



Operation and Maintenance
Manual for
KUTTIADI DAM (KAKKAYAM)
State of Kerala

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KUTTIADI DAM
KSEBL_07_v1.0



Chief Engineer
(Civil DRIP & Dam Safety)
Kerala State Electricity Board





Operation and Maintenance Manual for Kuttiadi Dam (Kakkayam)

Prepared by the Dam Safety Organisation
Kerala State Electricity Board Ltd

(A Government of Kerala undertaking)
State of Kerala



Front Cover Photographs: Views from right bank and downstream of Kuttiadi dam.

KSEB

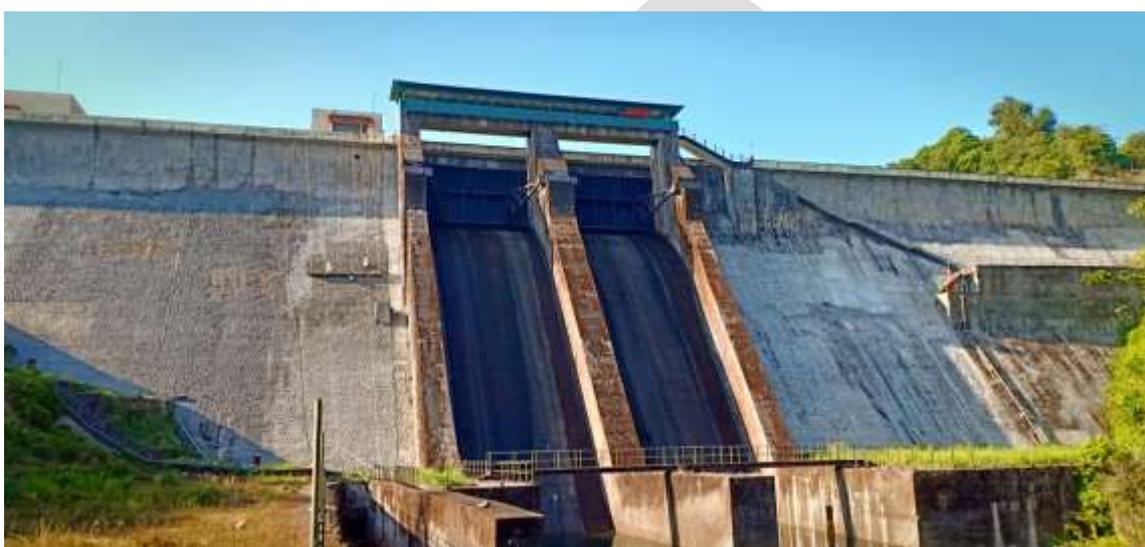
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Government of Kerala

Operation and Maintenance Manual

Kuttiadi Dam



Prepared

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Kerala State Electricity Board Ltd
Pallom, Kottayam.

January 2020

Kerala State Electricity Board Ltd

Dam Safety Organisation

Disclaimer

This Operation and Maintenance Manual for Kuttiadi Dam in no way restricts the dam operators in digressing from her/his responsibilities. The Dam Operators must exercise appropriate discretion and good judgement based on actual site condition when implementing and using the operation and maintenance manual for managing the workings of the dam and appurtenant structures.

The manual was developed for the purpose of organising and managing the operation, inspection and maintenance of the dam for reducing risk and optimizing performance of the dam as a general guide.

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Message

India has more than 5200 large dams. Their health and safety are of paramount importance for sustainable use of the valuable assets, besides providing protection to the people and property in the downstream areas. The Ministry of Water Resources, River Development & Ganga Rejuvenation through the Central Water Commission (CWC), with financial assistance from the World Bank, started the Dam Rehabilitation and Improvement Project (DRIP) to rehabilitate 198 large dam projects in seven states. Kerala State Electricity Board Ltd, through Government of Kerala participated in DRIP to rehabilitate 37 dams under 12 Hydro Electric Projects in the state.

For managing a dam in a sustainable and scientific manner, it is very crucial for each dam owner to have dam specific Operation and Maintenance Manual that lays down procedures for the daily upkeep of the dam. An Operation and Maintenance Manual for a dam is essential for ensuring its safe functioning and for deriving continued benefits. This Operation and Maintenance Manual for Dam has been prepared following the Guidelines for Preparation, Operation and Maintenance Manuals published by CWC in January 2018 under DRIP and covers requirements for project Operation, Inspection, Maintenance, Instrumentation and Monitoring the health of Dam both during monsoon and non-monsoon periods.

I recommend the dam officials to use this manual for the efficient and safe Operation and Maintenance of the Dams on regular basis.

I compliment all the experts who have contributed to the development of this manual and congratulate the Dam Safety Organisation, KSEB Ltd, Pallom and CWC for the initiation of such important policy protocol to address dam safety management in Kerala.


Bibin Joseph,
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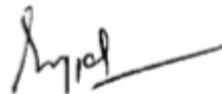
Foreword

Globally, the Operation and Maintenance (O&M) Manual of a dam is one of the most important documents which is supposed to be put in practice right from the initial filling of reservoirs. In order to address the operation and maintenance aspects, ongoing Dam Rehabilitation and Improvement Project (DRIP) has requisite scope to prepare new or update existing O&M manuals for all DRIP dams, which will become very helpful to Dam Owners in addressing the dam specific issues comprehensively in future.

This Operation and Maintenance (O & M) Manual developed is a detailed set of written descriptions with step-by-step procedures for ensuring that the dam is safely operated, frequently inspected and properly maintained. In this era of shrinking budgets, timely inspection and preventative maintenance is necessary for the safe functioning of the dam and continued productive use of the dam and reservoir.

The format of this manual is prepared following the principles published in 2018 CWC Guidelines for Operation and Maintenance of dams for the use by all Dam Owners in developing their own site-specific manuals. Each section of the document provides the necessary instructions to operate inspect and maintain their dams.

It is recommended that all dam officials in charge to use this manual for ensuring that the dam is operated and maintained in a sustainable manner and will continue to derive benefits.



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PREFACE

Operation and Maintenance Manual is a detailed written document of procedures and protocols for ensuring that a Dam is operated and maintained properly and timely to avoid further health deterioration and extend service life of these assets. An Operation and Maintenance Manual is essential for a Dam for ensuring its safe functioning and for deriving desired benefits from it by describing all the elements systematically for its operation, inspection, maintenance, instrumentation and monitoring of the health.

Central Water Commission has published the guidelines for the development of new manual and updating of existing manual vide CDSO_GUD_DS_03_v1.0 Page xii January 2018. Accordingly Kerala State Electricity Board Ltd is developing and updating the Operation and Maintenance Manual of Dams under their ownership for a healthy Dam Safety management system.

Kuttiadi Dam under KSEBL has no Operation and Maintenance Manual according to the present standards. Hence an attempt is being made here to prepare the manual as per the new guidelines by CWC.

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CHAPTER 1

GENERAL INFORMATION

1.1 Introduction

Kuttiadi Project is a High Head Hydro Electric Project located at Kakkayam in Kozhikode District of Kerala State. Kuttiadi Dam is constructed across Kuttiadi river which originates from Wayanad hills of Western Ghats. Nearest City and railway station is Kozhikode which is 66 km from Kuttiadi Dam and nearest Airport is Calicut International Airport which is at 87 km from Dam site. The Project got importance because of its multipurpose utility towards power generation, irrigation and water supply.

1.2 Purpose, Location & Description of Dam

The project envisages creation of a reservoir of gross capacity 38.40 Million Cum. by construction of a 39.51 m high masonry dam across Kuttiadi river and diversion of this water through a water conductor system consisting of 920 m long tunnel, 2083 m long surface penstock, two stretches of penstock tunnels of 554 m and 93.60 m length to the 75 (3 x 25) MW generating station located at Kakkayam to produce 245 Million units of power per annum.

The 75 MW Kuttiadi Hydro Electric Project was commissioned on 30.09.1972. Later in 2001, a new power house was added through Kuttiadi Extension Scheme by installing an additional 50MW machine. In 2005, the Kuttiadi Hydro Electric Project was augmented with Kuttiadi Augmentation Scheme having a live storage of 186.25 Million Cum by diverting the water of Karamanthodu in to existing Kakkayam reservoir. In 2010, the installed capacity at the Kuttiadi Hydro Electric Project was further raised with Kuttiadi Additional Extension Scheme by adding (2x50 MW). In addition to the above extension schemes, two tail race schemes are also working under Kuttiadi Hydro Electric Projects. The Kuttiadi Tail Race Scheme (KTR - 3x1.25 MW) and the Kakkayam Small Hydro Electric Project (KSHP-2x1.5 MW). As such, the Kuttiadi Hydro Electric Projects is having a total installed capacity of 231.75 MW with 595.49 Mu, firm power.

The tail water from all these projects are flowing to Peruvannamoozhi Irrigation reservoir, less than 1 Km from the Power Houses. A new small hydroelectric project, Peruvannamoozhy SHEP (6 MW) is under construction to utilize the water at Peruvannamoozhi reservoir for further generation of power when there is no irrigation release.

Location

The Kuttiadi Dam is Located at Kakkayam in Koorachund Panchayath of Koyilandi Taluk in Kozhikode District.



Fig 1.1 Location Map



Fig 1.2 Kuttiadi Dam at Kakkayam - View From Google earth



Fig 1.3 Layout Plan

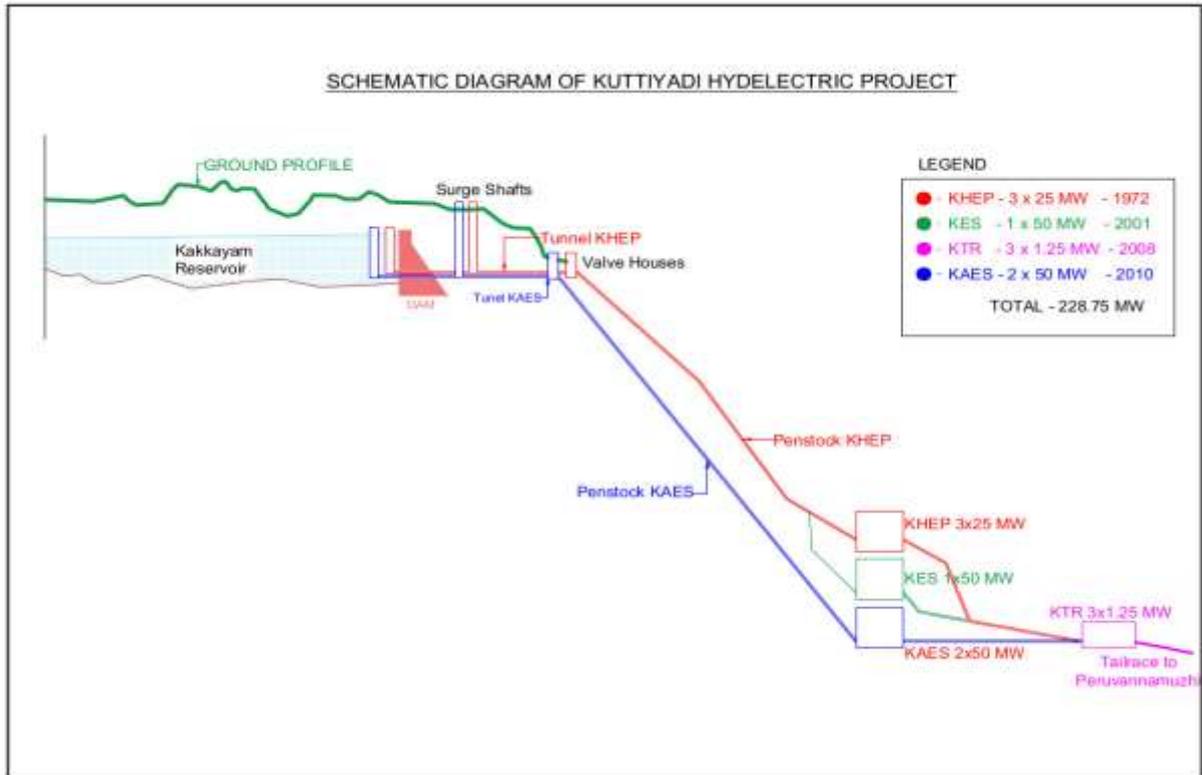


Fig 1.4 Schematic diagram

Description of Dam



Fig 1.5 Kuttiadi Dam - View from downstream

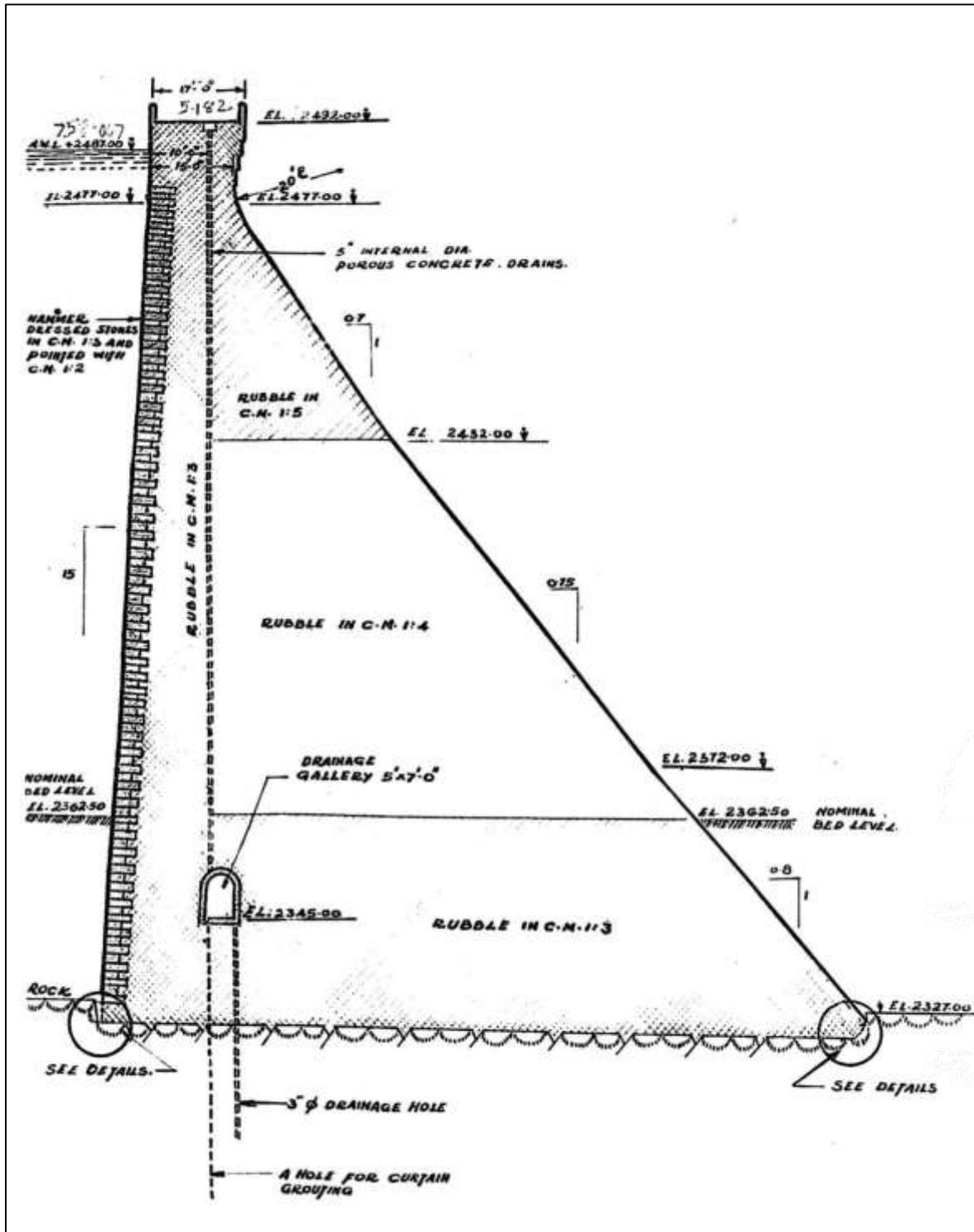


Fig 1.6 Non overflow section of Kuttiadi Dam

Kuttiadi dam is a straight gravity masonry dam with length of 228.6m at top. The dam has - 10 blocks covering non- overflow and overflow sections. The spillway structure is provided in block no.4. Two vents are provided for the spillway. The construction was started in 1962 and

completed in 1972. Even though it is a masonry dam, the upstream face is lined with concrete. The important components of the dam are covered in the salient features as under.

1.3 Salient Features of the Dam

Sl. No	Items	Description
Location of Dam		
1	State	Kerala
2	District	Kozhikode
3	River	Kuttiadi
4	Kuttiadi Dam	Latitude : 11° 33' 04" North Longitude: 75°55' 29" East
5	Kuttiadi Power House at Kakkayam	Latitude : 11° 33' 04" North Longitude: 75°54' East
Hydrology		
1	Catchment area	38.50 sq. kms (GTS Map No.49 M 14)
2	Average annual rainfall	6710 mm
3	Average annual Runoff	209.50 Mm ³
4	Original Design Flood	736.20 m ³ /sec
5	Revised Design Flood	771.00 m ³ /sec
Reservoir		
1	Full Reservoir Level	+758.04 m
2	Maximum Water Level	+758.04 m
3	Minimum Draw Down Level	+737.62 m
4	Gross Storage at FRL	38.40 Mm ³
5	Dead Storage below MDDL	4.42 Mm ³
6	Live Storage at FRL	33.98 Mm ³
7	Water spread area at FRL	2.79 sq.km
Dam		
1	Type of dam	Masonry

2	Deepest foundation level	+720.05 m
3	Dam top level	+759.56 m
4	Height of dam above deepest foundation	39.51 m
5	Length of dam at top	228.60 m
6	Top width	5.18 m
7	Bottom width	41.91 m
Spillway		
1	Type	Ogee
2	Crest level of spillway	+751.64 m
3	Spillway gates	Radial gates 2 nos., 10.97m(H) x 6.40 m(W)
4	Maximum spillway discharge	736.20 m ³ /sec
5	Gate Hoisting Arrangement	Rope-Drum Type
Outlet		
1	Size	1.5m x 1.5m
2	Level	+725.12 m
Power Intake		
1	Sill level	+731.10 m
Power Tunnel		
1	Shape, Type and size	Horse shoe type 2.70 m dia.
2	Length	920.00 m
3	Slope	1 in 250
4	Maximum flow	14.86 cumecs
5	Maximum velocity of flow	2.20 m/sec
Surge Shaft		
1	Type	Simple
2	Diameter	9.14 m
Penstock Tunnel		
1	Length of first section	554 m

2	Length of second section		93.6 m
Penstock Pipe			
1	No. of pipe		1 no.
2	Length		2083.00 m
3	Diameter	Higher reaches	2000 mm
		Lower reaches	1900 mm
Power Station			
1	Installed capacity		3 x 25 MW
2	Type of turbine		Pelton vertical shaft four jet, single runner
3	Centre line of runner		+91.95 m
4	RPM		600
5	Generator floor level		+96.95 m
6	Maximum gross head		666.29 m
7	Average gross head		658.37 m
8	Firm power		19.30 MW
9	Average power		24.20 MW
10	Date of commissioning	1 st unit	September 1972
		2 nd and 3 rd	November 1972
Cost			
1	Cost of the scheme		Rs. 970 lakhs
2	Cost per KW installed		Rs.1295/-

Table 1.1 Salient Features of Kuttiadi Dam

Development of the project

The average annual inflow from Kuttiadi river is 209.50 Mm³ and the Kuttiadi reservoir has a live storage capacity of only 33.98 Mm³. Hence the Kuttiadi HEP was expanded through Kuttiadi Extension Scheme for generating more power by utilising the spill from the reservoir. The Extension Scheme was implemented by constructing a new power house with an installed capacity of 50 MW and using the same water conductor system of Kuttiadi HEP and a 155m

long penstock branching off from a 'Y' piece inserted in the existing penstock, just behind the old power house.

The Kuttiadi Augmentation Scheme, better known as BanasuraSagar Multipurpose scheme, aims at harnessing the potential of the river Karamanthodu, a tributary of Kabani by diversion of waters to the Kuttiadi reservoir for increasing the power potential of Kuttiadi power station .

The Scheme essentially consists of a reservoir of gross storage capacity of 209 Mm³ formed by constructing a homogeneous rolled earth fill dam, 38.5 m high, at Padinjarethara across Karamanthodu and six other saddle dams of height varying from 5 to 20m, in addition to a separate spillway dam. About 155.76 Mm³ of water is being diverted to the Kuttiadi hydel reservoir (Kakkayam) through a 4.763 km long tunnel. Previously, the power generation at Kuttiadi Power Station varied from 75 MW during the peak monsoon months to 14 MW during summer, for want of sufficient storage capacity. The augmentation scheme has increased the average annual power generation at Kuttiadi power station from 211 Mu to 434 Mu.

