Operation and Maintenance Manual for MADUPETTY DAM State of Kerala

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MADUPETTY DAM
KSEBL_15_v1.0

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

सत्यमेव जयते

Operation and Maintenance Manual for Madupetty Dam

Prepared by the Dam Safety Organisation
Kerala State Electricity Board Ltd

(A Government of Kerala undertaking)
State of Kerala

Front Cover Photographs: Upstream and downstream views of Madupetty dam.

Government of Kerala

Operation and Maintenance Manual

Madupetty Dam

KSEB

Prepared	Approved
Sd/-	Sd/-
Deputy Chief Engineer (Civil) **Dam Safety & DRIP**	**Chief Engineer (Civil)** **Dam Safety & DRIP**

Kerala State Electricity Board Ltd
Pallom, Kottayam.

May 2020

Kerala State Electricity Board Ltd
Dam Safety Organisation

Disclaimer

This Operation and Maintenance Manual for Madupetty 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 dams and appurtenant structures.

The manual was developed for the purpose of organising and managing the operation, inspection and maintenance of the dams for reducing risk and optimizing performance of the dams 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,
Director Generation (Civil),
KSEBLtd
Kerala

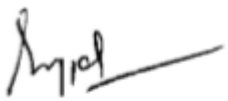
Foreword

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.



Smt. Supriya S,
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Kerala State Electricity Board Ltd,
Pallom, Kottayam

PREFACE

Operation and Maintenance Manual is a detailed document containing procedures and protocols for ensuring that a Dam is operated and maintained properly and timely to avoid further health deterioration and to extend the 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.

Madupetty 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.

Team Involved in preparing this O & M Manual of Madupetty dam

Review and Approval

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GENERAL INFORMATION

1.1 Introduction

Pallivasal Hydro Electric Project is the first Hydro Electric project of Kerala with installed capacity 37.5 MW. The project is located in Idukki District and is near to Munnar. The Project comprises of Kundala Dam, Madupetty Dam & R A Head Works constructed on Mudirappuzha stream, a tributary of River Periyar. These are cascading structures with Kundala at the upstream and R A Head Works at downstream. The Madupetty Dam is located at about 15 km upstream of R. A. Head works and Kundala Dam is further upstream and is about 12 km from Madupetty Dam. The water stored in Kundala reservoir is released to the downstream Madupetty reservoir through the river when water level in Madupetty reservoir lowers. The water stored in the Madupetty reservoir plus the water released from Kundala is further released to downstream through a Dam Toe Power Station having a capacity of 2MW. The controlled release from Madupetty Dam reaches R A Head Works, a gated diversion structure, constructed downstream of Madupetty and from there, the water is diverted through a water conducting system to the 37.5MW Power house of Pallivasal HEP located on the right bank of Mudirapuzha river. After generating power, the tail water is pumped to the balancing reservoir of Sengulam Hydro Electric Project and the surplus water from the sump of pumping station is spilled to the Mudirapuzha river itself.

1.2 Purpose, Location & Description of Madupetty Dam

Madupetty dam is constructed about 12 km downstream of Kundala Dam. It is a concrete gravity dam. This reservoir stores the water from the catchment downstream of Kundala dam. It also routes the releases from Kundala dam to R A Head works from where it is diverted to Pallivasal Power Station. This dam was constructed in 1956 and is intended to store water for power generation.

