation Project in Thanniyam Panchayath.

E.5.21. Construction of Regulator across Chitturpuzha Valavupalam in Nalleppilly GramaPanchayath in Palakkad District

E.5.22. Construction of Regulator across Chittoor Puzha at Vadakarappalli palathulli in Peruvembu and Polpully GramaPanchayath in Palakkad District.

E.5.23. Removal of silt accumulation from Pamba River from Aranmula Jalothsava Patha to Cherukolpuzha. Pathanamthitta.

E.5.24. Testing of Samples from Sedimentation survey at Kanjirapuzha dam.

E.5.25. Construction of canal bridge at Kurinjikkal Puthurkkara in Thrissur District.

E.5.26. Construction of Regulator at Parapuram across Anjarakkandy river in Pinarayi..

E.5.27. Sedimentation Study of Pothundy Reservoir using IBS & Sub Bottom Profiler Testing of Soil samples

E.5.28. Construction of regulator across Manimala River on the Downstream side of intake well of RWSS to Nedungunnam & Kangazha at Kulathoormoozhy - Kottangal Panchayat in

E.5.29. Execution of Valanthode SHE Project (7.5 MW)

E.5.30. Testing of soil sample for finding out the suitability for construction purpose, constructing a house at Chavakkad, Thrissur

E.5.31. Rejuvanation and protection of Kolarayar in Thiruvalla Constituency

E.5.32. Soil Investigation for the construction of Regulator Cuum Bridge across Neyyar River at Mavilakkadavu, D/S of KWA pump House to prevent salinity intrusion.

E.5.33. Pambar Basin - Chngalar Scheme - Pattissery Dam - Reconstruction of Pattissery dam and canal system - testing of Earth samples.

E.5.34. Investigation for Regulator cum bridge across Ummenchirapuzha at Chekkupalam.

E.5.35. Investigation works for the construction of Check Dam across Thoothappuzha at Mannathikkadavu, Cherpulassery Panchayath in Palakkad District.

E.5.36. Qualitative analysis of sediments from Chulliyar Reservoir.

Appendix – V

Times and Places of observation

Serial No.	Month	Date of observation
1.	April	26/04/2017
2.	May	25/05/2017
3.	June	24/06/2017
4.	July	23/07/2017
5.	August	21/08/2017
6.	September	20/09/2017
7.	October	19/10/2017
8.	November	18/11/2017
9.	December	18/12/2017
10.	January	27/01/2017
11.	February	26/02/2017
12.	March	28/03/2017

Appendix-VI

Details of Simultaneous Observations

Sl. No.	Name of Station	Time and C. P. Nos.				
		9 AM	10 AM	11 AM	11.45 AM	12.30 PM
1	Vettukadu	112	114	116	114	112
2	Anjengo	223	228	233	228	223
3	Eravipuram	317	322	327	322	317
4	Thottappilly	597	600	602	600	597
5	Alapuzha	704	707	710	707	704
6	Thanki	926	930	935	930	926
7	Kannamaly	1025	1037	1047	1037	1025
8	Kuzhupilly	1140	1147	1149	1147	1140
9	Perinjanam	1269	1274	1279	1274	1269
10	Nattika	1323	1330	1333	1330	1323
11	Blangad	1418	1421	1428	1421	1418
12	Vakkad	1595	1599	1605	1599	1595
13	Calicut	1830	1826	NCP	1826	1830
14	Melody	2013	2009	2004	2009	2013
15	Thalassery(Old CP)	Back of Bishop's house	1067	1075	1067	Back of Bishop's house
16	Kanhangad	2608	2603	2598	2603	2608
17	Kasargod(Old CP)	531	541	550	541	531
18	Kannuvatheertha (Old CP)	103	111	121	111	103

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