Type of Project	Hydro Power
Average Annual Energy Generation	223 Mu
Gross Storage Capacity	209.18 Mm ³
Dead Storage Capacity	23.75 Mm ³
MDDL	+754.86 m
FRL	+775.60 m
MWL	+775.60 m
Water spread area at FRL	1277 Ha
A. Spillway Dam	
Type	Concrete
Top level of the dam	+778.50 m
Crest level	+767.00 m
Height of Dam above deepest foundation level	36.50 m
Length at top	56.38 m
Type of Spillway	Ski-jump

Length of spillway	56.38 m
No of Bays	4
Type of Gate	Radial
Size of gate	10.97m x 9.20m
Total Spillway Capacity of all bays	1664 m ³ /s
River Outlet	One number (1.50 m dia. circular)
Irrigation outlet	One number (1.50 m dia. circular)
B. Main Dam	
Type	Embankment (Homogeneous rolled earth fill)
Top level	+778.50 m
Length at top	685.00 m
Width at top	7m
Width at bottom	245m
Spillway	No spillway arrangement
Outlet	Nil
C. Kuttiyadi Saddle Dam	
Type	Concrete gravity
Height of Dam above saddle level	16.50 m
Length at top	121 m
Width at top	4 m
Outlet	2.50 m dia.
D. Kottagiri Saddle Dam	
Type	Homogeneous earth fill
Height of Dam above saddle level	14.50 m
Length at top	90 m
Width at top	7 m
E. Saddle Dam Near Kottagiri	
Type	Homogeneous earth fill
Height of Dam above saddle level	11 m
Length at top	110 m

Width at top	7 m
F. Kosani Saddle Dam	
Type	Homogeneous earth fill
Height of Dam above deepest foundation level	13.80 m
Length at top	140 m
Width at top	7 m
G. Manjoora Saddle Dam	
Type	Homogeneous earth fill
Height of Dam above saddle level	4 m
Length at top	74 m
Width at top	7 m
H. Nayanmoola Saddle Dam	
Type	Homogeneous earth fill
Height of Dam above saddle level	3.50 m
Length at top	24 m
Width at top	7 m

Table 1.2 Salient features of Kuttiadi Augmentation Scheme

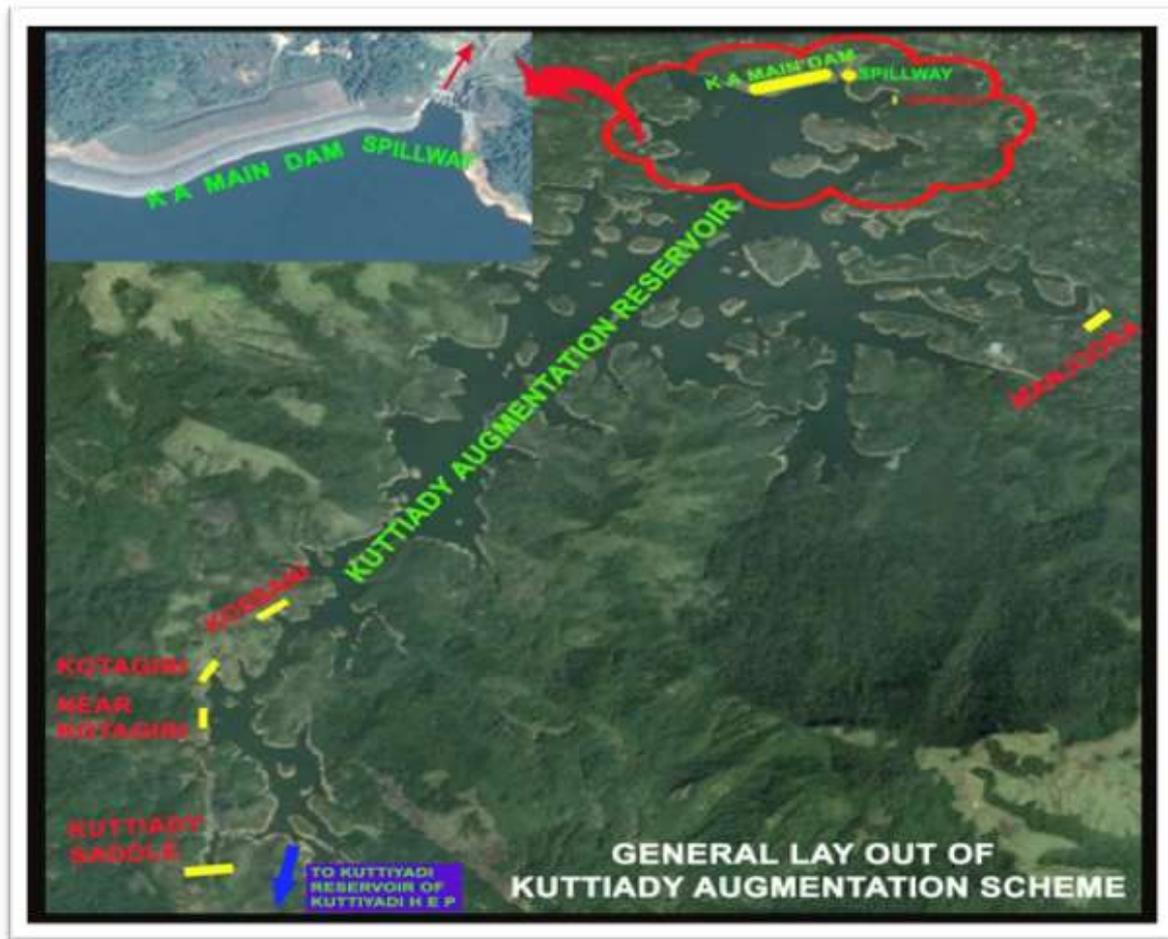


Fig 1.7 Lay out of Kuttiadi Augmentation Scheme

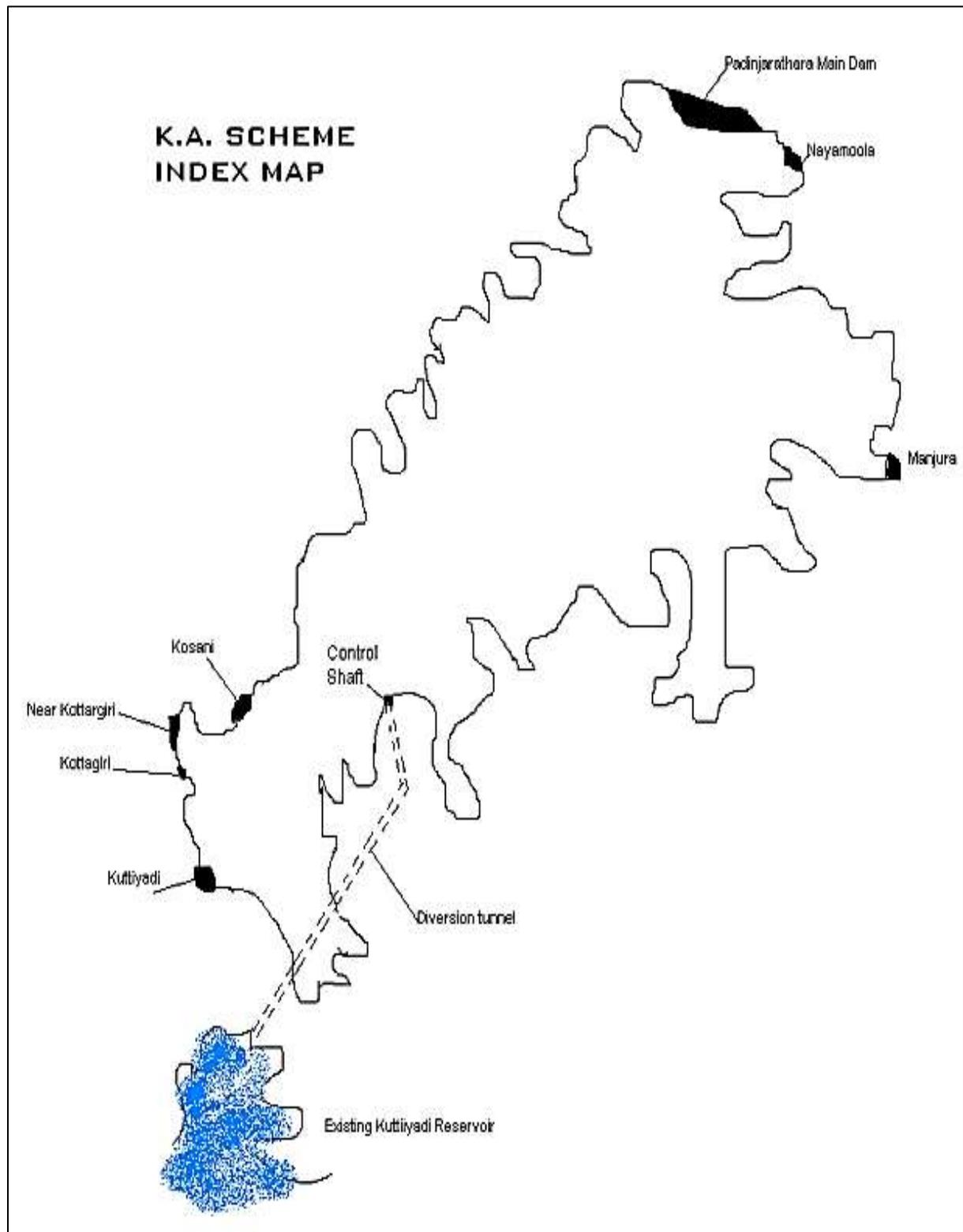


Fig 1.8 Index map of Kuttiadi Augmentation Scheme

The Kuttiadi HEP was further augmented through Kuttiadi Additional Extension Scheme (2x50MW). It was implemented as a new project with all the components of a hydel scheme except dam. The newly constructed structures were a separate water conductor system consisting

of an intake, power tunnel, surge shaft, LPP, penstock, power house, tail race and switchyard. Water for this additional extension scheme is obtained from Kuttiadi Augmentation Scheme.

In addition to the above extension schemes, two tail race schemes are also functioning under Kuttiadi Hydro Electric Projects. The Kuttiadi Tail Race Scheme (KTR – 3x1.25MW) and the Kakkayam Small Hydro Electric Project (KSHP – 2x1.5MW). KTR is utilising the tail race water of KHEP and KES. KSHP is utilising the tail race water of KAES.

KSHP

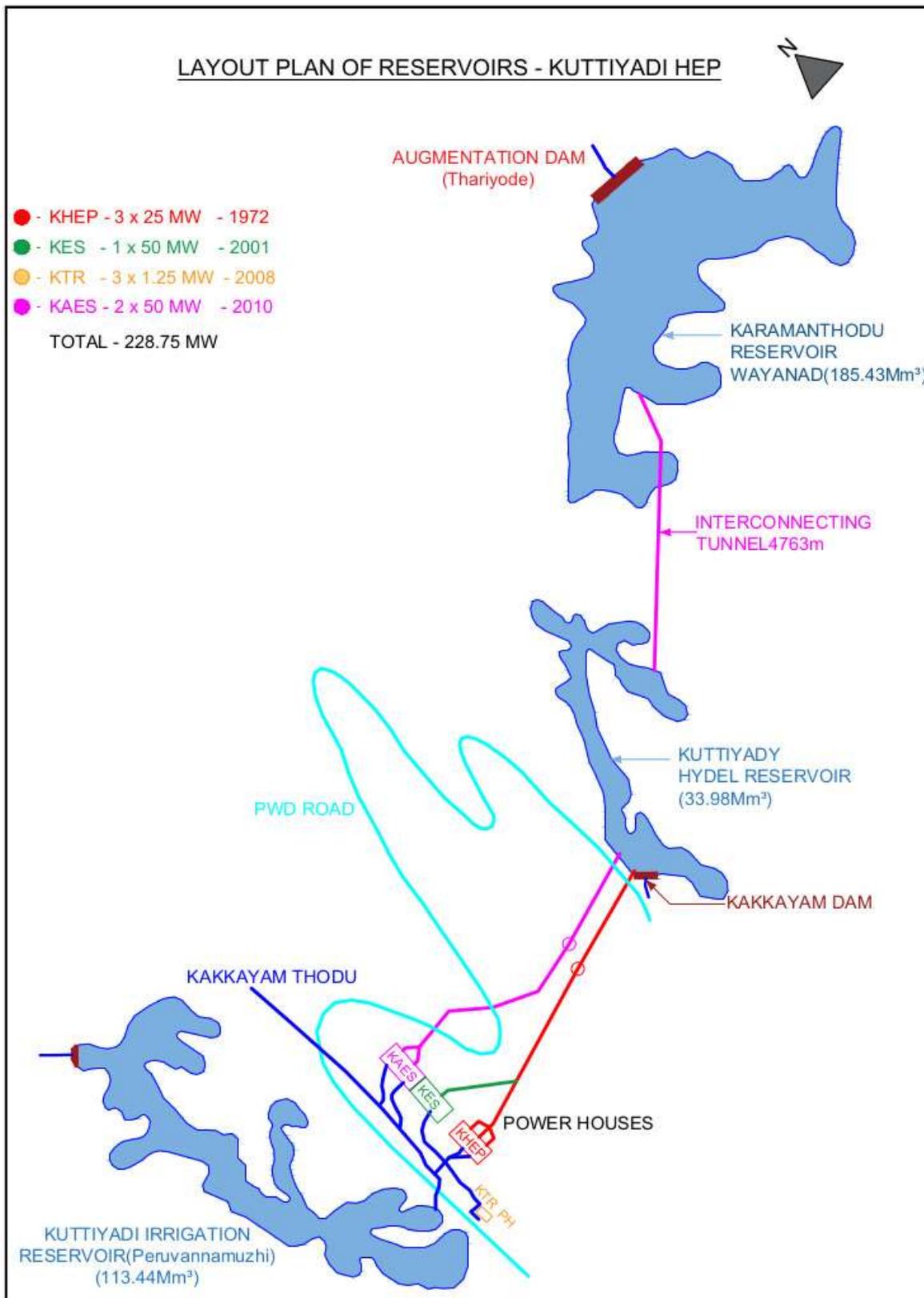


Fig 1.9 Layout Plan of Reservoirs

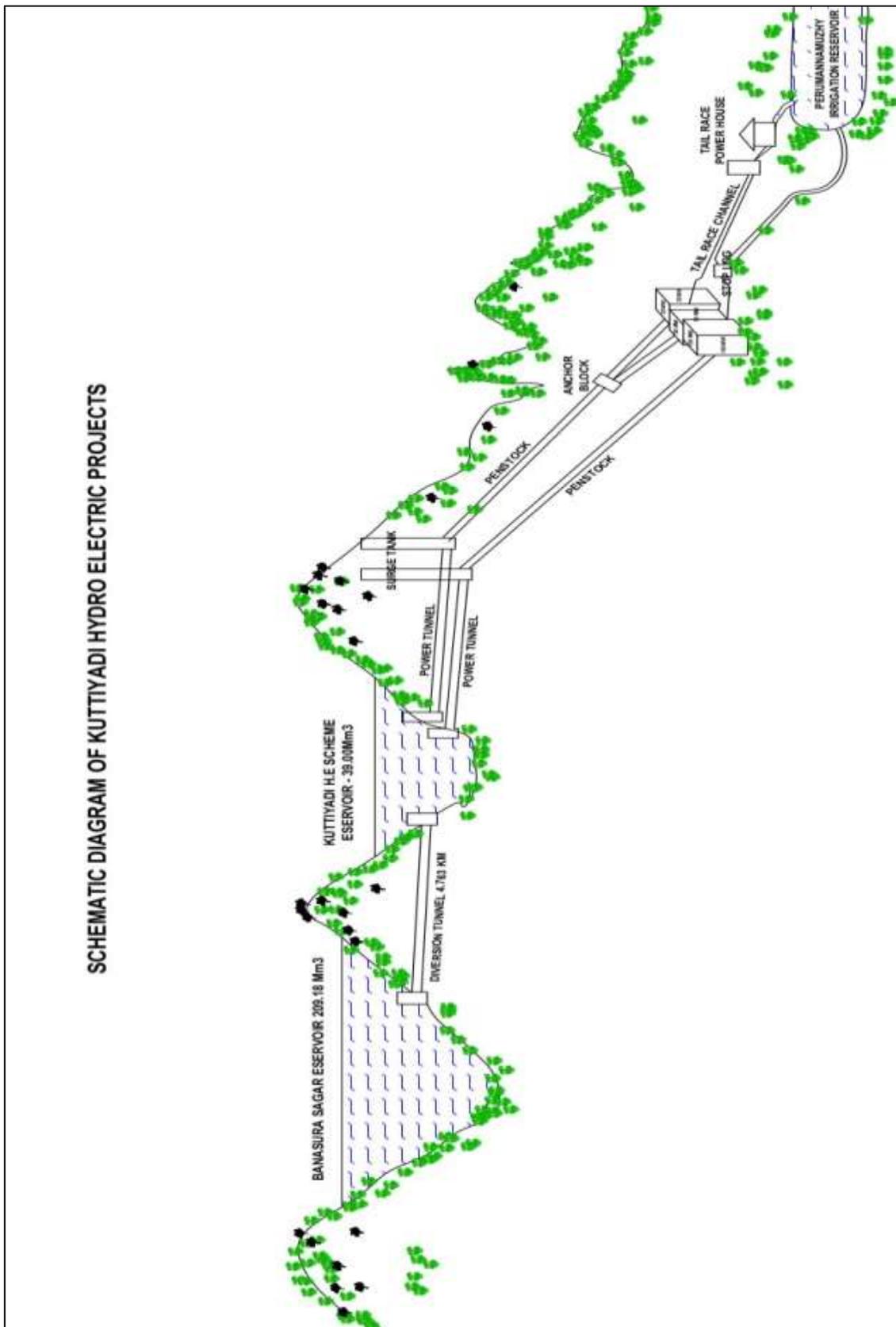


Fig 1.10 Schematic diagram

1.4 Assignment of Responsibilities

Kerala State Electricity Board Ltd is the owner and has the final authority and responsibility for the operation and maintenance of the dam. Identification of all areas of responsibilities connected with the operation and maintenance of the dam are covered in this section. The officer's responsibilities for the various functions (civil, mechanical, electrical, instrumentation etc.) are identified by their designation and, in particular, the responsibilities of operating personnel are specifically identified below including the regularly scheduled duties which staff personnel are required to perform as outlined in the following tables.

Sl. No	Particulars	Remarks
1	Project Administration Officer	Chairman & Managing Director, KSEB Ltd.
2	Chief Controlling Officer	Chief Engineer (Civil – DS&DRIP), KSEB Ltd.
3	Authority of Spillway operations and Flood Releases	Chief Engineer (Civil – DS&DRIP), KSEB Ltd.
4	Operation and safety of the dam	Deputy Chief Engineer, Research & Dam Safety Organization & DRIP, KSEB Ltd. Pallom.
5	Controlling and Operation Officer at dam site	Executive Engineer, Research & Dam Safety Division No. V, Thariyod.
6	Dam Health Engineer and for Reservoir Operations, inspection & maintenance	Executive Engineer, Research & Dam Safety Division No. V, Thariyod.
7	Dam Maintenance Engineer. Recording reservoir data, inspection, monitoring and maintenance at site	Assistant Executive Engineer, Research & Dam Safety Sub Division, Kakkayam.
8	Handling Dam operations, inspection, monitoring and performing duties as Maintenance Officer at dam	Assistant Engineer, Research & Dam Safety Sub Division, Kakkayam.

Table 1.3 – Overall Responsibilities of Kuttiadi Dam

1.4.1 Roles and Responsibilities of the AEE and AE during Monsoon

	Flood condition assessment, warning, flood mitigation, and other responsibilities
1	Collect information on the rainfall in the catchment and inflow status and to bring it to the notice of the EE/Dy CE.
2	Assist the EE/ Dy CE /CE to issue notification to the inhabitants downstream in Newspapers, Radio, TV News channel to alert regarding the flood situation.
3	Assist the EE/ Dy CE /CE to coordinate with the Revenue authorities (District Administration) to alert the downstream inhabitants to evacuate from the flood zone to prevent loss of life and livestock.
4	Assist the EE/ Dy CE /CE to coordinate with the CWC flood monitoring authorities on the flood condition
5	Maintain the reservoir water level gauge register and to update on hourly basis during floods and report to EE/ Dy CE /Chief Engineer
6	Assess the inflows in the reservoir as per the approved reservoir operation and to prepare proforma consisting of the status of the reservoir capacity and releases from the reservoir as per the standard Performa and to submit to the EE/ Dy CE /CE
7	Submit details to the EE/ Dy CE /CE on the inflows and releases from the reservoir and status of the reservoir twice in the day
8	Maintain the spillway crest gate operation log book
9	Operate the Spillway crest gates for flood mitigation as per the instructions of the EE/ Dy CE /CE and to update the Gate operation Log book
10	Observe the seepages in the drainage Gallery with respect to the reservoir head and record the seepages and to immediately bring to the notice of the EE/ Dy CE /CE in case of excessive seepage/leakage in any specific blocks.
11	Observe the gates and to see that its drain holes are not clogged and floating debris is not deposited in the gate components
12	Monitor the condition of the Welding transformers, gas cutting sets, umbrellas, tool kits, torches, chain blocks, ropes etc. on daily basis and to see that things are in place to handle any emergency situation
13	Observe the Gates, hoists and handling equipment during operation for the smooth movements and to immediately report any untoward excessive sounds in the motors,

	pumps or vibrations in the gate
14	Observe the dam top, it's appurtenants & approach roads and ensure that all are well maintained by housekeeping personnel
15	Observe the performance of the Dam and its appurtenant structures / Gates and Hoists during flood water releases and to report to the EE/ Dy CE /CE in case of any untoward incidents or malfunctioning of the gates or excessive seepages, leakages etc.
16	Assist EE/ Dy CE /CE to coordinate with the Generating staff of Kuttiadi Powerhouse downstream in the operation and power generation.
17	Assist EE/Dy CE /CE to share the flow data and the reservoir storage details to the Media on day to day basis during flood.

Table 1.4 – Roles & Responsibilities of AEE & AE

1.4.2 Roles and Responsibilities of the Dy CE and EE during Monsoon

SL No	Flood condition assessment, warning, flood mitigation, and other responsibilities
1	Conduct Periodical inspections to assess the health of the Dam and to direct the Executive Engineer for the immediate repair and maintenance. Submit the inspection reports to the Chief Engineer and upload in DHARMA
2	Observe the performance of the Dam and its appurtenant structures/Gates and Hoists before and after monsoon and to issue necessary instructions to the Executive Engineer
3	To issue notification to the inhabitants downstream in Newspapers, Radio, TV News channel to alert them regarding the flood situation
4	Assist the CE to coordinate with the Revenue authorities (District Administration) to alert the downstream villagers to evacuate from the flood zone to prevent loss of life and live stock
5	Assist the CE to coordinate with the CWC flood monitoring authorities on the flood condition
6	Submit to the CE the daily inflows and releases from the reservoir and status.

7	Operate the Spillway crest gates for flood mitigation as per the instructions of the CE and to update the Gate operation Log book
8	Observe the seepages in the drainage Gallery with respect to the reservoir head and record the seepages and to immediately bring to the notice of the CE in case of excessive seepage, leakage in any specific blocks and porous drains
9	Observe the Gates, hoists and handling equipment during operation for the smooth movements and to immediately report any untoward excessive sounds in the motors, pumps or vibrations in the gate
10	Observe the dam top, ensure that the approach roads are well maintained by housekeeping personnel
11	Observe the performance of the Dam and its appurtenant structures/Gates and Hoists and to report to the CE in case of any untoward incidents or malfunctioning of the gates or excessive seepages, leakages etc.

Table 1.5 – Roles & Responsibilities of Dy. CE& EE

1.4.3 Roles and Responsibilities of the Chief Engineer during Monsoon

SL No	Flood condition assessment, warning, flood mitigation, and other responsibilities
1	To issue sanction for flood release notification after discussing with Kerala Disaster Management Authority and Revenue Authority (District Administration).
2	Coordinate with the CWC flood monitoring authorities on the flood condition
3	Issue necessary instructions to the Engineers to Operate the reservoir based on the in-flows, rainfall data, releases from the upstream reservoirs and status of the reservoir
4	Observe the performance of the Dam and its appurtenant structures / Gates and Hoists during flood water releases and to issue necessary instructions to the Dy CE/EE
5	Conduct Pre and Post Monsoon inspections of the Dam and submit the report to CWC.

Table 1.6 – Roles & Responsibilities of the Chief Engineer

1.5 Collection & Reporting of Dam and Reservoir Data

Dam Reservoir Data and vital information as below are collected, recorded and documented for the record.

- Reservoir water surface elevation.
- Reservoir inflow.
- Spillway outflow
- River releases.
- Irrigation, Water supply and Hydropower releases.
- Weather related data
- Instrumentation data
- Water quality

MWL (m)	FRL (m)	Crest Level (m)	Present Water Level (m)	Previous Year Water Level	Percentage Storage	Rainfall (mm)	Generation (Mu)	Spill	Gate operation details
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Table 1.7 Daily Reservoir Data

Instruction is given to the Executive Engineer for daily collection and reporting of inflow and outflow data in standard proforma as in **Table 1.7** above to the Deputy Chief Engineer.

On collecting the details in the above format, a daily reservoir status is submitted to the Chief Engineer as in the **Table 1.8**.

Date	Water Level (m)	Previous Year Same day Water Level (m)	Rainfall (mm)	Previous Year Rainfall (mm)	Storage ()	Generation ()	Gross Inflow ()	PH Discharge + Losses ()	Spill ()	Net Inflow ()	Remarks
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Table 1.8 Daily Reservoir Status

Records/Logbooks of the operations of the following activities at Kuttiadi Dam are maintained in a chronological manner for reference. These records are helpful for identifying preventative maintenance measures that may need to be taken up, troubleshooting the cause of potential equipment failure and documenting development of any unusual conditions.

- Date and Time of record
- Attendance statement during normal operations – both during monsoon and non-monsoon periods.
- Operations of the spillway gates and outlet works.
- Operating hours of mechanical equipment.
- Testing / Operation of spillway gates, and associated controls.
- Testing/operation of Outlets and associated controls.
- Maintenance activities carried out.
- Reservoir and dam inspections.
- Unusual conditions or occurrences.
- Safety and special instructions.
- Names of officers and staff carrying out inspections and maintenance.

Periodical collection of Dam and Reservoir Data are done as follows:

Reservoir water surface elevation:	This is collected daily
Reservoir inflow:	This is calculated daily
Spillway outflow:	This is calculated during spill
Irrigation releases:	The tail water from the Kuttiadi projects are flowing to Peruvannamoozhi Irrigation reservoir, less than 1 Km from the Power Houses.
Hydropower releases:	The reservoir water is used for power generation
Weather related data:	Collected and reported daily
Security arrangements:	At the entrance of the Dam site, there is a security check post building. Dam safety security staff (Ex-Servicemen) and police appointed by State Government are posted there.
Water quality:	The quality of water is tested every six months.
Communication network checks:	Regularly checked
Safety and special instructions:	Safety equipment provided
Names and addresses of official visitors:	Record of inspections maintained at office.

1.6 Public and Project Staff - Health and Safety

As safety of Project Staff is of prime concern, safety instructions & protection measures at the dam are to be followed by all staff / project personnel. Security personnel are posted for providing public notices of events and status of security of the dam and downstream river conditions.

Access Roads

Kuttiadi Dam is located at Kakkayam in Kozhikode District of Kerala State. Nearest City and railway station is Kozhikode which is at 66 km from Dam site. The nearest Airport is Calicut International Airport which is 87 km from Kuttiyadi dam.

Location of public conveniences: Inspection Bungalow is located 16 km away from the dam. Primary health centre is located at Kakkayam, 15 km away from dam. Police station is at Koorachund which is 26km away from dam. Nearest fire station is Perambra, 38 km away from dam.

The Safety Equipment available at dam are:

1. First Aid Box
2. Fire Extinguishers
3. Safety belts
4. Helmets

1.7 Restricted Areas

Certain areas of the dam and reservoir are restricted for entry of the general public. The purpose of restrictions is for security of the dam, public safety and uninterrupted safe operation of the dam. Sign boards are displayed at the prohibited areas of the dam.

- Confined spaces such as gallery.
- Spillway approach areas, chutes, energy dissipation areas, Power Intake area, trash rack area, spillway & Intake gates and hoists etc.

1.7.1 Details of the Security arrangements at Dam Site

At the entrance of the Dam site, there is a security check post building. Dam Safety Security Staff (Ex-Servicemen) and police appointed by State Government are posted. Several warning

boards are also provided at various locations at Dam site, for the information of the public (tourists) as part of security measures.

1.8 Staff Position, Communication & Warning System

An engineering organizational chart for the control and safety of Kuttiadi dam is shown in **Figure 1.11** below. Means of communications both in normal and emergency situations are identified in the Communication Directory. Communication means available include land line, mobile phone and satellite phones.

Sirens are being arranged at dam site and Kariyathumpara for ensuring immediate and fool - proof warning.

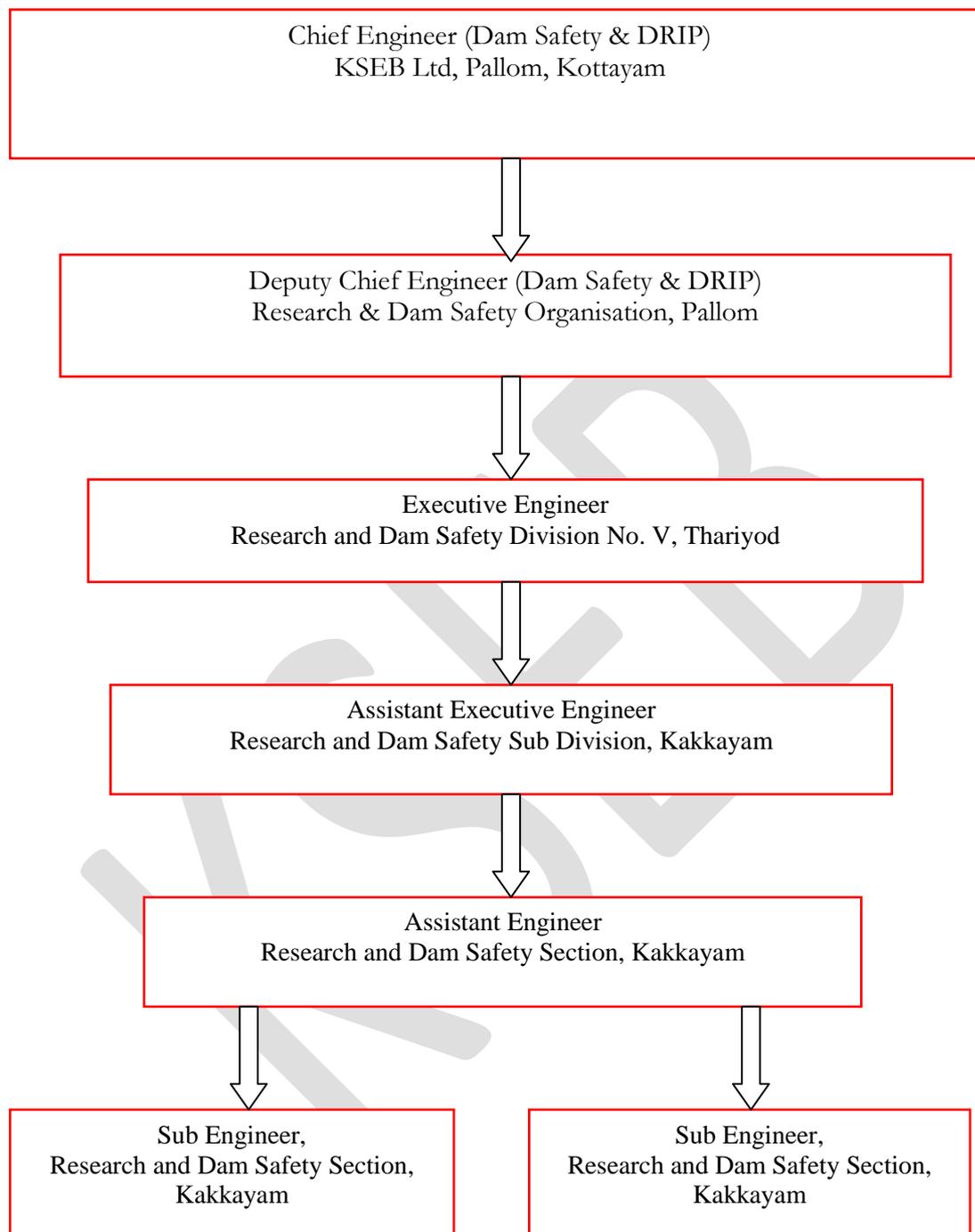


Fig 1.11 – Dam Safety Organisation Structure for Kuttiadi Dam

Present hierarchy of Controlling officers and their contacts are as below:

Designation & Office Address	Contact number	e-mail
Chief Engineer Civil (Dam safety & DRIP), KSEBL, Pallom, Kottayam	9496018719	cedamsafety@kseb.in , cedamsafety@gmail.com
Deputy Chief Engineer, Research & Dam Safety Organization, Pallom	9446008492, 0481-2432290, 9496011540	dirroplm2@gmail.com .
Executive Engineer, Research & Dam Safety Division No. V, Thariyod	9446008415	eerdskkm@gmail.com .
Assistant Executive Engineer, Research & Dam Safety Sub Division, Kakkayam	9496003772	aedskkm@gmail.com
Assistant Engineer, Research & Dam Safety Section, Kakkayam	9496011978	

Spillway flood releases

During flood season, while opening the gates of Kuttiadi Dam, the spill water flows to Peruvannamoozhi irrigation reservoir of Irrigation department after flowing about 3KM through the natural river (Kuttiyadipuzha). The Tourism spot “Urakkuzhi water fall ” is about 0.5Km downstream of the dam. When spillway gates are opened, water reaches Urakkuzhi and then flows to ‘Kariyathumpara’ (one of the upstream edges of Peruvannamoozhi irrigation reservoir). In this flow of about 3 KM, the first half is through forest land and remaining portion is through inhabited areas. Kariyathumpara is also a tourist location. Hence advance information has to be given to the public as well as concerned officials before opening the spillway gates.

Since Kuttiadi reservoir is of medium storage capacity, it may not be possible to have a three stage Alert system, as the reservoir can reach the spilling level from normal operating level within one or two days. Hence it is proposed to have a two colour Alert system (Orange and Red).

The first warning (Orange Alert) as water level reaches +756.50 m and second warning (Red Alert) as water level reaches +757.50m are given for opening of spillway gates. Warnings are given in local media including TV etc. regarding the possible opening of spillway gates continuously up to +758.04 m level. Also intimations are given to Disaster Management, District

Administration, and Police Department etc. Spillway gates are opened at +758.04 m level based on “Guidelines for Operation of Reservoirs” (IS 7323:1994) and Gate Operation Manual.

The different stage/colour Alert levels are fixed considering the normal rainfall intensity and for general guidance. As per the instructions issued during the flood period of 2018, first opening of dam during night (between 6pm and 6am) has to be avoided.

In the case of extreme rainfall event or identifying any distress in the dam, appropriate protective action shall be initiated by the Dam managers. Sanction has to be obtained from the District Collector for spilling the water. Evacuation is required only in the case of large release/extreme rainfall event.

Releases for various purposes like irrigation, water supply and hydropower.

Water from the reservoir is used for power generation at Kuttiyadi Power Station of KSEBL. Water let out at Kakkayam after generation of power is being utilized by the State Irrigation Department for irrigation release at the Peruvannamoozhi dam. Water from Peruvannamoozhi reservoir is used for augmenting the drinking water supply in Kozhikode district.

Routine inspection.

Usually monthly inspection and quarterly inspections as per KDSA are carried out by the operating/controlling officers. Pre-monsoon inspection and Post-monsoon inspection as per CWC are carried out and reports intimated to CWC. The pre-monsoon and post-monsoon reports are to be updated in DHARMA web site.

Maintenance

Routine maintenance is carried out for Spillway gates and other appurtenant structures before the onset of monsoon. Details are given under the Chapter, Project Maintenance.

1.9 Typical Schedule of Duties

Schedule of duties/inspections to be carried out for the operation and maintenance of the dam by the concerned official are tabulated below in **Table 1.9**.

Sl. No.	Component/ Duty	Frequency	Personnel
1	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream	Daily	Sub Engineer/Dam operators on contract

	faces, visible portions of foundation and abutments, Spillway and its energy dissipation arrangements		
2	Record water surface elevation, reservoir inflow and spillway discharge.	Daily (Hourly basis during monsoon)	Sub Engineer/Dam operators on contract
3	Record meteorological data, Record releases from outlets /sluices	Daily	Sub Engineer/Dam operators on contract
4	Check security and safety devices, Complete logbook / site register which include the above information.	Daily	Assistant Engineer
5	Record seepage from drainage systems etc. and record meteorological data.	Weekly	Sub Engineer/Dam operators on contract
6	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream faces, visible portions of foundation and abutments, Spillway and its energy dissipation arrangements	Weekly	Assistant Engineer
7	Check stand by generator (DG Sets), Drainage systems etc.	Weekly	Assistant Engineer
8	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream faces, visible portions of foundation and abutments, Spillway and its energy dissipation arrangements	Fort nightly	Assistant Executive Engineer
9	Check security and safety devices, logbook and site register which include the above information.	Fort nightly	Assistant Executive Engineer
10	Check stand by generator (DG Sets), Drainage systems, etc.	Fort nightly	Assistant Executive Engineer
11	Measuring devices, communication devices, status of instruments, vegetation growth	Fort nightly	Assistant Executive Engineer
12	Check Sign/Warning display boards near vulnerable locations	Fort nightly	Assistant Executive Engineer
13	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream faces, visible portions of foundation and abutments, Spillway and its energy	Monthly	Executive Engineer

	dissipation arrangements		
14	Check measuring devices/Instruments, Security and safety devices, Communication Devices, Status of Vegetation growth – rectification, if needed.	Monthly	Executive Engineer
15	Check Sign/Warning display boards near vulnerable locations	Monthly	Executive Engineer
16	Replace fuse light bulbs, Inspect to maintain ventilation system, cleaning of control panel boards.	Monthly	Assistant Engineer
17	Check outlet works, updating operating instruction, check gate air vents, clean gate control switchboxes, check operation of gates, grease gate hanger/dogging	Quarterly	Executive Engineer
18	Check condition of Outlet works and its Energy Dissipation Arrangement	Quarterly	Executive Engineer
19	Check condition of spillway, log and safety boom, Check for debris in inlet channel, Check operation of gates, Check for damages in spillway glacis, energy dissipation arrangement, d/s area etc., Check and clear spillway bridge drains, Clean inside of motor control cabinet.	Quarterly	Executive Engineer
20	Check for adherence to instrumentation schedule, Record pertinent information in Operation of Gates, Check condition of V-notch/seepage measuring devices, Check hydro mechanical components.	Quarterly	Executive Engineer
21	Inspection of Spillway & outlet works, hydro mechanical components, Check paint on gates, Check lubrication of wire ropes and application of cardium compound, Check mechanical hoist bearings and flexible coupling bearings, Check gear systems, Exercise gates and valves, Check oil reservoir level in hydraulic system, Check pressure release valve, Check lubrication of gate rollers, Check rubber seals and seal clamp bar.	Half yearly (Pre and Post Monsoon)	Deputy Chief Engineer along with Executive Engineer in charge of dam

22	Submission of Inspection report to State DSO, CWC and uploading into DHARMA.	Half yearly	Chief Engineer/Deputy Chief Engineer
23	Comprehensive inspections	Annually	Dam Safety Authority along with Dam Owners
24	Inspect dam and gate structures and stilling basin / energy dissipation arrangement, which normally are underwater (by dewatering or by divers/ROV as necessary). Review Dam operation procedures and EAP and update as necessary.	Five Yearly	Chief Engineer/Deputy Chief Engineer
25	Comprehensive inspection of performance of the dam and gate structures and reservoirs and stilling basin/energy dissipation arrangement.	Ten Yearly	DSRP

Table 1.9 Schedule of duties/inspections

1.10 Hydro-Mechanical Inspections / Checks.

Frequency of inspections / checks for hydro-mechanical components and necessary actions to be taken up during maintenance

Spillway Gates - 2 Nos.

a. Embedded Parts

Sl. No	Embedded Part	Frequency
1	Checking of seal beams. Seal Seats, Guide track & all other exposed embedded parts with respect to their alignment, distortion :if any due to continuous use, pitting and un-necessary cracks due to wear & carrying out requisite repairs, rectification by welding, grinding etc.	Half Yearly
2	Removing debris & other foreign material deposited on embedded parts& cleaning the same.	Monthly
3	All cracks & defective weld joints to be ascertained & rectified.	Half Yearly
4	All dirt, debris, grit, foreign material etc. to be removed from trunnion assemblies as well as trunnion chair and lubricate trunnion bearing & the sliding surface on trunnion chair with specified lubricant/ grade to ensure smooth sliding movement of	Monthly

	trunnion.	
5	All nut bolts connecting Trunnion Assembly & Trunnion Chair and Trunnion & Yoke, girder Trunnion pin lock plate to be checked & Tightened and replacement the same if found defective.	Monthly

b. Gate structure

Sl. No	Gate & Hoists	Frequency
1	Regular inspection of the gate along with the hoist to be carried out daily to ensure that there is no unusual development/ observation	Daily
2	Check all welding for soundness & rectify defects	Quarterly
3	Check welding between arms & horizontal girders as well as arms & Trunnion with the help of magnifying glass for cracks/ defects and rectify the defects	Quarterly
4	Clean all drain boles including those in end arms, horizontal girders & defective nuts & bolts	Quarterly
5	Check all nuts & bolts provided and tighten them, and replace the defective nuts & bolts	Quarterly
6	Check upstream face of skin plate for pitting, scaling and corrosion. Scaling formations are to be removed. Pitting shall be filled with weld and corroded surface shall be cleaned & painted	Yearly
7	Joints of side & bottom rubber seals to be checked for their proper alignment and fixing & to be rectified/ adjusted if there is leakage through joints	Monthly
8	Nuts & bolts for rubber seal connection to be tightened and damaged nuts and bolts to be replaced	Quarterly
9	The excessive or widespread leakages if any shall be reported to the Engineer in charge. If the seals are required to be replaced, the same shall be carried out.	Quarterly
10	The guide roller pin is to be lubricated	Quarterly

Table 1.10 Frequency of inspection of Hydro Mechanical components

1.11 Supporting Documents & Reference Material

This O&M Manual is the key instruction document. Supporting documents and necessary instructions for all phases of the operation, inspection and maintenance of the dam, reservoir and appurtenant works shown below are available at the dam control room:

- Operation criteria for reservoir & spillway
- Emergency Action Plan (EAP)
- Flood forecasting and operating criteria
- Basin or river operating plan
- Power station operating instructions
- Administrative procedures
- Dam site security plan
- Reservoir / River pollution contingency plan
- Maintenance schedules
- Manufacturer's instructions & drawings
- Regional communication directory
- Instrumentation reports / results

1.12 Distribution of Operation & Maintenance Manuals

The list of officers to whom the O&M Manual is required to be distributed is shown in the table below.

Sl. No.	Officer	Number of Manual Distribution
1	Director Generation (Civil), KSEBL, Vidyuthi Bhavan, Thiruvananthapuram	1
2	Chief Engineer Civil (Dam Safety & DRIP), KSEBL, Pallom, Kottayam	1
3	Deputy Chief Engineer, Research & Dam Safety Organization, Pallom	1
4	Executive Engineer,	1

	Research & Dam Safety Division No. V, Thariyod	
5	Assistant Executive Engineer, Research & Dam Safety Sub Division, Kakkayam	1
6	Assistant Engineer, Research & Dam Safety Section, Kakkayam	1
7	Officer at dam site	1

Table 1.11 Distribution of O&M Manual and Revisions

CHAPTER 2

PROJECT OPERATION

The operation of a dam will involve regulation of its reservoir as per project specific requirements, keeping records and ensuring public safety. Proper operation procedures are crucial for normal or day to day operation of a dam for maintaining a safe structure.

2.1 Basic Data

The Kuttiadi Dam is associated with the Kuttiadi Hydro Electric Projects of 231.75 MW. The water in the reservoir is utilized for power generation in the above hydro project. The Power Houses (3x25 MW, 1x50MW, 2x50 MW and two tail race schemes of 3x1.25MW and 2x1.5 MW machines) are located at Kakkayam which is about 3km (Length of water conductor system) away from Dam. In addition to the water in the Kuttiadi Reservoir, the water from Banasurasagar reservoir (Kuttiadi Augmentation Scheme, Thariod) is also diverted to this reservoir for power generation.

The operation plan consists of step-by-step instructions for operating the dam and reservoir during routine (normal) and emergency conditions. The operating procedures for normal operations are discussed in this chapter. The operation of a dam involves regulation of its reservoir as per rule curve/project specific requirements. This includes the use of elevation storage curve and design flood; both are described below.

2.1.1 Elevation Storage curve

The elevation storage curve for Kuttiyadi Dam in tabular and graphical form are shown in **Fig. 2.1 and Table 2.1.**

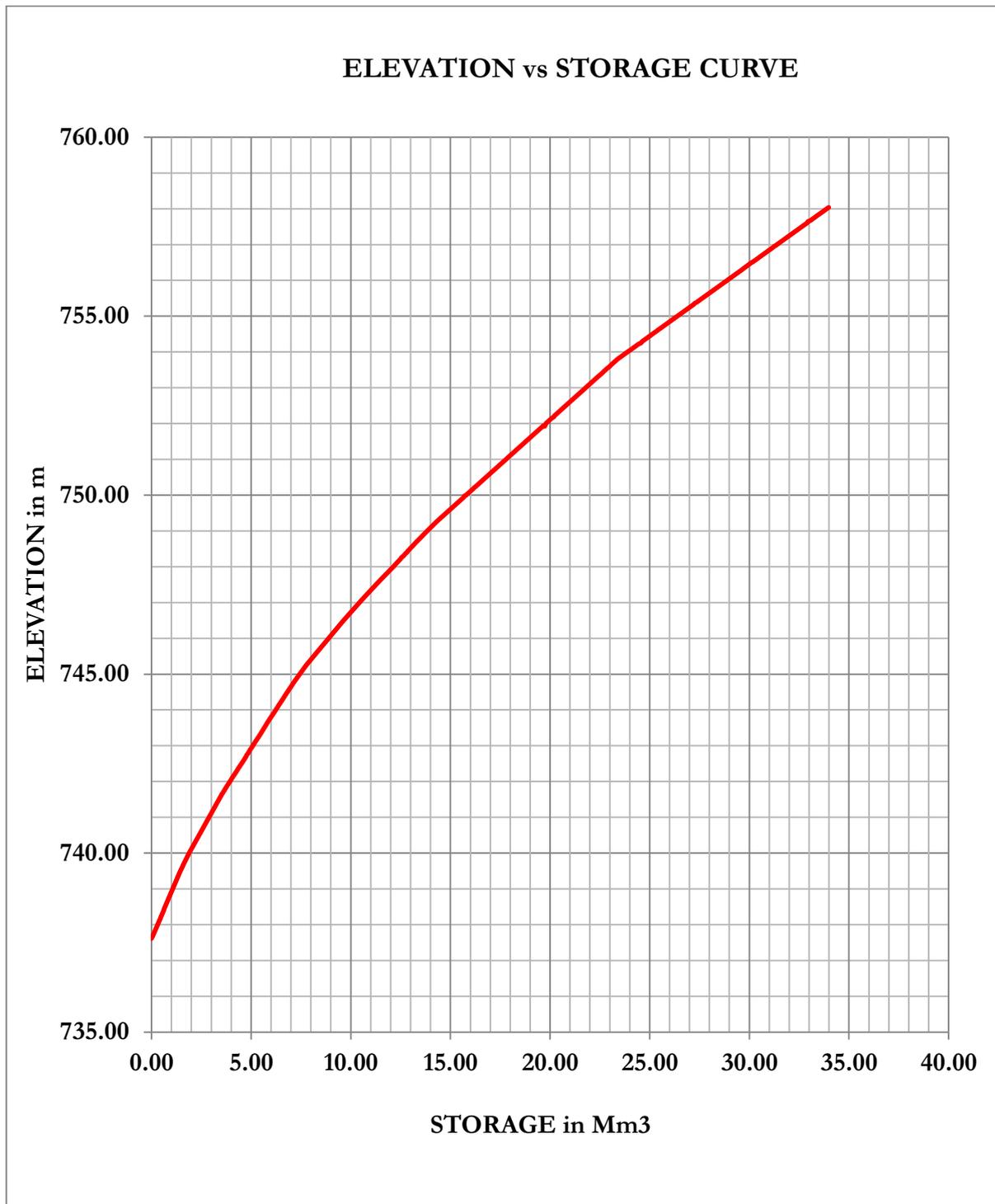


Fig 2.1 Elevation storage curve for Kuttiadi reservoir

ELEVATION - STORAGE TABLE OF KUTTIADI RESERVOIR							
Elevation in m	Storage in Mm ³	Elevation in m	Storage in Mm ³	Elevation in m	Storage in Mm ³	Elevation in m	Storage in Mm ³
737.62	0.00	738.84	0.94	740.0550	1.9422	741.34	3.22
737.65	0.02	738.87	0.96	740.1470	2.0337	741.37	3.25
737.68	0.06	738.90	0.98	740.1770	2.0642	741.40	3.28
737.71	0.08	738.93	1.01	740.2080	2.0947	741.43	3.31
737.74	0.10	738.96	1.03	740.2380	2.1252	741.46	3.34
737.77	0.13	738.99	1.05	740.2690	2.1557	741.49	3.37
737.80	0.15	739.02	1.08	740.2990	2.1862	741.52	3.41
737.83	0.17	739.05	1.10	740.3300	2.2167	741.55	3.44
737.86	0.20	739.08	1.12	740.3600	2.2472	741.58	3.47
737.89	0.22	739.11	1.15	740.3900	2.2776	741.61	3.50
737.92	0.24	739.14	1.17	740.4210	2.3080	741.65	3.53
737.95	0.27	739.17	1.19	740.4510	2.3384	741.67	3.56
737.98	0.29	739.20	1.22	740.4820	2.3688	741.70	3.60
738.01	0.31	739.23	1.24	740.5120	2.3992	741.73	3.63
738.04	0.34	739.26	1.26	740.5420	2.4296	741.76	3.67
738.07	0.36	739.29	1.29	740.5730	2.4600	741.79	3.70
738.10	0.38	739.32	1.31	740.6030	2.4904	741.82	3.73
738.13	0.41	739.35	1.33	740.6340	2.5208	741.85	3.77
738.16	0.44	739.38	1.36	740.6640	2.5512	741.88	3.80
738.19	0.45	739.42	1.38	740.6950	2.5817	741.91	3.83
738.23	0.48	739.45	1.40	740.7250	2.6122	741.94	3.87
738.26	0.50	739.48	1.43	740.7560	2.6427	741.98	3.91
738.29	0.52	739.51	1.45	740.7860	2.6732	742.01	3.94
738.32	0.55	739.54	1.48	740.8170	2.7037	742.04	3.98

738.35	0.57	739.57	1.51	740.8470	2.7342	742.07	4.01
738.38	0.59	739.60	1.54	740.8780	2.7647	742.10	4.04
738.41	0.62	739.63	1.56	740.9080	2.7952	742.13	4.08
738.44	0.63	739.66	1.58	740.9390	2.8257	742.16	4.12
738.47	0.65	739.69	1.61	740.9690	2.8562	742.19	4.15
738.50	0.68	739.72	1.63	741.00	2.89	742.22	4.19
738.53	0.70	739.75	1.66	741.03	2.91	742.25	4.23
738.56	0.73	739.78	1.69	741.06	2.95	742.28	4.26
738.59	0.75	739.81	1.72	741.09	2.98	742.31	4.29
738.62	0.77	739.84	1.75	741.12	3.01	742.34	4.33
738.65	0.80	739.8720	1.7720	741.15	3.04	742.37	4.36
738.68	0.82	739.9030	1.7995	741.18	3.07	742.40	4.40
738.71	0.84	739.9330	1.8259	741.21	3.10	742.43	4.44
738.74	0.86	739.9640	1.8544	741.24	3.13	742.46	4.47
738.77	0.89	739.9940	1.8818	741.27	3.16	742.49	4.51
738.80	0.91	740.0250	1.9117	741.31	3.19	742.52	4.55

742.55	4.58	743.83	6.04	745.08	7.55	746.33	9.39
742.59	4.62	743.87	6.08	745.11	7.59	746.37	9.43
742.62	4.65	743.90	6.11	745.15	7.63	746.40	9.48
742.65	4.69	743.93	6.15	745.18	7.67	746.43	9.53
742.68	4.72	743.96	6.18	745.21	7.70	746.46	9.57
742.71	4.75	743.99	6.22	745.24	7.75	746.49	9.62
742.74	4.78	744.02	6.26	745.27	7.79	746.52	9.66
742.77	4.82	744.05	6.29	745.30	7.83	746.55	9.72
742.80	4.86	744.08	6.33	745.33	7.88	746.58	9.76

742.83	4.89	744.11	6.36	745.35	7.92	746.61	9.81
742.86	4.92	744.14	6.39	745.39	7.97	746.64	9.86
742.89	4.95	744.17	6.43	745.42	8.02	746.67	9.91
742.92	4.99	744.20	6.47	745.45	8.06	746.70	9.96
742.95	5.03	744.23	6.50	745.48	8.11	746.73	10.01
742.98	5.06	744.26	6.54	745.51	8.15	746.76	10.05
743.01	5.10	744.29	6.58	745.54	8.20	746.79	10.10
743.04	5.13	744.32	6.61	745.57	8.24	746.82	10.15
743.07	5.17	744.35	6.65	745.60	8.29	746.85	10.20
743.13	5.24	744.38	6.68	745.63	8.34	746.88	10.25
743.16	5.27	744.41	6.71	745.66	8.38	746.91	10.30
743.20	5.31	744.44	6.75	745.69	8.43	746.94	10.35
743.23	5.35	744.48	6.79	745.72	8.47	746.97	10.40
743.26	5.38	744.51	6.82	745.76	8.52	747.00	10.44
743.29	5.42	744.54	6.86	745.79	8.57	747.03	10.49
743.32	5.46	744.57	6.90	745.82	8.61	747.07	10.54
743.35	5.49	744.60	6.93	745.85	8.66	747.10	10.59
743.38	5.52	744.63	6.97	745.88	8.70	747.13	10.64
743.41	5.56	744.66	7.01	745.91	8.75	747.16	10.69
743.44	5.59	744.69	7.04	745.94	8.79	747.19	10.74
743.47	5.62	744.72	7.08	745.97	8.84	747.22	10.80
743.50	5.66	744.75	7.12	746.00	8.89	747.25	10.85
743.53	5.69	744.78	7.15	746.03	8.93	747.28	10.90
743.56	5.72	744.81	7.19	746.06	8.98	747.31	10.95
743.59	5.76	744.84	7.23	746.09	9.02	747.34	11.00
743.62	5.79	744.87	7.27	746.12	9.07	747.37	11.05
743.65	5.82	744.90	7.31	746.15	9.11	747.40	11.10

743.68	5.86	744.93	7.35	746.18	9.16	747.43	11.15
743.71	5.89	744.96	7.39	746.21	9.21	747.46	11.20
743.74	5.93	744.99	7.43	746.24	9.25	747.49	11.26
743.77	5.97	745.02	7.47	746.27	9.30	747.52	11.31
743.80	6.00	745.05	7.51	746.30	9.34	747.55	11.36
747.58	11.41	748.92	13.70	750.30	16.38	751.67	19.12
747.61	11.46	748.96	13.76	750.33	16.44	751.70	19.18
747.64	11.51	748.99	13.81	750.36	16.50	751.73	19.24
747.68	11.57	749.02	13.87	750.39	16.56	751.76	19.31
747.71	11.62	749.05	13.92	750.42	16.62	751.79	19.37
747.74	11.67	749.08	13.98	750.45	16.68	751.82	19.43
747.77	11.73	749.11	14.03	750.48	16.75	751.85	19.49
747.80	11.78	749.14	14.09	750.54	16.87	751.88	19.55
747.83	11.83	749.17	14.14	750.57	16.93	751.91	19.61
747.86	11.89	749.20	14.20	750.60	16.99	751.94	19.67
747.89	11.94	749.23	14.26	750.63	17.05	751.92	19.73
747.92	11.99	749.26	14.31	750.66	17.11	752.00	19.80
747.95	12.05	749.29	14.37	750.69	17.17	752.03	19.85
747.98	12.10	749.32	14.43	750.72	17.23	752.06	19.92
748.01	12.15	749.35	14.49	750.75	17.29	752.09	19.98
748.04	12.20	749.38	14.55	750.78	17.36	752.13	20.04
748.07	12.25	749.41	14.61	750.81	17.42	752.16	20.10
748.10	12.30	749.44	14.67	750.84	17.48	752.19	20.19
748.13	12.35	749.47	14.73	750.88	17.54	752.22	20.22
748.16	12.40	749.50	14.80	750.91	17.60	752.25	20.28
748.19	12.45	749.53	14.85	750.94	17.66	752.28	20.34
748.22	12.51	749.56	14.92	750.97	17.72	752.31	20.40

748.25	12.54	749.59	14.98	751.00	17.78	752.34	20.46
748.29	12.61	749.63	15.04	751.03	17.84	752.37	20.53
748.31	12.67	749.66	15.10	751.06	17.90	752.40	20.59
748.35	12.71	749.69	15.16	751.09	17.96	752.43	20.65
748.38	12.76	749.72	15.22	751.12	18.02	752.46	20.71
748.40	12.82	749.75	15.28	751.15	18.09	752.49	20.77
748.44	12.86	749.78	15.34	751.18	18.15	752.52	20.83
748.47	12.91	749.81	15.40	751.21	18.21	752.55	20.89
748.50	12.96	749.84	15.46	751.24	18.27	752.58	20.95
748.53	13.01	749.87	15.53	751.27	18.33	752.61	21.01
748.56	13.07	749.90	15.59	751.30	18.39	752.64	21.07
748.59	13.12	749.93	15.65	751.33	18.45	752.67	21.14
748.62	13.17	749.98	15.71	751.36	18.51	752.70	21.20
748.65	13.22	749.99	15.77	751.39	18.57	752.73	21.26
748.68	13.27	750.02	15.83	751.42	18.63	752.76	21.32
748.71	13.33	750.08	15.95	751.45	18.70	752.80	21.38
748.74	13.38	750.11	16.01	751.48	18.76	752.83	21.44
748.77	13.44	750.14	16.07	751.52	18.82	752.86	21.50
748.80	13.49	750.17	16.14	751.55	18.88	752.89	21.56
748.83	13.54	750.20	16.19	751.58	18.94	752.92	21.62
748.86	13.60	750.24	16.26	751.61	19.00	752.95	21.68
748.89	13.65	750.27	16.32	751.64	19.06	752.98	21.74

753.01	21.80	754.35	24.76	755.63	27.96	756.95	31.24
753.04	21.87	754.38	24.84	755.66	28.04	756.97	31.31
753.07	21.93	754.41	24.92	755.69	28.12	757.00	31.39

753.10	21.99	754.44	24.99	755.72	28.19	757.03	31.47
753.13	22.05	754.47	25.07	755.75	28.27	757.06	31.54
753.16	22.11	754.50	25.14	755.78	28.34	757.09	31.62
753.19	22.17	754.53	25.22	755.81	28.42	757.12	31.69
753.22	22.23	754.56	25.30	755.84	28.50	757.15	31.77
753.25	22.29	754.59	25.37	755.87	28.57	757.18	31.85
753.28	22.35	754.62	25.44	755.90	28.65	757.21	31.92
753.31	22.41	754.65	25.52	755.93	28.72	757.25	32.00
753.34	22.48	754.69	25.60	755.97	28.80	757.28	32.08
753.41	22.61	754.72	25.68	755.99	28.88	757.31	32.15
753.47	22.72	754.75	25.75	756.03	28.95	757.34	32.23
753.50	22.78	754.78	25.83	756.06	29.03	757.37	32.30
753.53	22.84	754.81	25.90	756.09	29.10	757.40	32.38
753.56	22.90	754.84	25.98	756.12	29.18	757.43	32.46
753.58	22.96	754.87	26.06	756.15	29.26	757.46	32.53
753.62	23.02	754.90	26.13	756.18	29.33	757.49	32.61
753.65	23.09	754.93	26.21	756.21	29.41	757.55	32.76
753.68	23.15	754.96	26.29	756.24	29.49	757.58	32.84
753.71	23.21	754.99	26.36	756.27	29.56	757.61	32.91
753.74	23.27	755.02	26.44	756.30	29.64	757.64	32.94
753.77	23.33	755.05	26.51	756.33	29.71	757.67	33.07
753.80	23.39	755.08	26.59	756.37	29.79	757.70	33.14
753.83	23.47	755.11	26.67	756.40	29.87	757.73	33.22
753.86	23.54	755.14	26.74	756.43	29.94	757.76	33.30
753.89	23.62	755.17	26.82	756.46	30.02	757.80	33.37
753.92	23.69	755.20	26.90	756.49	30.10	757.82	33.44
753.95	23.77	755.23	26.97	756.51	30.17	757.85	33.52

753.98	23.85	755.26	27.05	756.54	30.25	757.89	33.60
754.01	23.92	755.30	27.12	756.57	30.32	757.92	33.68
754.04	24.00	755.33	27.20	756.64	30.48	757.95	33.75
754.08	24.08	755.37	27.28	756.67	30.55	757.98	33.83
754.11	24.16	755.39	27.35	756.70	30.63	758.01	33.90
754.14	24.23	755.42	27.43	756.73	30.71	758.04	33.98
754.17	24.31	755.45	27.51	756.76	30.78		
754.20	24.38	755.48	27.58	756.79	30.86		
754.23	24.46	755.51	27.66	756.82	30.93		
754.25	24.57	755.54	27.73	756.85	31.01		
754.29	24.61	755.57	27.81	756.88	31.09		
754.32	24.69	755.60	27.89	756.91	31.16		

Table 2.1 Elevation – Storage of Kuttiadi Reservoir

2.2 Operation Plan

An effective operation plan and schedule is required for the safe project operation for which the project specific features shall be known. Salient features of the Reservoir are given below.

1	Type of dam	Masonry
2	Top level of dam	+759.56m
3	Height above deepest foundation	39.51m
4	No and size of radial gates	2 Nos. of size 10.97m x 6.40m each
5	Crest level of spillway	+751.64m
6	Maximum spillway discharge	736.20 cumecs
7	FRL	758.04m
8	MWL	758.04m
9	MDDL	737.62m
10	Dead Storage Level	737.62m

11	Gross Storage Capacity	38.40 Mm ³
12	Live Storage Capacity	33.98 Mm ³
13	Water spread Area at FRL	2.79 sq. km

Table 2.2 Salient features of Reservoir

2.2.1 Data of the historic floods

As per historical records, the maximum flood observed in Western Ghats was during 1924. The centre of the storm of the 1-day rainfall of 17th July 1924 and 2-day rainstorm of July 16-17 was located at Devikulam in Kerala in which rain fall of 484 mm and 751 mm respectively were recorded.

The SW monsoon of the year 2018 in the State was similar to that of 1924 Devikulam storm and Kerala experienced an abnormally high rainfall from 1 June 2018 to 19 August 2018 which resulted in severe flooding in 13 out of 14 districts in the State. It is seen that the 2-day and 3-day rainfall depths of 15 -17, August 2018 rainfall in Pamba, Periyar and Bharathapuzha sub-basins are almost comparable to the Devikulam storm of 16-18, July 1924. Out of 758.6 mm rainfall from 1 August 2018 to 19 August 2018, about 414 mm rainfall occurred in just three days viz. 15-17, August 2018, which created severe flooding in the state, while the same during 16-18, July 1924 was 443 mm. The three day rainfall of 15-17 August 2018 at Kuttiyadi Dam site was 836 mm.

The spillway shutters were opened during 2007, 2008, 2009, 2010, 2011, 2013, 2014 & 2018 for excess flood moderation. Spill details of the above years are tabulated below in **Table 2.3**.

Date	Rain fall in mm	Water level in m	Spill in MCM
02-07-2007	145.00	757.89	2.50
03-07-2007	123.00	758.04	5.49
04-07-2007	112.00	758.04	7.34
05-07-2007	71.00	758.04	2.51
06-07-2007	85.00	758.04	3.72

07-07-2007	127.00	758.04	6.87
08-07-2007	95.00	758.04	4.26
09-07-2007	60.00	758.04	2.01
10-07-2007	66.00	757.98	0.64
11-07-2007	87.00	758.04	2.08
12-07-2007	102.00	757.85	1.85
13-07-2007	182.00	758.04	6.97
14-07-2007	57.00	757.98	2.00
15-07-2007	42.00	758.04	4.05
16-07-2007	250.00	758.04	12.87
17-07-2007	250.00	758.04	13.04
18-07-2007	255.00	758.04	9.17
19-07-2007	45.00	758.04	5.62
20-07-2007	23.00	758.04	4.99
21-07-2007	115.00	758.04	4.99
22-07-2007	26.00	757.98	1.40
06-08-2007	252.00	758.04	4.63
07-08-2007	77.00	758.04	4.99
08-08-2007	113.00	758.04	5.17
09-08-2007	78.00	758.04	5.42
10-08-2007	158.00	758.04	8.18
11-08-2007	44.00	758.04	4.52
12-08-2007	32.00	757.95	0.52
27-08-2007	73.00	757.64	0.63
06-09-2007	120.00	757.95	0.26
25-09-2007	176.00	757.67	1.05
26-09-2007	60.00	758.04	0.86

27-09-2007	2.00	757.89	0.33
28-09-2007	11.00	757.82	0.32
29-09-2007	29.00	757.85	0.41
30-09-2007	84.00	757.89	1.01
01-10-2007	80.00	758.04	2.50
02-10-2007	46.00	758.04	0.07
Total Spill for 2007			145.23
01-08-2008	77.00	758.04	0.83
02-08-2008	30.00	758.01	0.34
11-08-2008	98.00	757.98	0.59
12-08-2008	58.00	758.04	1.18
13-08-2008	130.00	758.04	1.60
14-08-2008	77.00	758.04	0.53
Total Spill for 2008			5.08
15-07-2009	137.00	2484.60	1.67
16-07-2009	182.00	2487.00	4.14
17-07-2009	254.00	2487.00	6.80
18-07-2009	245.00	2487.00	6.13
19-07-2009	50.00	2487.00	2.51
20-07-2009	80.00	2487.00	0.94
21-07-2009	57.00	2486.70	0.29
22-07-2009	77.00	2486.80	1.50
23-07-2009	17.00	2486.70	0.29
Total Spill for 2009			24.26
28-07-2010	115.00	2485.00	0.91
29-07-2010	83.00	2487.00	3.11
30-07-2010	116.00	2487.00	2.97

31-07-2010	73.00	2487.00	2.20
01-08-2010	56.00	2487.00	0.75
02-08-2010	5.00	2487.00	0.43
03-08-2010	28.00	2486.70	0.22
04-08-2010	81.00	2487.00	1.05
05-08-2010	51.00	2487.00	0.50
06-08-2010	28.00	2487.00	0.72
07-08-2010	26.00	2487.00	0.68
08-08-2010	59.00	2487.00	0.62
09-08-2010	16.00	2487.00	0.46
17-08-2010	60.00	2486.90	0.50
28-08-2010	29.00	2486.80	0.82
29-08-2010	71.00	2486.90	0.28
30-08-2010	32.00	2486.90	2.17
31-08-2010	165.00	2487.00	1.26
01-09-2010	0.00	2487.00	0.47
03-09-2010	31.00	2487.00	0.39
04-09-2010	71.00	2486.80	0.16
08-09-2010	13.00	2487.00	0.50
11-09-2010	45.00	2487.00	0.29
13-09-2010	35.00	2486.90	1.11
14-09-2010	50.00	2487.00	0.89
15-09-2010	22.00	2487.00	1.38
	Total Spill for 2010		24.83
31-08-2011	77.00	757.95	0.91
01-09-2011	145.00	758.04	6.51
02-09-2011	161.00	758.04	4.99

03-09-2011	42.00	758.04	5.39
04-09-2011	50.00	758.04	2.51
05-09-2011	22.00	758.04	1.06
	Total Spill for 2011		21.37
26.06.2013	8.00	757.91	1.12
27.06.2013	78.00	758.04	0.93
05.07.2013	113.00	758.04	2.61
06.07.2013	107.00	758.04	2.48
07.07.2013	94.00	758.04	0.47
21.07.2013	99.00	757.98	0.85
24.07.2013	50.00	758.04	0.76
25.07.2013	75.00	757.98	0.76
26.07.2013	94.00	758.04	2.26
27.07.2013	102.00	758.04	2.04
28.07.2013	64.00	758.04	0.82
01.08.2013	82.00	758.04	2.24
02.08.2013	131.00	758.04	4.81
03.08.2013	59.00	758.04	1.70
05.08.2013	108.00	757.92	0.08
06.08.2013	70.00	758.04	0.99
07.08.2013	49.00	757.95	0.53
08.08.2013	52.00	757.95	0.12
20.09.2013	68.00	758.04	0.66
	Total Spill for 2013		26.23
22.07.2014	110.00	758.04	0.38
23.07.2014	126.00	758.04	7.23
24.07.2014	115.00	758.04	1.95

25.07.2014	59.00	758.04	0.39
31.07.2014	120.00	757.64	0.08
01.08.2014	102.00	758.04	8.59
02.08.2014	100.00	758.04	1.24
03.08.2014	38.00	758.00	0.69
04.08.2014	54.00	758.04	1.26
05.08.2014	102.00	758.04	4.90
06.08.2014	128.00	758.04	6.57
07.08.2014	108.00	758.13	1.62
08.08.2014	62.00	757.98	0.64
09.08.2014	46.00	757.98	0.07
02.09.2014	160.00	757.98	0.68
03.09.2014	220.00	758.04	0.42
05.09.2014	28.00	758.04	0.45
07.09.2014	48.00	758.04	0.29
08.09.2014	35.00	758.04	0.92
09.09.2014	102.00	758.04	0.79
10.09.2014	22.00	758.04	0.42
11.09.2014	17.00	758.04	0.59
	Total Spill for 2014		40.17
14.06.2018	208.00	757.61	3.98
11.07.2018	222.00	758.04	6.47
13.07.2018	110.00	758.04	2.09
14.07.2018	114.00	7.58	3.23
15.07.2018	120.00	758.04	4.32
16.07.2018	112.00	758.04	3.82
17.07.2018	102.00	757.92	0.16

18.07.2018	131.00	758.04	1.90
19.07.2018	106.00	758.01	0.73
20.07.2018	5.00	758.04	1.14
24.07.2018	116.00	757.89	1.95
25.07.2018	69.00	758.04	0.24
26.07.2018	102.00	758.04	1.24
27.07.2018	66.00	757.98	0.22
01.08.2018	119.00	757.70	0.29
8.08.2018	175.00	757.03	1.51
9.08.2018	238.00	758.04	12.50
10.08.2018	80.00	758.04	3.99
11.08.2018	107.00	758.04	2.51
12.08.2018	0.00	757.98	2.71
13.08.2018	95.00	757.95	4.99
14.08.2018	167.00	758.04	15.74
15.08.2018	410.00	758.04	8.78
16.08.2018	310.00	758.04	11.92
17.8.2018	116.00	758.22	5.44
18.08.2018	0.00	757.52	1.16
19.08.2018	0.00	757.61	1.20
20.08.2018	0.00	757.79	1.23
21.08.2018	0.00	757.52	0.71
Total Spill for 2018			106.17

Table 2.3 Spill Details

2.2.2 Design Flood and Features Related to Safety

Hydrology

The Kuttiadi Hydro Electric Project is situated in Kuttiadi river basin. Kuttiadi river starts from western side of Wayanad Plateau. The river runs through Kakkayam, Peruvannamuzhy, Kuttiadi, Perambra and reaches Vadakara and falls into Arabian Sea. The river Kuttiadi is a major tributary of Kuttidypuzha originating from the Kakkayam Hills at about elevation 1340 m. The Kuttiadi reservoir at Kakkayam is augmented from a reservoir named as Kuttiadi Augmentation scheme (KAS) which is situated at Padinjarathara and Thariod near Vythiri in Wayanad District. The Kuttiadi reservoir at its FRL 758.04 m submerges an area of 279 hectares. The catchment area of Kuttiadi reservoir is approximately 38.50 sq. km. The catchment receives comparatively good rains almost throughout the year. It is observed that the rains contributed by South-West monsoon are comparatively heavier than the rain precipitated during North-East monsoon. The average annual rainfall of the project is 6710 mm and the average annual runoff is estimated as 209.50 Mm³.

Design Flood Studies

As per BIS: 11223-1985 criteria, the dam is classified as large dam and therefore, qualifies for PMF as design flood. The project was originally designed for 736.20 m³/s flood.

Hydrology review carried out in DRIP

The revised design flood of Kuttiadi is estimated as per FER 5 (a) & (b) published by Central Water Commission and IS-11223. The revised design flood is estimated as 771 m³/s. The revised design flood has been approved by the CWC vide letter No.7/Kerala-57/2011Hyd(S)/314-15 dated 26th May 2014. The spillway capacity provided is 736 m³/s. Discharge capacity of river outlet at FRL is 34 m³/s. Total out-flow possible at FRL is 770 m³/s. **The spillway can safely pass the flood downstream** without exceeding the water level in the reservoir above FRL and hence flood routing is not required for this reservoir. Review of Design Flood Studies is attached as **Annexure 2**.

2.2.3 Spillway Operation

The spillway of Kuttiadi Dam is Ogee type with 2 bays. The crest level of spillway is +751.64m. The maximum discharge capacity of spillway is 736.20 Cumecs.

2.2.4 Hoisting Arrangements for Radial Crest Gates

The main component of hoisting system (rope drum hoists) for operation of the crest gates of spillway is mounted on the spillway hoist bridge. The spillway is provided with two radial gates of size 10.97 m x 6.40 m each which can be operated both by power and manually. Stop log gates are not provided for the spillway. The gates are operated and tested in every season when the water is below the crest level. Periodical maintenance like painting, greasing, oiling etc. is also done from time to time.



Fig 2.2 Spillway Gates



Fig 2.3 Gate Hoisting System



Fig 2.4 Main Switch at hoist bridge



Fig 2.5 Reverse/Forward switch and starter/stopper



Fig 2.6 Winch and shaft gears



Fig 2.7 Motor and gear box brake

2.3 Scour Sluice

The scour sluice is generally meant for silt removal and hence its gates are intended to be operated during heavy rainy season only or when reservoir emptying is necessary. It will also be a planned operation.

The Scour sluice consists of two gates viz. an Emergency gate and a Service gate. Both are electrically operated vertical lift gates. It can be operated manually too.

The relevant details of the gates are given below.

	EMERGENCY GATE	SERVICE GATE
Scour tunnel (Inside dam)	: 1.52m dia.	
Gate size	: 2.9 x 2.33 m	2.9 x 2.33 m
Gate opening size	: 2.254x 1.97m	2.254x 1.97m
Gate sill level	: 728.51m	728.51m
Maintenance plat- form level	: 754.08m	754.35
Service floor level	: 759.21m	759.21m
River Bed level	: 720.09m	720.09m
Rope size	: 22mm	22mm



Fig 2.8 Scour sluice structure



Fig 2.9 Scour gate hoisting system



Fig 2.10 Winch Drum

2.3 A Power Intake

Intake structure is constructed as part of dam. It consists of a gate hoisting structure with maintenance platform, operating platform, winch arrangements, trash rack, electrical installations etc. It is installed with a single vertical lift gate of size 3.3 x 4.7m which is electrically operated with two winches driven by a 25 HP motor. The gate can be operated manually also in case of power failure. But it cannot be treated as an emergency measure, since the time taken for manual closing is more than a day.



Fig 2.11 Intake structure



Fig 2.12 Intake gate hoisting system

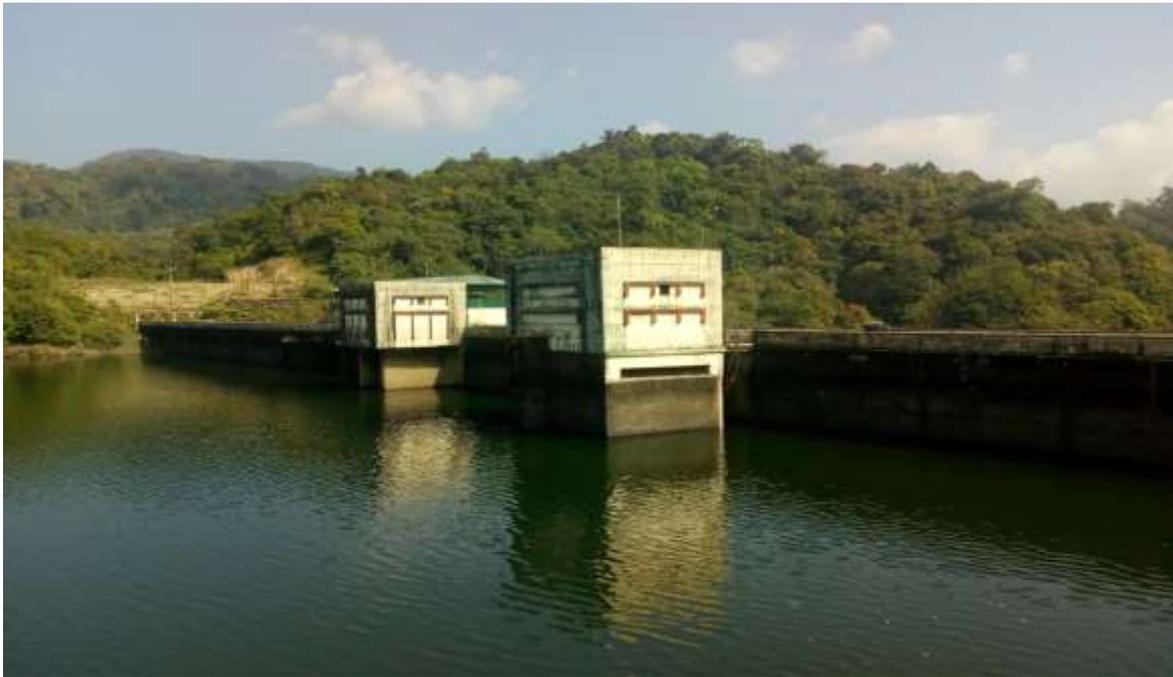


Fig 2.13 Scour sluice structure (left) and intake structure (right)

2.4 Normal Operation of the Reservoir

2.4.1 Operation of Control Mechanisms

The spillway gate hoist motor is having 3 HP Capacity, the scour sluice gate hoist motor is having 15 HP Capacity and the intake gate hoist motor is having 25 HP Capacity. The Operation manual of control mechanism and installation is attached as **Annexure 6**.

2.4.2 Operation of the Reservoir

Kuttiadi reservoir is being operated as per “Guidelines for Operation of Reservoirs” (IS 7323:1994), for storage reservoirs for conservation purposes like power generation, no spilling of water over the spillway will normally be permitted until FRL is reached. Hence no rule curve was prepared for this dam. The reservoir water is released through spillway gates on reaching the Full reservoir Level i.e. 758.04 m level. Discharge through a single spillway gate for different gate openings and reservoir levels is tabulated in **Table 2.4**. Discharge (Rating) curve is given in **Fig. 2.14**.

Discharge through a single spillway gate for different gate openings and reservoir levels							
Reservoir Level (m)	Gate opening (m)/Bottom level of gate (+m)						
	0.1	0.2	0.3	0.6	0.9	1.2	1.5
751.64 (Crest level)	751.74	751.84	751.94	752.24	752.54	752.84	753.14
754.00	5.29	10.47	15.54	30.00	43.33	55.46	66.30
754.20	5.52	10.92	16.22	31.41	45.52	58.50	70.27
754.40	5.73	11.35	16.87	32.76	47.62	61.39	74.03
754.60	5.94	11.77	17.50	34.05	49.62	64.15	77.59
754.80	6.13	12.17	18.10	35.30	51.54	66.79	81.00
755.00	6.33	12.56	18.69	36.49	53.38	69.32	84.26
755.20	6.51	12.93	19.26	37.65	55.17	71.76	87.40
755.40	6.69	13.29	19.81	38.78	56.89	74.12	90.42
755.60	6.87	13.65	20.34	39.87	58.56	76.40	93.34
755.80	7.04	13.99	20.86	40.93	60.19	78.61	96.17
756.00	7.21	14.33	21.36	41.96	61.77	80.76	98.92
756.20	7.37	14.65	21.86	42.97	63.30	82.85	101.58
756.40	7.53	14.97	22.34	43.95	64.80	84.89	104.18
756.60	7.68	15.29	22.81	44.90	66.26	86.87	106.70
756.80	7.83	15.59	23.27	45.84	67.69	88.81	109.17
757.00	7.98	15.89	23.72	46.76	69.09	90.70	111.57
757.20	8.13	16.18	24.16	47.65	70.46	92.55	113.93
757.40	8.27	16.47	24.60	48.53	71.79	94.36	116.23
757.60	8.41	16.75	25.02	49.40	73.11	96.14	118.48
757.80	8.55	17.03	25.44	50.24	74.40	97.88	120.69
758.00	8.69	17.30	25.85	51.08	75.66	99.59	122.86
758.04	8.71	17.36	25.93	51.24	75.91	99.93	123.28

Reservoir Level (m)	Gate opening (m)/Bottom level of gate (+m)					
	1.8	2.1	2.4	2.7	3	6.4
751.64 (Crest level)	753.44	753.74	754.04	754.34	754.64	758.04

754.00	75.76	83.73	90.04	94.52	96.91	
754.20	80.76	89.86	97.46	103.42	107.56	
754.40	85.45	95.59	104.34	111.60	117.22	
754.60	89.90	100.99	110.79	119.21	126.14	
754.80	94.13	106.11	116.87	126.35	134.45	
755.00	98.17	110.98	122.65	133.10	142.26	
755.20	102.04	115.64	128.15	139.51	149.66	149.98
755.40	105.77	120.12	133.42	145.64	156.70	163.83
755.60	109.36	124.42	138.49	151.50	163.43	178.01
755.80	112.84	128.58	143.36	157.14	169.88	192.55
756.00	116.21	132.60	148.07	162.58	176.09	207.54
756.20	119.47	136.50	152.63	167.83	182.07	223.00
756.40	122.65	140.28	157.05	172.92	187.86	238.90
756.60	125.74	143.96	161.34	177.85	193.47	255.26
756.80	128.75	147.54	165.52	182.65	198.90	272.07
757.00	131.69	151.04	169.58	187.31	204.19	289.33
757.20	134.56	154.44	173.55	191.85	209.34	307.02
757.40	137.37	157.77	177.42	196.28	214.35	325.17
757.60	140.12	161.03	181.20	200.61	219.25	343.75
757.80	142.81	164.22	184.90	204.84	224.03	362.78
758.00	145.44	167.34	188.52	208.98	228.70	382.24
758.04	145.96	167.95	189.24	209.80	229.62	386.18

Table 2.4 Discharge for different reservoir levels with different gate openings

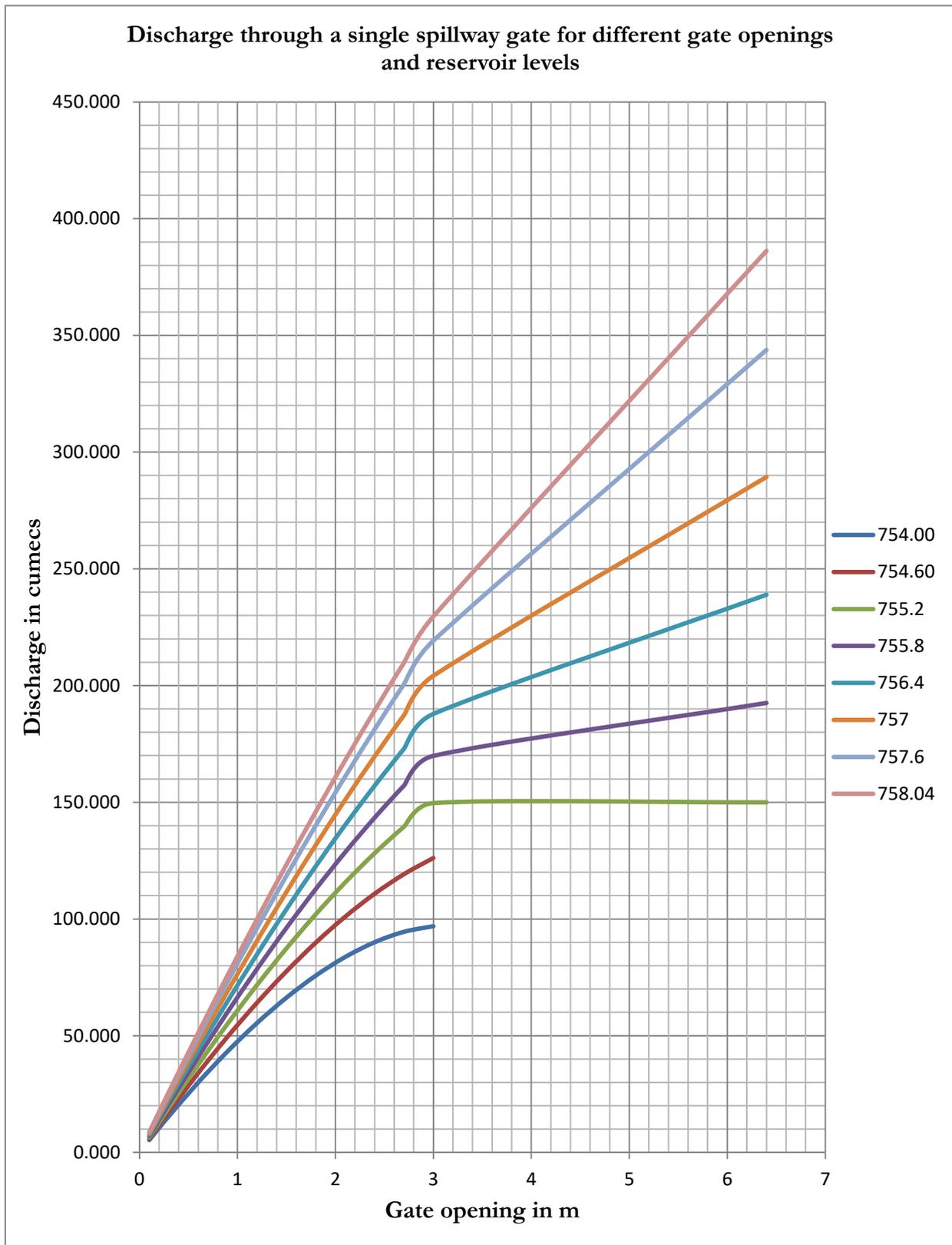


Fig. 2.14 Discharge Curve

2.4.3 Rule Curve

As per the Kerala flood study report of August 2018, CWC has recommended for reviewing the rule curves of all the reservoirs in Kerala. The rule curves need to be formulated for both conservation as well as operations during the flood. Accordingly, rule curve for reservoirs under KSEB Ltd considering the historic inflow after the filling of reservoir and the power demand during respective months are arrived.

However considering the rainfall, inflow, power generation from 2009 to 2018, an average reservoir water level pattern is arrived as shown in **Table 2.5**. The peak level is proposed at FRL 758.04 m during September 10th considering the SW monsoon. A rule curve is arrived as shown in **Fig 2.15**. The reservoir water exceeding the rule curve level will be spilled or adjusted with power generation. This can be used till further revision.

Month/ Year	June			July			August		
	1-10	10-20	20-30	1-10	10-20	20-31	1-10	10-20	20-31
2009-10					756.53	757.90	756.83	754.50	755.42
2010-11	743.36	746.91	751.47	753.01	754.03	756.16	758.01	757.87	757.90
2011-12	747.97	749.73	751.19	747.19	750.21	754.82	754.41	755.73	757.27
2012-13	744.17	744.46	744.87	747.07	747.89	749.66	754.24	753.74	753.36
2013-14	747.74	750.40	755.36	756.67	757.23	757.69	757.95	757.25	755.80
2014-15	742.01	746.12	748.96	746.15	750.41	757.43	757.84	756.26	756.11
2015-16	746.45	746.98	751.15	752.04	751.44	752.10	751.03	752.43	752.31
2016-17	746.01	746.03	750.14	753.85	752.15	750.45	751.55	752.40	752.31
2017-18	750.07	749.31	750.14	750.72	750.07	748.94	749.35	750.78	752.48

Average	747.07	747.92	751.20	753.26	754.03	754.52	755.23	755.39	755.97
Rule curve	748.84	749.69	752.97	755.03	755.80	756.29	757.00	757.16	757.74

Month/ Year	September			October			November		
	1-10	10-20	20-30	1-10	10-20	20-31	1-10	10-20	20-30
2009-10	757.22	756.23	756.74	757.63	757.28	756.32	755.89	756.01	755.74
2010-11	758.03	757.92	756.95	754.33	752.60	752.74	752.31	751.18	750.72
2011-12	757.50	756.63	753.89	750.31	749.22	751.24	753.18	751.70	750.88
2012-13	754.70	754.06	751.87	751.56	746.71	745.84	752.06	752.83	751.31
2013-14	755.59	757.13	756.56	753.38	749.97	749.46	751.50	752.65	752.63
2014-15	757.69	757.61	756.97	755.39	754.09	753.77	752.59	753.83	756.14
2015-16	751.14	750.56	749.60	751.20	752.42	749.59	748.90	749.35	751.68
2016-17	750.14	748.02	750.54	753.18	750.46	749.23	749.09	746.21	748.15
2017-18	753.18	751.97	751.61	750.25	751.51	751.94	751.32	750.31	749.91
Average	756.27	755.93	754.94	753.81	753.06	752.60	752.69	752.64	752.73
Rule curve	758.04	757.70	756.71	755.58	754.83	754.37	754.46	754.41	754.50

Month/ Year	December			January			February		
	1-10	10-20	20-31	1-10	10-20	20-31	1-10	10-20	20-38
2009-10	755.46	754.84	754.63	755.24	755.90	756.20	756.50	756.61	755.60
2010-11	750.25	750.99	754.03	755.23	754.59	754.64	754.90	755.04	755.21
2011-12	752.21	753.00	753.21	753.33	753.44	753.93	754.40	754.09	754.23
2012-13	751.28	753.67	754.28	751.43	750.66	753.44	754.37	752.07	748.38
2013-14	752.30	753.12	754.63	755.25	755.33	755.25	754.96	754.54	753.68
2014-15	755.96	754.78	755.06	755.68	755.04	755.04	754.78	754.03	753.44
2015-16	754.38	753.98	753.63	753.66	754.09	755.26	755.20	754.33	753.60
2016-17	751.64	750.42	747.51	748.34	749.05	748.39	750.87	750.66	747.37
2017-18	752.57	752.20	751.64	754.04	754.21	751.45	750.80	753.10	752.73
Average	753.22	753.65	754.21	754.63	755.01	755.05	755.01	754.53	754.07
Rule curve	754.99	755.42	755.98	756.40	756.78	756.82	756.79	756.30	755.84

Month/ Year	March			April			May		
	1-10	10-20	20-31	1-10	10-20	20-30	1-10	10-20	20-31
2009-10	754.17	752.45	750.72	749.87	748.75	747.22	746.03	744.86	743.91

2010-11	755.04	754.66	754.44	753.99	753.07	752.33	751.84	751.22	750.01
2011-12	754.99	754.88	750.77	746.70	746.49	747.42	748.36	747.99	746.15
2012-13	747.02	746.75	745.77	745.97	746.34	745.88	745.65	746.53	748.17
2013-14	753.48	753.69	752.26	750.24	750.10	749.51	748.47	747.04	743.44
2014-15	752.77	752.05	749.10	746.52	747.80	749.54	748.45	746.35	745.74
2015-16	752.60	751.13	749.50	748.76	748.71	747.63	747.58	749.49	748.79
2016-17	746.56	748.68	748.28	746.46	745.91	745.82	745.75	745.78	747.74
2017-18	749.50	749.43	751.06	750.51	749.32	747.20	746.12	746.61	747.46
Average	753.84	753.14	751.85	748.78	747.62	747.53	747.58	746.83	745.74
Rule curve	755.61	754.91	753.62	750.55	749.39	749.30	749.35	748.60	747.51

Table 2.5 Reservoir Water Levels

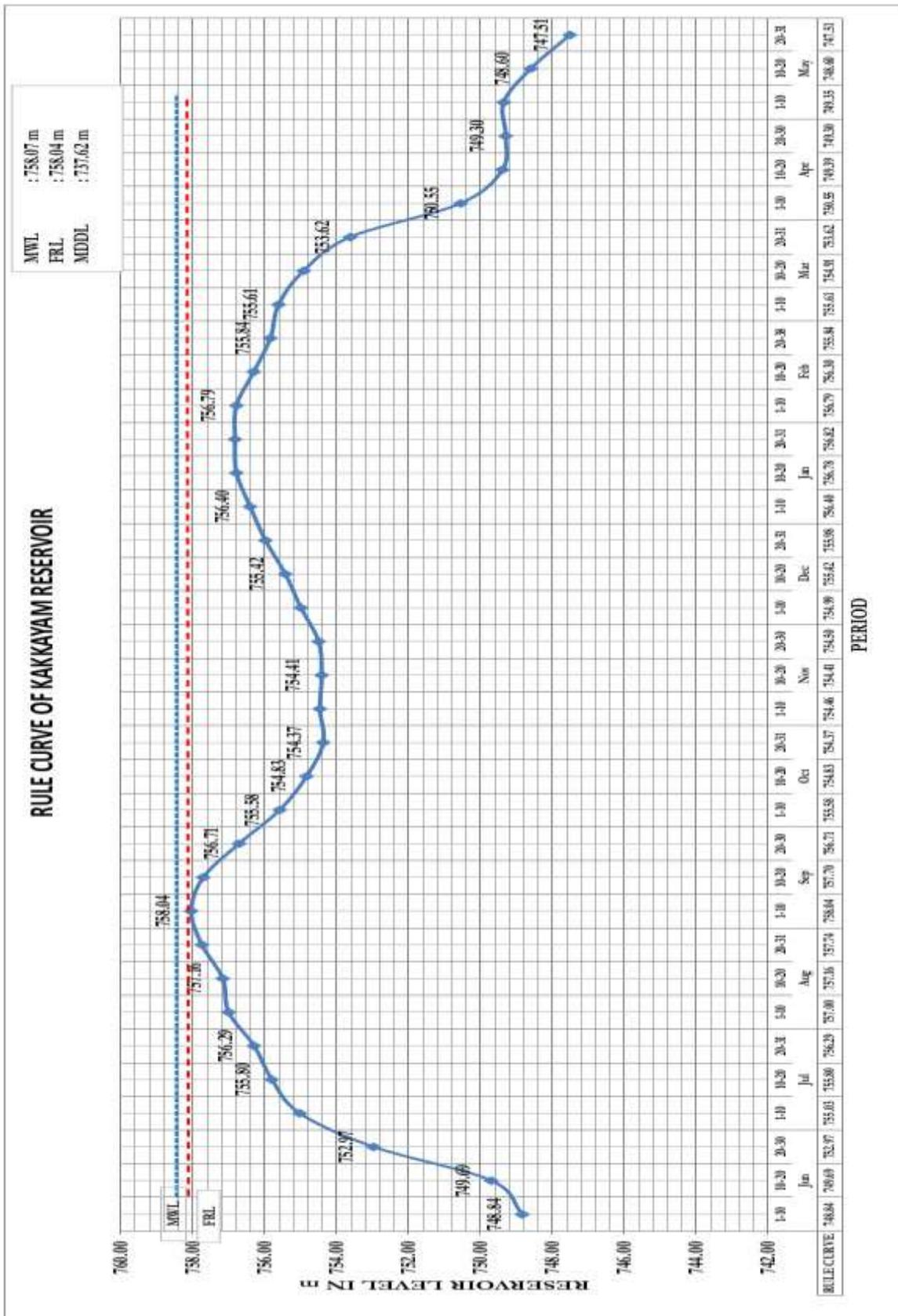


Fig 2.15 Rule curve

2.4.4 Flood Release Procedure

The flood water is released through spillway gates based on the operation manual of gates and flood routing studies attached in the hydrology review **Annexure 2**. Flood release is planned so as to avoid releasing huge quantity water to the river during a short period. In normal case, the spillway gates are operated when the water level reaches FRL. But in case of flood release, spillway gate will be operated in advance, well before the water level reaching the FRL, so as to avoid sudden release of water to the river. There are two spillway gates. Both the gates are operated for flood release in such a way that the required quantity of release is equally distributed between both gates. Gate 1 is opened first and gate 2 is opened immediately following.



Fig 2.16 Spillway of Kuttiadi Dam

2.4.5 Safety Aspects

The spillway gates are operated step by step after assessing the reservoir water level and inflow and the sequencing is defined.

2.4.6 Reservoir Capacities



Fig 2.17 Kuttiadi Reservoir

The Gross storage of the reservoir 38.40 Million Cubic Meters and the Live Storage is 33.98 Million Cubic Meters at FRL of +758.04m.

2.4.7 Climate

The climate is generally hot with a high degree of atmospheric humidity. The summer and winter are practically controlled by south west and north east monsoons. On account of thick vegetation the atmospheric humidity is relatively high even during non-monsoon months.

2.4.8 Inflow forecasting

Average annual rainfall of the project is 6710 mm and the average run off is 209.50 Mm³.

Based on the recent flood, a flood forecasting method may be introduced under DRIP. The gross storage of Kuttiyadi Hydro Electric Project at FRL+758.04m is 38.40 Mm³. The revised design flood of the scheme is 771m³/s. The reservoir was fully impounded in 1972 and data is available from the year of impounding. During years of heavy monsoon incessant rains in the catchment area are likely to cause flood in the river. The floods may lead to problems like people getting displaced from their homes, huge damage to crops and other assets. The floods can have disastrous impact on the environment also. Adequate measures are required to be taken up in advance to control and regulate the flow of water in the river.

The following measures are essential for effective management of floods during monsoon.

- 1) Nomination of liaising officers for respective reservoirs.
- 2) Sharing of Sub-basin wise directory of concerned officers responsible for flood management.
- 3) Exchange of data regarding rainfall, releases from dams, reservoir water levels.
- 4) Reservoir operation schedules.

During monsoon, daily water releases from the Dams/Barrages at 8 hrs. & 16 hrs.in normal situation and hourly data exchange during heavy floods is necessary.

Flood communication system: The widely time tested communication to reach every corner of the flood affected zones have been radio and television and private media for the people to move to safer places by themselves in an emergency. Communication is very important in such occasions. These days due to revolution in the telecommunication system, network of mobile phones is available. Advantage of this facility will be taken. Mobile numbers of all such staff will be listed and made available to all the personnel who have been assigned duty of disaster management.

2.4.9 Methodology of Flood Regulation

2.4.9.1 Inflow Computation

Inflow into reservoirs is normally estimated by the reservoir gauging method (also called the rise and fall method or inflow-outflow method). All the outflows are added together and to it the rate of rise in storage (Positive if the level rises, and negative if it falls) is added. Expressed as an equation, this will be. $\text{Inflow (cumecs)} = \text{Total outflow (cumecs)} + \text{Rate of increase in storage (cumecs)}$.

The rate of increase or decrease in storage can be determined from the observed rate of increase or decrease in reservoir level and the elevation capacity tables.

2.4.10 Summary of Flood Regulation Procedure

The flood regulation procedures at Kuttiyadi Hydro Electric Project can be summarized in the following 5 steps:

1. Observe the reservoir level at 1 hour interval.

2. Determine the total outflow occurring at all outlets
3. Estimate the inflow
4. Determine the gate opening of dam as the case maybe.
5. Open the gates of dam to the extent required to maintain constant reservoir level ie. release is equal to the inflow.

2.4.11 Emergency Operation

The Emergency operation will be carried out following the Emergency Action Plan (EAP). The Emergency conditions are outlined in Chapter 4 under clause 4.2.1 on Immediate Maintenance. The EAP together with this Manual will be available at site at all times.

2.4.11.1 Emergency Action Plan

The purpose of Emergency Action Plan is to identify emergency situations that could threaten Kuttiadi Dam and to plan for an expedited, effective response to prevent failure of the dam and warn downstream residents of impending danger. This plan defines the notification procedures to be followed in the event of a potentially hazardous situation. The procedures are intended to protect lives and prevent property damage from and excessive release of water from the dam spillways or an uncontrolled outflow of water from the breached portion of dam.

Dam owner's responsibilities before and during an Emergency event, Responsibilities for Notification, Responsibilities for Evacuation, Responsibilities for Termination and Follow-Up, Communication Networks, Emergency Detection, Evaluation and Classification, Preparedness, Remedial Actions, Emergency Operations Centre, Inundation Areas, Local Evacuation Plan, Implementation, Vicinity Map, Inundation cum Evacuation Maps etc. are provided in the detailed EAP document. Summary of Alert Conditions during Emergency are given in **Annexure 8**.

2.5 Drawdown Facility

The spill way gates and the scour sluice gates are to be used for lowering of reservoir in emergency.

2.6 Initial Filling of Reservoir

The initial filling of the reservoir was carried out during 1972.

2.7 Intake Gate Structure

The Intake gate controls the flow of water of KHEP (3x25MW) and KES (1x50MW) and thereby the KTR (3x1.25MW).

The Intake Gate Structure consists of a gate hoisting structure with maintenance platform, operating platform, winch arrangements, trash rack, electrical installations etc. It is installed with a single vertical lift gate of size 3.3x 4.7m. It is operated by Electrical Winch. It can be operated manually also in case of power failure.

Salient Features of the intake gate are given below:

Gate operating floor level	: 759.756 m
Gate Maintenance floor level	: 759.821 m
Gate sill level	: 731.00 m
MDDL	: 737.62 m
RCC Conduit from Intake to Tunnel	: 38m long, 3.05m dia.
Tunnel clear opening	: 4.56 x 2.43 m

Trash rack is provided for the intake, which is located under water all the time. As it is fully embedded in water, usually no damage occurs to the trash rack. However, the condition of the trash rack has to be examined, when any reservoir lowering is done and immediate repair shall be done if any damage is observed.



Fig 2.18 Main panel Board in Intake



Fig 2.19 Manual operation of gate



Fig 2.20 Motor, gear and brake arrangement

Power Tunnel

Power tunnel is having a length of 920 m and is horse shoe shaped with 2.7 m diameter. The driven area of the power tunnel is 9.3 sq. m and the finished area is 6.7 sq. m. The tunnel is driven

at a slope of 1 in 250. The maximum discharge of the tunnel is $14.86 \text{ m}^3/\text{sec}$ at a maximum velocity of $2.2 \text{ m}/\text{sec}$.

Penstock Tunnel

Penstock tunnel is constructed in two sections. The first section is having a length of 554 m with 2.65 m diameter. The second section is 93.6 m long and consists of three tunnels of 1.75 m diameter.

Penstock pipe

Penstock pipe is laid along the surface and is having a length of 2083 m with 2000 mm diameter in higher reaches and 1900 mm diameter in lower reaches.



Fig 2.21 Penstock pipe

2.8 Record Keeping

The records regarding dam and appurtenant structures including detailed drawings and construction details are kept at the field office. Essential documents as per the dam safety guidelines are kept at the dam site office.

Following records of reservoir operations are being maintained:

1. Rainfall record on daily basis throughout the year.
2. Reservoir levels on daily basis during non-monsoon and hourly basis during monsoon.
3. Depth of outflow over the spillway of spillway dam on hourly basis during monsoon.

4. Estimated spillway outflows of spillway dam during monsoon on hourly basis.
5. Power releases.
6. Water audit register to be maintained for estimating the inflows on hourly basis during monsoon and daily basis during non-monsoon by accounting all the releases/outflows and the incremental change in storage in the reservoir.

KSSEB

Chapter 3

Project Inspection

An effective inspection program is essential to identify problems and to keep a dam in a good and healthy condition. Inspection details and suggestions are kept at field office and reports are sent to higher offices. The current practice of Inspection at Kuttiadi dam envisages the Deputy Chief Engineer accompanied by Executive Engineer at site to carryout pre-monsoon and post-monsoon inspections as per CWC guidelines in the format issued by CWC. The Chief Engineer will review the inspection report and submit to CWC. The Executive Engineer at Site will conduct quarterly inspections and will prepare health reports as per KDSA. The format followed as per CWC is now revised during January 2018 and new guidelines issued vide Doc No. CDSO_GUD_DS_07_ v1.0, CWC 2018 for Safety Inspection of Dams. Now since the health reports are to be uploaded in DHARMA, the inspection reports are prepared in the new format incorporated in DHARMA. Detailed description on project inspections is available in the Guideline for Safety Inspection of dams. However an overview of the various types of inspections to be carried out at Kuttiadi dam is given below. Note that for uploading Inspection Data into DHARMA, the Inspection Instructions & Forms given in the above mentioned Guideline for Safety Inspection of Dams must be used. This Chapter provides guidance on carrying out other inspections.

3.1 Types of inspections

Four types of dam safety inspections are required to be carried out at Kuttiadi Dam. These include, but not limited, to the following:

1. Comprehensive evaluation inspections
2. Scheduled inspections (Pre & Post monsoon inspections & other scheduled inspections)
3. Special (Unscheduled) inspections
4. Informal inspections

The frequency of each type of inspection depends on the condition of the dam and State DSO regulations etc.

Typical inspection elements and the detail of the safety inspections are provided below. More detailed descriptions are given in the “Guideline for Safety Inspection of Dams” (CWC 2018). A comprehensive health checklist for recording the status of each item being inspected and the overall condition of the equipment along with any consequential risks on the health of the dam is also to be maintained.

3.2 Comprehensive Evaluation Inspections

For comprehensive dam safety evaluation for each dam an independent panel of experts known as Dam Safety Review Panel (DSRP) needs to be constituted for determining the condition of the dam and appurtenant works. The panel will undertake evaluation of the dam once in 10 years or on occurrence of any extreme hydrological or seismic event or any unusual condition of the dam or in the reservoir rim. The terms of reference of the comprehensive dam safety evaluation shall include but not be limited to;

- General assessment of hydrologic and hydraulic conditions, review of design flood, flood routing for revised design flood and mitigation measures.
- Review and analysis of available data of dam design including seismic safety, construction, operation maintenance and performance of dam structure and appurtenant works.
- Evaluation of procedures for operation, maintenance and inspection of dam and to suggest improvements / modifications.
- Evaluation of any possible hazardous threat to the dam structure such as dam abutment slope stability failure or slope failures along the reservoir periphery.

A comprehensive evaluation inspection of Kuttiadi dam consists of five major parts:

1. Review of project records (i.e. study of all design / construction records/drawings, history of the dam’s performance, past inspection notes/reports, notes on distress observed/ any rehabilitation measures undertaken earlier, instrumentation data and its interpretation.
2. Inspection of the dam and its appurtenant works.
3. To review the results and reports of additional field investigations & laboratory testing as required.

4. Review of design studies, review of design flood, checking of the adequacy of Spillway capacity, freeboard requirements, dam stability and any special study.
5. Preparation of a detailed report of the inspection.

3.2.1 Details to be provided to DSRP before inspection.

Each component of the project is to be inspected, evaluated and specific problems are to be brought out. Recommendations for necessary remedial measures need to be included in the panel's report. Various project components to be inspected and included in the report are:

Dam

Upstream face

Downstream face

Top of dam

Structural behavior as observed visually and as per evaluation of instrumentation data (any visible cracking deflections etc.)

Seepage assessment.

Condition of natural / excavated slopes in the abutments, both on u/s and d/s of the dam.

Any specific problems / deficiencies

Spillway

Civil structure

Energy Dissipation Arrangements

Spill channel, drop structures etc. if any.

Spillway Gates & Hoists.

Downstream safe carrying capacity of river / channel.

River

River flow path.

Review of Sedimentation of the Reservoir

Assessment of sedimentation and its effect on flood routing, operation / life of reservoir.

Flood Hydrology

- Extent & sufficiency of data available
- Method used for estimating the design flood.
- Design flood review study.
- Flood routing studies with the revised flood.
- Adequacy of free board available

Miscellaneous services / facilities

- Access Roads / Bridges / Culverts
- Elevators
- Standby power arrangements
- Flood forecasting arrangements
- Communication facilities (Telephone, Satellite, Wireless, Mobile etc.)
- Earlier reports of experts / DSRP etc., if any,
- Photographs of dam project showing problem areas.

The report of the latest DSRP inspection conducted at Kuttiyadi Augmentation Scheme is included as **Annexure 4**.

General information and Scope of the Project

General information of the project, Salient features, and issues related to dam, Emergency preparedness, Details of key personnel, Hydrology Original and reviewed, Geology, Special problems if any at site and their treatment, Drawings, Reservoir operation and regulation plan are to be handed over in detail.

Basic data and Issues related to safety of dam

The basic data and salient features are elaborated in Chapter 1.

Problems if any during construction

Special problems and treatments done if any are to be brought to the notice of DSRP.

A major problem encountered during the construction was lack of hard rock in the left bank. As a remedial measure, a new feature, the relief tunnel was introduced for this dam.

Drawings

Drawings of dam and appurtenant structures etc. are available at the field office for reference.

Seismicity

Seismic zone of the scheme area at the time of design was III and the revised seismic zone is also III of the seismic zone map of India. The maximum intensity to be felt at the Dam site has ranged from 5 to 7 on M.M. Scale. The Dam is required to be safe using the appropriate seismic coefficients in the BIS code and as approved by NCSDP. Historical significant earthquake events in the near vicinity are as under.

- Event 1: Date: 12/12/2000, Epicenter: Erattupetta, Magnitude: 5 and
- Event 2: Date: 1/7/2011, Epicenter: Erattupetta, Magnitude: 4.8

Erattupetta is at a distance of about 300 km from Kakkayam dam.

Geological Report

Geological report of the dam site is given in **Annexure 5**.

Dam Incidents and Reservoir fill

Kuttiadi Hydro Electric Project was dedicated to nation on 30.09.1972. The reservoir was fully impounded in 1972.

Field Inspection- Observation & recommendation regarding Remedial Measures

Based on the field inspection, remedial measures recommended by the DSRP are to be undertaken.

3.3 Scheduled Inspections

Scheduled inspections shall consist of Pre-monsoon & Post-monsoon inspection and any other inspections carried out by the State Dam Safety Organization/any Expert panels constituted by the dam owner. These inspections are performed to gather information on the current condition of the dam and its appurtenant works. This information is then used to

establish needed repairs and repair schedules, and to assess the safety and operational adequacy of the dam. Scheduled inspections are also performed to evaluate previous repairs.

The purpose of scheduled inspections is to keep the dam and its appurtenant structures in good operating condition and to maintain a safe structure. As such, these inspections and timely maintenance will minimize long-term costs and will extend the life of the dam. Scheduled inspections are performed more frequently than comprehensive evaluation inspections to detect at an early stage any development that may be detrimental to the dam. These inspections involve assessing operational capability as well as structural stability and detection of any problem and to correct them before the conditions worsen. The field examinations should be made by the personnel assigned responsibility for monitoring the safety of the dam. If the dam or appurtenant works have instrumentation, the individual responsible for monitoring should analyze measurements as they are received and include an evaluation of that data. Dam Inspection Report or an inspection brief should be prepared following the field visit (Dam Inspection Report is recommended).

Scheduled inspections include the following components as a minimum:

- Review of past inspection reports, monitoring data, photographs, maintenance records, or other pertinent data as may be required
- Visual inspection of the dam and its appurtenant works
- Preparation of a report or inspection brief, with relevant documentation and photographs.

The inspection is conducted by the Executive Engineer and Deputy Chief Engineer and the Inspection report is submitted to the higher offices in the prescribed format. The inspection is usually conducted during May (Pre-monsoon) and December (Post Monsoon) every year.

3.3.1 Pre- and Post-Monsoon Checklist and Example of Report Proforma

Detailed checklists are required to ensure the health of the dam and to ensure that it continues to operate in satisfactory and safe condition. The proforma to be used for inspection should be the one enclosed in the Doc. No. CDSO.GUD.DS07 v 1.0, CWC 2018 on the Guide lines for Safety Inspection of Dams (**Annexure 3**).

3.4 Special (Unscheduled) Inspections

Special inspections may need to be performed to resolve specific concerns or conditions at the site on an unscheduled basis. Special inspections are not regularly scheduled activities, but are usually made before or immediately after the dam or appurtenant works have been subjected to unusual events or conditions, such as an unusually high flood or a significant earthquake. These inspections are to be carried out by teams to be constituted by State DSO after an initial assessment based on informal inspection carried out by project personnel reveal dam safety related concerns like cracking in the dam, damages, erosion/ scour, undermining/ piping/ sink holes/ liquefaction or any such undesirable feature. A special inspection may also be performed during an emergency, such as an impending dam breach, to evaluate specific areas or concerns. They are also made when the ongoing surveillance program identifies a condition or a trend that appears to warrant a special evaluation. Special inspections should focus on those dam components that are affected by the unusual event and should include at least three elements:

- 1) Review of available relevant files or data
- 2) Visual inspection of all components of the project and surroundings
- 3) Report preparation covering status of project and recommendations.

More detailed site investigations / studies may be required (such as drilling, surveys, or seepage flow estimates) if the special inspection reveals the need for the same. Photographic documentation is to be included as part of the inspection.

3.5 Informal Inspections

The last type of inspection, an informal inspection, is a continuing effort by on-site personnel (dam owners/operators and maintenance personnel) performed during their routine duties. Informal inspections are critical specially to keep an eye on the proper operation and maintenance of the dam. They consist of frequent observations of the general appearance and functioning of the dam and appurtenant structures.

Operators, maintenance crews, or other staff who are posted at dam site are supposed to conduct informal inspections on regular basis. These people are the “first-line of defence” in assuring safe dam conditions, and it is their responsibility to be familiar with all aspects of the dam. Their vigilance in walking through the dam, checking the operating equipment, and noting changes in conditions may prevent serious mishaps or even dam failures.

Informal inspections are important and are performed at every available opportunity. These inspections may only cover one or two dam components as the occasion presents itself, or they may cover the entire dam and its appurtenant structures. The informal inspections are not as detailed as comprehensive evaluation, scheduled, and special inspections and will only require that a formal report is submitted to the dam owner's project files if a condition is detected that might endanger the dam. Report is to be submitted detailing the condition discovered along with photographs, time, reservoir water level etc.

KSSEB

Chapter 4

Project Maintenance

A good maintenance program is required to protect a dam against deterioration, prolong its life and reduce the chance of failure. Maintenance program for a dam should be developed primarily based on systematic and frequent inspections. Nearly all the components of a dam and its materials are susceptible to damage and deterioration if not well maintained. Moreover, the cost of a proper maintenance is small compared to the costs of major repairs, loss of life property and litigation. If maintenance of a dam is neglected the consequences and costs could be enormous.

4.1 Maintenance Plan

A basic maintenance schedule for the various monitoring components prepared for Kuttiadi Dam based on frequent inspections, priority, and interval is attached as **Annexure 9**. This shows the tasks to be performed and how frequently that is to be inspected/observed and repaired.

4.2 Maintenance Priorities

Maintenance activities need to be prioritized. In order of priority they need to be classified under the heads immediate maintenance & preventive maintenance.

4.2.1 Immediate Maintenance

The following conditions are critical and call for immediate attention & reservoir lowering, if warranted. These conditions may include, but are not limited to:

- The dam is about to be overtopped or being overtopped during high flood.
- A dam showing signs of failure due to aging/cracking, sliding, overturning etc.
- The dam is about to be breached by erosion, slope failure etc.
- The dam showing signs of piping or internal erosion along shear zones, faults etc. indicated by increasingly cloudy seepage or other symptoms.
- The spillway being blocked or with some inoperable gates.
- Evidence of excessive seepage as seen in the dam as seen in the gallery/on downstream face of the dam.

An EAP is to be activated when any of the above conditions are noted.

4.2.2 Preventive Maintenance

This can be further classified as Condition based Maintenance and Routine Maintenance.

4.2.2.1 Condition Based Maintenance

The following maintenance works are to be undertaken as soon as possible after the defective condition is noted. These include but are not limited to:

- Remove all vegetation and bushes by roots from the dam surface and restoring any eroded areas.
- Repair of defective gates, valves, and other hydro-mechanical equipment.
- Repair any concrete / masonry or metal components that have deteriorated.
- Repair any damages on spillway glacis, piers, energy dissipaters, training/divide walls, downstream areas etc.
- Repair of the upstream face of masonry dams, where the pointing of masonry joints is damaged.
- Cleaning of the choked drainage holes in the dam body/ foundations in dams.
- Repair any damages on upstream and downstream areas.
- Controlling any heavy seepage in the foundation/ inspection galleries in Concrete dam from drainage holes.
- Repairs of any cracks/cavities/joints in dams/structures.

However many of these works will require the services of experienced engineers/expert panels.

4.2.2.2 Routine Maintenance

Several tasks should be performed on a continuous basis. These include but are not limited to the following:

- Observation of any springs or seepage areas, comparing quantity and quality (clarity) with earlier observations.

- Monitoring of downstream development which could have an impact on the dam and its hazard category.
- Maintenance of Electrical and Hydro-Mechanic equipment and systems eg. Servicing of spillway gates and hoisting arrangements, scour gates and hoisting arrangements, intake gate and hoisting arrangements, dewatering pumps and standby generator.
- Maintaining proper lighting in dam premises.
- Monitoring of seepage in foundation gallery.
- Monitoring/ cleaning & removal of leached deposits in formed drains in dam body and foundation drainage holes.
- Maintenance of all dam roads & access roads.
- Operation of electrical and mechanical equipment and systems including exercising gates and valves.
- To keep the gate slots clear of silt/debris.
- Maintenance/testing of monitoring equipment (instruments) and safety alarms.
- Testing of security equipment.
- Testing of communication equipment.
- Any other maintenance considered necessary.

4.3 Procedures for Routine Maintenance

4.3.1 Controlling Damage from Vehicular Traffic

Vehicles, except for maintenance, are restricted on the dam top and kept out by fences or barricades. Any damages are repaired as soon as possible. Also vehicles are to be permitted only after security checking at check posts.

4.3.2 Controlling Vegetation

Since it is a masonry gravity dam problem of vegetation is not a major concern. However, tiny vegetation growth are seen on the downstream face of dam. These are removed

periodically.

Removal of vegetation around the dam and premises is done 2 times in a year.

4.3.3 Spillway Radial Gates & Hoisting Equipment

The safe and satisfactory operation of Kuttiadi Dam depends on proper operation of its Gates & Hoisting Equipment. Maintaining spillway gates in working condition is critical for dam safety and is to be assigned the highest priority. If routine inspection of the Hydro- Mechanical Equipment reports the need for maintenance, the work should be completed as soon as possible.

The gates are to be operated through their full range twice annually (before monsoon & after monsoon keeping a gap of at least six months). As operating gates under full reservoir pressure can result in large discharges, exercising of gates should preferably be carried out during dry conditions or lean times of the year.

The aspects to be inspected and maintained periodically for ensuring proper operation of gates in general are given below. The O&M manuals of the gates manufacturer's would however govern the overall maintenance of Gates & Hoists whenever there is any contradiction with the instructions given in the Manual.

- i) The gate slot and bottom platform/sill beam should be cleaned periodically. Scales formed over the embedded parts should be removed. Second-stage concrete should be checked for any development of cracks / leakages and repairs should be attended to immediately.
- ii) The gate leaf should be thoroughly cleaned and repainted as and when necessary according to the procedure or guidelines- indicated in IS: 14177 or as per the recommendations of the paint manufacturer. All drain holes provided in the gate assembly should be cleaned.
- iii) Rubber seals should be smoothened, if required, for proper alignment. All nuts and bolts fixing the seal to the gate should be tightened uniformly to required torques. Seals, if found damaged or found leaking excessively should be adjusted, repaired or replaced as considered necessary.
- iv) The wheel shall be rotated to check their free movement. Gate roller bearings and guide roller bushes should be properly lubricated. Whenever necessary these should be opened for rectifications of defects, cleaning and lubrication and should thereafter be refitted. These may be replaced if repairs are not possible.

- v) Hoisting connection of the gate leaf should be lubricated where necessary and defects if any should be rectified.
- vi) All nuts, bolts, check nuts and cotter pins of the lifting devices should be checked periodically.
- vii) All components should be greased and lubricated.
- viii) Recommended and approved oils and grease only should be used.
- ix) Roller assembly should be adjusted by the eccentricity arrangement to ensure all rollers rest uniformly on the track plates particularly in the closed position of the gate. Where filling valves are provided as part of the gate structure, all the nuts, bolts, check nuts etc. should be tightened.
- x) All welds shall be checked for cracks/ damages. Any weld that might have become defective should be chipped out and redone following the relevant codal provisions. Damaged nuts, bolts, rivets, screws etc. should be replaced without delay. The filling-in valves allow passage of water when it is lifted by lifting beam & crane due to creation of space between stem seat and exit passage liner. The springs and associated components should be checked periodically for damages and replaced if necessary.
- xi) The guide-assemblies, wheel-assemblies and sealing-assemblies shall be cleared off grit, sand or any other foreign material.
- xii) The wheel pin shall be coated with corrosion resistant compound.
- xiii) All nuts and bolts shall be tightened.

The aspects to be inspected and maintained periodically for ensuring proper operation of these gates are as under:

a) Rubber Seals:

- i) Seals shall be inspected for leakages. Locations of excessive leakages shall be recorded for taking remedial measures. Weeping or slight flow in localized area will not require immediate remedial measures. However, measures like tightening of bolts are carried out. Further adjustment is carried out during annual maintenance.

b) Trunnion block assembly and anchorages:

- i) All the nuts and bolts of Trunnion block assembly and its anchorages shall be checked for tightness.
- ii) Check all the welds for soundness and rectify defects.

- iii) Check whether the Yoke girder and thrust block is covered or not. If not, cover it with mild steel plates.
- iv) Cover the trunnion pin with anti- corrosive jelly.
- v) Remove all dirt, grit etc. from trunnion assembly and lubricate trunnion bearings of the gate with suitable water resisting grease as recommended by bearing manufacturers.

c) Gate structures:

- i) Check all the welds for soundness and rectify defects.
- ii) Check welds between arms and horizontal girders as well as between latching bracket and skin plate with the help of magnifying glass for cracks/defects and rectify the defects.
- iii) Clean all drain holes including those in end arms and horizontal girders.
- iv) Check all the nuts and bolts and tighten them. Replace damaged ones.
- v) Check upstream face of skin plate for pitting, scaling and corrosion. Scaling may be filled with weld and grinded. Corroded surface shall be cleaned and painted.

d) Embedded Parts:

- i) All the sill beams and wall plates shall be inspected for crack, pitting etc. and defects shall be rectified.
- ii) The guide roller pins shall be lubricated.

e) General Maintenance:

Defective welding should be chipped out and it should be re-welded duly following the relevant codal provision (IS: 10096, Part-3).

- i) Damaged nuts, bolts, rivets, screws etc. should be replaced.
- ii) Any pitting should be filled up by welding and finished by grinding if necessary.
- iii) The gate leaf, exposed embedded metal parts, hoists and hoist supporting structure etc., should be thoroughly cleaned and repainted when required keeping in view

the original painting system adopted and as per the guidelines contained in IS: 14177.

- iv) Trunnion bearing should be greased as and when required. Keeping trunnion bearings in perfect working condition is very important. All other bolted connections should also be checked up for proper tightness.
- v) Bolts and trunnion bearing housing should be tightened wherever required.
- vi) The seals of the gate should be checked for wear and tear and deterioration. These should be adjusted/replaced as and when necessary.
- vii) The wall plates, sill beams shall be checked and repaired if necessary
- viii) Wire ropes should be properly lubricated.
- ix) Oil level in the worm reduction unit should be maintained by suitable replenishment. Oil seals should also be replaced if required. Lubrication of other parts of hoists such as chains, position indicators and limit switches should also be done.
- x) The stroke of the brake should be reset to compensate for lining wear. Worn out brake linings should be replaced in time.
- xi) Flexible couplings should be adjusted if required.
- xii) Repairs and replacements of all electrical relays and controls should be attended to.
- xiii) Maintenance of alternative sources of Power such as Diesel Generating sets and alternative drives wherever provided should be carried out.

The list of essential spare parts to be kept available should be reviewed and updated periodically. The condition of spares should be checked periodically and protective coating given for use. Ensure availability of essential spare parts at site as per the list of essential spares.

4.3.4 Maintenance of Electrically operated fixed hoists

General Instructions:

- a. Operation of fixed hoist without lifting the gate is not possible and need not therefore be attempted. It will be possible to operate the unit and observe operation of load carrying hoist component when gate is being lifted or lowered.
- b. Never open any bolt or nut on motor, gear boxes, rope drums and other load carrying hoist components when the gate is in raised position. The gate should be fully closed or rested on the gate latches before carrying out any work on hoist components including motor brake and other electrical equipment.

- c. The aspects to be inspected and maintained periodically for ensuring proper operation of Rope drum hoists are as under:
- i. Entrance to all hoist platforms shall be kept locked. All keys shall remain with the shift supervisor.
 - ii. A cursory daily inspection shall be made of hoist and gate to ensure that there is no unusual happening.
 - iii. Clean all hoisting equipment and hoist platform.
 - iv. Check oil level in gearboxes and replenish as and when required with oil of proper grade.
 - v. Apply grease of suitable grade by grease gun.
 - vi. Lubricate all bearings, bushings, pins, linkages etc.
 - vii. Check all the fuses on the power lines.
 - viii. All bolts and nuts on gear boxes, hoist drum and shaft couplings should be checked for tightness.
 - ix. Check the supply voltage.
 - x. Drain sample gear oil from each of the gear boxes. If excessive foreign particles or sludge is found, the gear box shall be drained, flushed and filled with new oil.
 - xi. All the geared couplings shall be greased.
 - xii. Raise and lower the gate by hoist motor and check for smooth, and trouble free operation of gate without excessive vibration.
 - xiii. Observe current drawn by motor at the time of lifting and check if it is more than normal. If so, stop the hoist and investigate the cause and rectify.
 - xiv. Check the condition of painting of various components and remove rust wherever noticed and repaint the portion after proper cleaning as per painting schedule.
 - xv. All trash, sediments and any other foreign material shall be cleared off the lifting rope and lifting attachment.

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- xvi. All ropes shall be checked for wear and tear and if broken wires are noticed, the rope shall be replaced.
 - xvii. All the wire ropes shall be checked and all visible oxidation shall be removed. All wire ropes shall be greased with cardium compound.
 - xviii. Check the overload relays for proper functioning.
 - xix. Check all the nuts, bolts, rivets, welds and structural components for hoisting platform and its supporting structure for wear, tear and damage. All damages shall be rectified. All bolts shall be tightened. The portion with damaged painting shall be touched up.
 - xx. Check the pulleys, sheaves and turn-buckles.
 - xxi. Raise and lower the gate for its full lift several times (at least three to four) and observe the following:
 - a) Check the limit switches and adjust for design limits.
 - b) The effectiveness and slip of the breaks shall be checked by stopping the gate in raising and lowering operations. The brakes shall be adjusted if needed.
 - c) When the gate is operated, there should not be any noise or chatter in the gears.
 - xxii. Adjust the rope tension of wires if unequal. Check for all gears and pinions for uneven wear and adjust for proper contact. Grease the gears.
 - xxiii. Repaint the hoist components, hoisting platform and its supporting structures as per requirement.
 - xxiv. The periodic maintenance of commercial equipment like motors, brakes, thrusts etc. shall be carried out as per manufacturers operation and maintenance manual.

4.3.5 Maintenance of Electrical components of Fixed Rope Drum Hoists:

- a) The Electrical components to be inspected and maintained periodically are as under:
 - i) Starters should be cleaned free of moisture and dust.
 - ii) Each individual contactor should be tried by hand to make sure that it operates freely.

- iii) All wearing parts should be examined in order to take note of any wear which may have occurred during operation.
- iv) If the contactor hums, the contact faces should be cleaned.
- v) Examine all connections to see that no wires are broken and no connections are loose.
- vi) Clean the surface of the moving armature and magnet core which comes together when the contactor closes, free of dust or grease of any kind.
- vii) Examine the mechanical interlocks between the reversing contactor and see when the contact tips of one of the contactor units are touching, it is impossible to get the contact tips of the other unit to touch.
- viii) The contact tips should be kept free from burns or pits by smoothing with fine sand paper or emery paper.
- ix) Replace the contact tips which have worn away half-way.
- x) Do not lubricate the contacts.
- xi) Blow out windings thoroughly by clean and dry air to clear air passage in the stator and the rotor of any accumulated dirt. The air pressure shall not be too high to damage the insulation.
- xiv) Examine earth connections and motor leads.
- xv) Examine motor windings for overheating
- xvi) Examine control equipment
- xvii) Examine starting equipment for burnt contacts
- xviii) Check and tighten all nuts and bolts
- xix) Clean and tighten all terminals and screw connections all contact surfaces shall be made clean and smooth.
- xx) Lubricate the bearings
- xix) Overhaul the controllers
- xx) Inspect and clean circuit breakers
- xxi) Wipe brush holders and check bedding of brushes.

- xxii) Blow out windings thoroughly by clean and dry air. The pressure shall not be so high that insulation may get damaged.
- xxiii) Check the insulation resistance of the motor between any terminal and the frame. If the measured resistance is less than the prescribed value, then steps shall be taken to dry- out the motors either by passing a low voltage current through the windings or by placing the stator and rotor only in a warm dry place for a day or so.

WARNING: The complete motor shall never be put in an oven for drying as that may melt the grease out of bearings.

- xxiv) Coat the windings with an approved high temperature resisting insulation enamel or varnish.
- xxv) Over haul the motor, if required.
- xxvi) Check the switch fuse units and renew, if required.
- xxvii) Check resistance or earth connections.
- xxviii) Check air gap.

b) Solenoid Operated Brakes

- i) All fixing bolts shall be checked and tightened at least once in three months.
- ii) The magnet stroke should be reset to compensate for wear.
- iii) Re-adjust the brake when the magnet stroke reaches the value given on the instruction plate.
- iv) Brake lining should be checked and replaced when required.
- v) Examine all electrical leads and connections.
- vi) Rubber bushes or couplings should be checked and replaced if defective.
- vii) The pins should be tightened.

4.3.6 Electrical System

Electricity is typically used at a dam for lighting and to operate the gates, hoists, recording equipment, and other miscellaneous equipment. It is important that the Electrical system be well

maintained, including a thorough check of fuses and a test of the system to ensure that all parts are properly functioning. The system should be free from moisture and dirt, and wiring should be checked for corrosion and mineral deposits.

All necessary repairs should be carried out immediately and records of the works kept. Maintain generators used for auxiliary emergency power - change the oil, check the batteries and antifreeze and make sure fuel is readily available.

Monitoring devices usually do not need routine maintenance. Open areas are particularly susceptible to vandalism. As such all electrical fittings like bulbs, lights, loose wires etc. in open areas should be checked routinely and replaced/repared where needed. The recommendations of the manufacturer should also be referred to.

4.3.7 Maintenance of Metal Gate Components

All exposed, bare ferrous metal of an outlet installation, whether submerged or exposed to air, will tend to rust. To prevent corrosion, exposed ferrous metals must be either appropriately painted (following the paint manufacturer's directions) or heavily greased in respect of moving parts & on surfaces like guides & track seats on which there is movement of gates. When areas are repainted, it should be ensured that paint is not applied to gate seats, wedges, or stems (where they pass through the stem guides), or on other friction surfaces where paint could cause binding. Heavy grease should be applied on friction surfaces to avoid binding. As rust is especially damaging to contact surfaces, existing rust is to be removed before periodic application of grease.

4.3.8 Access Roads

For a dam to be operated and maintained, there must be a safe means of access to it at all times. Access road surfaces must be maintained to allow safe passage of automobiles and any required equipment for servicing the dam in any weather conditions. Routine observations of any cut and fill slopes along the sides of the road should be made. If unstable conditions develop assistance of experienced Engineers/Expert Panels should be obtained and remedial measures initiated. Drains are required to be provided and maintained along roads to remove surface and subsurface drainage. This will prolong the life of the road and help reduce deterioration from rutting. Road surfacing should be repaired or replaced as necessary to maintain the required traffic loadings. In most cases, specialized contractors will be required to perform this maintenance.

4.3.9 General Cleaning

As already suggested, for proper operation of spillways, sluiceways, approach channels, inlet and outlet structures, stilling basin / energy dissipation arrangements, discharge conduit, dam slopes, trash racks, debris control devices etc., regular and thorough cleaning and removal of debris is necessary. Cleaning is especially important after large floods, which tend to send more debris into the reservoir. The dam top road and the gallery are to be cleaned regularly.

4.4 Materials and Establishment Requirements during Monsoon

Materials required during monsoon period for both immediate maintenance and preventive maintenance must be stocked in adequate quantities for emergency situations that may arise. At Dam, round the clock patrol is to be carried out during monsoon period. At the same time the man power requirements during monsoon period are to be enhanced. An Organisation Structure of the Control Unit is given in Chapter 1.

Materials normally required to be stocked in sufficient quantity are:-

- Gunny Bags
- Sand
- Boulders/Wire crates
- Bamboos/Balli's
- Baskets
- Ropes
- Petromax Lamps with Spares
- Torches with spare cells
- Kerosene Oil
- Match Boxes
- Rain Coats
- Gum Boots
- Warning sign indicator
- Danger zone lights

4.5 Preparation of O&M budget

The O&M budget for the Dam should essentially include but not be limited to the following items:

- i) Establishment Cost of Regular Staff – Salaries and allowances, Bonus, Medical Reimbursement, LTC, Leave Encashment, Pension benefits etc.
(As applicable)
- ii) Establishment Cost of Work charged – Salaries and allowances, Bonus, Medical Reimbursement, LTC, Leave Encashment, Pension benefits, TA and DA etc. (As applicable)
- iii) Establishment Cost of Daily Wage Staff – Salaries and allowances, TA and DA etc. (As applicable)
- iv) Office Expenses – Rent for Office, Telephone/Mobile/ any other Telecommunication bills, Electricity bills, Water bills, Office stationaries Day to day office requirements
- v) Motor Vehicles - Running and Maintenance cost of inspection vehicles, Cost of hiring of vehicles as required
- vi) Maintenance of Colony - Maintenance of staff quarters, colony roads, Electricity, Sanitary and Water supply systems etc.
- vii) T&P - The T&P requirements for offices, colony, works etc. as applicable
- viii) Works - Painting, oiling, greasing, overhauling of HM equipment's, Repair/ replacement of gates seals & wire ropes, POL for pumps & generator sets, Electricity charges and maintenance of Electric systems of dam site, specific requirements for all Civil, H.M & Electrical maintenance works, Vegetation removal, maintenance/cleaning of drains in dam, maintenance of lift/elevators in dam (as applicable), maintenance of access roads & basic facilities, provision for flood contingency works during monsoon, unforeseen events/items (about 10% of the cost of works) etc.

SL. NO.	BUDGET ITEM	PREVIOUS YEAR COST (Rs)	CURRENT YEAR BUDGET (YR _____) (Rs)	REMARKS
A. ESTABLISHMENT				
1	SALARY OF REGULAR STAFF INCLUDING ALL OTHER BENEFITS			
2	TRAVEL EXPENSES			
3	OFFICE EXPENSES			
4	MOTOR VEHICLE EXPENSES			
5	MAINTENANCE OF OFFICE & COLONY COMPLEX			
	SUB-TOTAL - A			

B. WORKS				
1	CIVIL			
1.1	CONCRETE / MASONRY DAM			
1.2	EARTHEN DAM			
1.3	INTAKE / OUTLETS IN EARTHEN DAMS			
1.4	SLUICES IN CONCRETE / MASONRY DAMS			
1.5	APPROACH / INSPECTION ROADS WITHIN DAM AREA			
2	HYDRO-MECHANICAL			
2.1	SPILLWAY GATES & HOISTS			
2.2	SPILLWAY STOP-LOG & GANTRY CRANE			
2.3	OUTLETS IN EARTHEN DAMS - SERVICE / EMERGENCY GATES & HOISTS			
2.4	SLUICES IN CONCRETE / MASONRY DAMS – SERVICE / EMERGENCY GATES & HOISTS			
3	ELECTRICAL			
3.1	ELECTRICAL FITTINGS, MOTORS, CONTROLS FOR ALL GATE HOISTS			
3.2	POWER SUPPLY LINES			
3.3	ELECTRICAL FITTINGS ON DAM TOP, DAM GALLERIES, ETC			
3.4	STANDBY POWER / DIESEL GENERATOR			
3.5	REMOTE CONTROL/CCTV			
4	INSTRUMENTATION			
5	MISCELLANEOUS WORKS			
6	SALARY OF WORK- CHARGED STAFF INCLUDING ALL BENEFITS			
7	MATERIALS TO BE STORED BEFORE MONSOON			
	SUB-TOTAL - B			
8	CONTINGENCY (10%) ON SUB-TOTAL OF A & B			
9	TOOLS & PLANTS			
	SUB-TOTAL- C			
10	TOTAL ANNUAL COST			

Table 4.1 O&M Budget Costs (Annual)

4.6 Maintenance Records

Maintenance records are of utmost importance. A record shall be kept for all maintenance activities, both immediate and preventive maintenance works. Information that must be recorded includes, but not limited to, the following:

- Date and time of maintenance
- Weather conditions
- The type of maintenance
- Name of person or contractor performing maintenance
- Description of work performed
- The length of time it took to complete the work with dates
- Equipment and materials used
- Before and after photographs.

The data should be recorded by the person responsible for maintenance.

Chapter 5

Instrumentation and Monitoring

A dam's instrumentation furnishes data for deciding if the structure is functioning as intended and provides continuous monitoring to warn of any unsafe developments or phenomena that can lead to dam failure by drawing information from a wide spectrum of instruments and procedures, ranging from simple to complex. The program must be based on prevailing geotechnical conditions at the dam, and must include consideration of the hydrologic and hydraulic factors present before and after the project is in operation.

The extent and nature of the instrumentation depends not only on the complexity of the dam and the size of the reservoir, but also on the potential for threat to life and property losses downstream. The involvement of personnel with experience in the design, installation, regular monitoring, and evaluation of an instrumentation system is of prime importance to the success of the program.

Instruments installed at a dam can indicate occurrence of any anomalous or problematic behavior. They can show that whether the dam behavior is as per design or otherwise. Actual measurements of uplift pressure in a Gravity dam and comparison with the uplift pressure assumed in original designs is an example.

5.1 Instrument Types and Usage

A wide variety of instruments and procedures are used to monitor dam behavior. The parameters often monitored by instruments include:

- movements (horizontal, vertical, rotational and lateral)
- pore pressure and uplift pressures
- water level
- seepage flow
- water quality
- temperature
- Crack width
- seismic activity
- weather and precipitation data

- stress and strains

The instruments installed in Kuttiadi Dam are appended below.

LIST OF INSTRUMENTS INSTALLED IN KUTTIADI DAM			
Sl. No.	Name of Instruments	Total No. installed Functioning	Location
1	V notch	6	Foundation Gallery

Table 5.1 Instrumentation present status

5.2 Parameters monitored

5.2.1 Uplift Pressure

Installation of pressure gauges are progressing for measuring uplift pressure.

5.2.2 Water Level

Water level gauge is provided at the side wall of intake. In addition to this, a water level scale arrangement is provided near check post, where operating staff are staying during night, for close and immediate monitoring.

The water levels are taken at 7 am and 4.30 pm every day. During monsoon, hourly readings are taken and recorded.

5.2.3 Seepage Flow

Seepage is measured with V notches installed in the foundation gallery. Readings are taken weekly. The discharge table of V notches are enclosed as **Annexure 10**.

5.2.4 Deformation

For deformation measurement, reference points and instrument stations are provided in the dam. Deformation measurements are taken periodically.



Fig 5.1 Location of station for Deformation measurement

5.2.5 Water Quality

Water samples from various points such as upstream of dam, inside gallery, pump pit and downstream pool and any other point as required are collected and tested for assessing the chemical changes if any, among the water samples, especially, between the upstream and downstream water samples. The water test is done every six months.

5.2.6 Seismic Activity

There is no Seismic observatory installed in Kuttiadi Dam site.

5.2.7 Weather Conditions

A rain gauge is installed on the side of saddle dam located near check post at dam site. Rainfall reading is taken daily and recorded in the rainfall register.

5.3 Frequency of Monitoring

Water level is monitored daily and the instruments readings are taken weekly.

5.4 Data Processing and Evaluation

The monthly reports are prepared for evaluation. The steps required to process and evaluate data, whether collected manually or automatically, are the same. Instrument data should be processed and evaluated according to the procedures established by the monitoring program. Accumulation of instrument data by itself does not improve dam safety or protect the public.

Interpretation of data, so collected, needs to be carried out judiciously. Help of experienced personnel from the concerned field from Institutes / manufacturers / instrument suppliers could prove to be useful.

5.4.1 Data Collection

On monthly basis as required.

5.4.2 Data Presentation

On monthly basis.

5.4.3 Data Interpretation

On 6 month / yearly basis as required.

5.4.4 Dam Performance Evaluation

Performance evaluation is conducted for safe normal operation involving all concerned engineers / officers before and after monsoon.

In case, the data deviates from expected behaviour or design assumptions, action should be taken. The action to be taken depends on the nature of the problem, and should be determined on a case-by-case basis.

Seepage assessment

Discharge from body drains and foundation drains provided in foundation gallery and relief tunnel are measured using V-notches installed in the gallery and measurements are recorded and analyzed. There are 23 body drain holes and 23 foundation drain holes in gallery.

The discharge from foundation drain holes and body drain holes are collected in the pump pit located at extreme bottom of foundation gallery and pumped out daily. The collection pit is having a size of 2.44 x 1.53 x 1.20m. The total discharge from drain holes, at FRL level is found about 65 liters/minute. The water accumulation may touch 93 m³/day. Dewatering is done daily.

For dewatering purpose, the pumps installed are:

- One 5HP submersible pump
- One 3 HP submersible pump
- One 10 HP centrifugal pump

These pumps are installed in the foundation gallery and operated from there itself. In addition to it, one 5 HP submersible pump is kept as stand by.

5.5 Methods of Behaviour Prediction

5.5.1 Visual Observations

Observations by on site personnel (dam owners/operators and maintenance personnel) may be the most important and effective means of monitoring the performance of a dam. An inspector should examine visually walking along the dam alignment for any leakages, any distress, wet spots on d/s face of dam, seepage from foundation gallery etc.

5.5.2 Monitoring Results

Analysis and observation of the instrument readings on water level, leakages, uplift and other parameters can ascertain the visually observed behavior. Any deviation from the normal behavior needs to be resolved critically by taking required remedial measures in consultation with senior / experienced engineers.

Seepage measurements of Kuttiadi dam during 2018 and 2019 are tabulated below.

Date	Water level in m	Discharge measured by V notch in lit/min						
		I	II	III	IV	V	VI	Total
29.09.2018	753.13	20.22	2.00	16.28	21.69	2.19	0.52	62.90
15.12.2018	752.34	14.93	1.70	14.32	12.63	9.69	0.07	53.34
04.01.2019	752.31	10.57	0.97	10.85	13.75	2.19	0.07	38.40
05.02.2019	751.97	20.22	2.00	13.40	9.61	2.94	0.39	48.56
29.03.2019	752.58	17.45	2.33	12.51	12.63	4.32	0.28	49.52
13.05.2019	743.99	4.39	0.35	7.29	3.83	2.94	0.07	18.87
30.07.2019	750.05	21.69	1.19	2.88	5.64	3.83	0.52	35.74
17.09.2019	758.01	77.78	9.62	63.64	59.77	34.15	21.65	266.61
17.10.2019	754.81	54.39	4.43	31.38	37.89	14.42	6.04	148.54
28.11.2019	754.99	31.89	3.07	31.38	31.89	16.64	9.69	124.55
08.12.2019	754.93	35.82	4.95	32.91	28.23	15.50	6.04	123.45

Table 5.2 Seepage measurements

Chapter 6

REHABILITATION WORKS UNDER DRIP

Before DRIP, maintenance activities were limited to routine greasing, oiling and patch painting of Hydro- mechanical devices, routine repair of electrical systems, gallery drainage, routine mowing, vegetation removal etc. Apart from these routine maintenance activities, no major rehabilitation was carried out before the involvement of DRIP. Under DRIP, major rehabilitation works have been carried out at a total cost of about Rs. 2,20,80,300.00 (with some activities still on-going during the preparation of this O & M Manual).

The rehabilitation works under DRIP include:

1. Providing wearing coat on the Dam top.

Wearing coat on the Dam top road is made of concrete and no maintenance works were done to dam top road for the past ten years. Hence the top roadway of dam is provided a wearing coat of 1:1.5:3 P.C.C with bituminous sheet insertion at the construction joints to prevent the seepage of water from the top of the dam body.

2. Re-construction of damaged RR masonry retaining walls.

The retaining wall near the right side upstream face portion at the entrance of the dam was severely damaged due to heavy rain and weathering and the end portion of the retaining wall at end of the sluice outlet on downstream of the dam was damaged due to turbulence of water during the spill of the dam. These damaged retaining walls are reconstructed.

3. Maintenance of roads from security check posts to Dam gallery entrance.

The road from main gate to dam entrance, road from dam road to junction near DG shed, road from check post junction to dam toe gallery entrance and road in front of site office were severely damaged due to weathering and heavy rain fall. No repair work had been done for the above roads during the last 15 years. These roads are repaired and made proper.

4. G I sheet roofing work for spillway gate controlling platform.

The spillway gate controlling platform of Kuttiadi dam was not provided with roofing. Practically, gates are required to be operated during heavy rains and the electrical control system of the hoists need to be protected from rains. Hence roofing is provided.

5. Maintenance of steps from dam top to downstream side.

The access steps from dam top road to downstream of dam were in a dilapidated condition due to weathering, heavy rain and movement of wild elephants along the steps. These steps are repaired.

6. Pressure washing and cement pointing to the downstream face.

No maintenance works such as pressure washing, pointing or painting had been done to Kakkayam dam for the past 15 years. Joints were in deteriorated condition and the downstream face was infested with dry fungus and vegetation growth. Hence pressure washing and pointing are carried out on the downstream face of the dam.

7. Painting of parapet, intake structure, sluice and other connected structures.

Due to weathering, the dam top parapets, intake and sluice chamber buildings, motor covering G.I. plates etc. were in a shabby condition and some portion of the G.I parts showed symptoms of corrosion. Hence painting is carried out on all the allied structures of the dam including steel items inside the chambers.

8. Reaming the existing drain holes.

The Dam was constructed long back and most of the body drain holes were choked due to calcination causing blocking of drain water through the holes. In order to make the drain holes functional for the free flow of seepage water, it is necessary to ream and clean the drain holes periodically. The experts who visited the dam had suggested reaming of drain holes and this has been arranged as part of DRIP works and completed. The work consisted of erecting drill at the hole site in body drains and foundation drains in gallery and relief tunnel and reaming the formed drain holes with Ax, Bx/Nx bit.

9. Renovation of Office building.

The Dam Safety field office building located at Kakkayam dam site was constructed about 50 years back, during the construction period of Kuttiadi Hydro Electric project. The roof, ceiling, partition walls, doors, windows, toilets, electrification etc. were damaged. Hence the building is renovated and the work consisted of providing new aluminium sheet roof over steel roof truss, flooring with vitrified tiles, replacing damaged doors and windows, water supply and sanitary works, electrical works etc.

10. Construction of security cabin and gate at the entrance of Kakkayam Reservoir (at the end of PWD Kakkayam dam road)

Since the Kakkayam reservoir is near to Wayanad forest, the vigilance and police department have given instructions to take more care for the security of the dam in the light of threat from Maoists. Moreover, the Hydel Tourism wing of KSEB Ltd. and Vana Samrakshana Samithi of Forest Department have started tourism activities in this area. As part of these activities, a lot of people visit the dam site. For proper protection, entry of men and vehicle is to be controlled. Hence a security cabin and gate are constructed at the entrance of KSEB land where dam and its allied components such as tunnel, intake structure etc. are located.

11. Supply and installation of High mast light.

The upstream end of Kakkayam reservoir is very adjacent to Wayanad forest and the area is under the threat of Maoist activities. Considering this security threat, armed police personnel are deployed for round the clock security of the dam. As part of enhanced security measures, for effective vision of the dam premises during night, high mast lights are installed at three places (one each at both ends of dam & one at check post area).

12. Supply, erection and commissioning of 25 KVA DG set.

Electricity supply failure happens frequently at Kuttiadi dam site. Alternate power supply arrangements are necessary, especially during heavy rains to operate the spillway gates. Hence a 25 KVA DG set is procured for Kuttiadi dam.



Fig 6.1 Dam top road before providing wearing coat



Fig 6.2 Dam top road after providing wearing coat



Fig 6.3 G I sheet roofing for spillway gate controlling platform



Fig 6.4 G I sheet roofing for spillway gate controlling platform



Fig 6.5 Downstream face of dam before pressure washing



Fig 6.6 Downstream face of dam after pressure washing and pointing



Fig 6.7 Dam and connected structures before painting



Fig 6.8 Dam and connected structures after painting



Fig 6.9 Security cabin constructed

Other non-structural measures under DRIP include preparation of inundation maps and Emergency Action Plan (EAP), review of design floods, preparation of O & M Manual, data entry to DHARMA etc.

Chapter 7

Updating the Manual

Whenever features of the dam and appurtenant structures change, the O&M Manual must be edited and portions rewritten to reflect these changes. This task is often ignored. Updating information in the O&M Manual should be done whenever major changes like construction of an additional spillway, construction of dam on the upstream etc. take place.

Aspects to be considered when updating include: Increase/decrease in the frequency of an inspection or the maintenance routine based on additional data/ experience acquired, Changes in the operation and/or maintenance procedures based on additional data/experience acquired, Alterations to the project data because of changes/modifications in the dam by way of additional spillway etc.

It is recommended that the O&M Manuals may be reviewed/updated after every 10 years by the respective Dam Owners.