Fig 1.1 Madupetty Dam – Upstream view

Fig 1.2 Madupetty Dam – Downstream view

Location Sketch

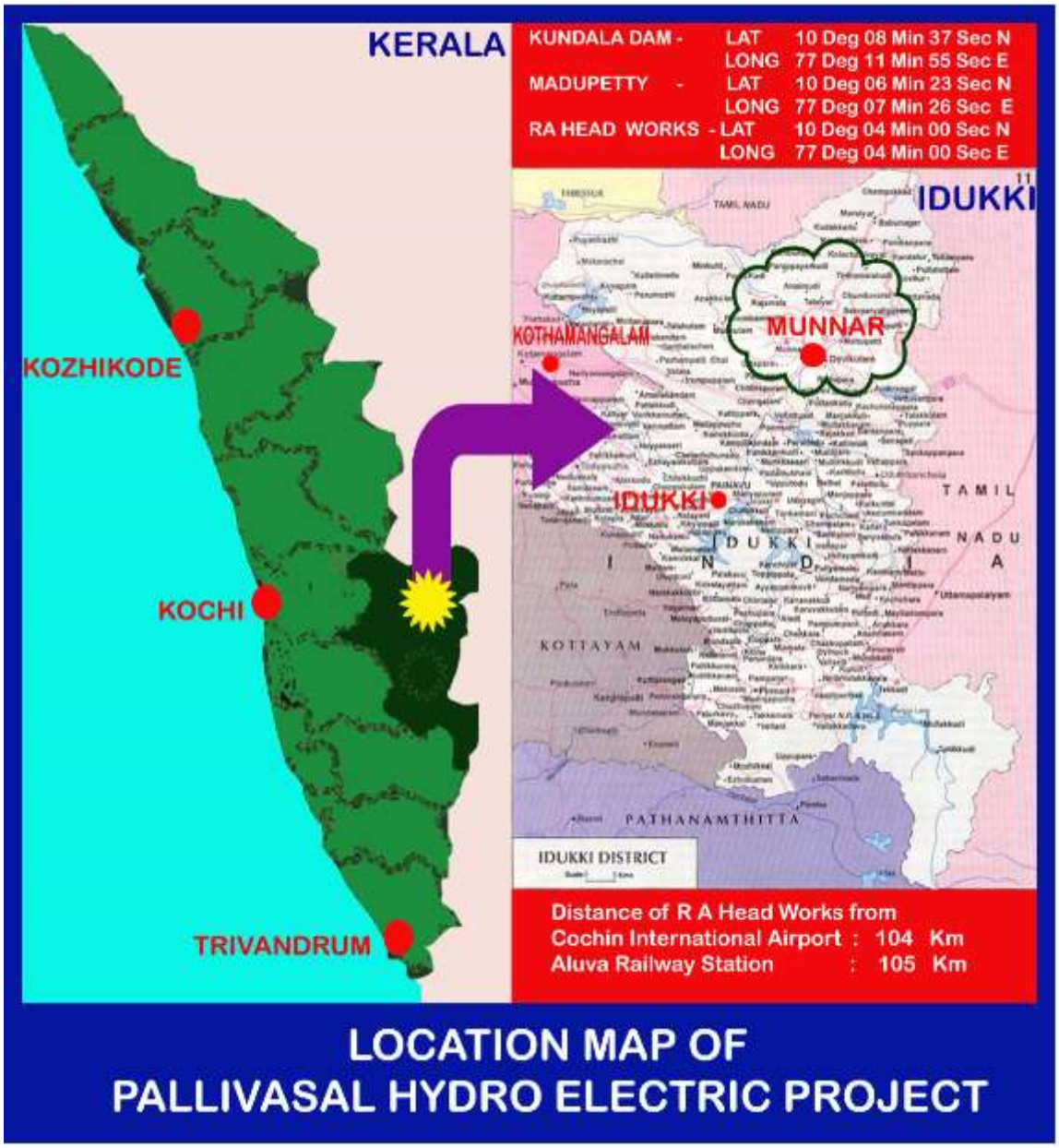

Fig 1.3 Location Map

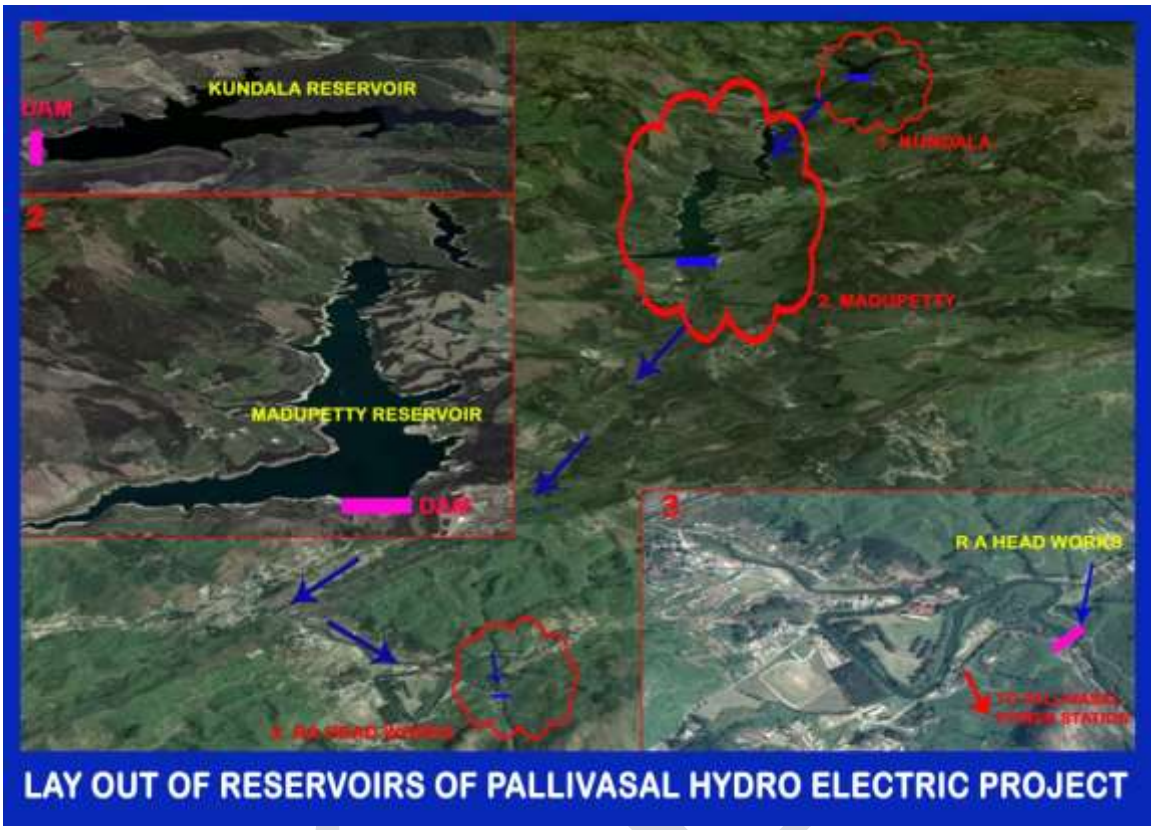

Fig 1.4 Layout of Pallivasal Hydro Electric Project

Fig 1.5 Madupetty dam – View from Google Earth

Fig 1.6 Pallivasal Power House – View from Google Earth

1.3 Background Details of the Project

The Pallivasal Hydro Electric Project utilises the flow of Mudirapuzha river for development of power. A head-works at Munnar diverts water to a tunnel about 3048 m in

length and the tunnel passes through the Nagamalai range of hills and delivers the water to the pipe lines running from the hills to Pallivasal power house, 609.60 m below. The first stage of the project utilised only the run of the river of 238.28 sq. km catchment, above the Munnar weir and generated only 9000 KW utilising a flow of 1.19cumec though the generating capacity of the station was 13500 KW. The first stage of the project was commissioned in 1940.

However, since the inauguration of the power generating system, the demand for power rose very steeply throughout the State, and attention was bestowed on the second stage of the Pallivasal Development viz. to regulate the run-off in the catchment by creating storage reservoirs. Various alternative storage sites were examined in the streams above Munnar head-works. The deltaic region above the Munnar head-works was found to be unsuitable for ideal reservoirs and the possible dam sites were extremely unsatisfactory owing to deep weathering and disintegration. Two possible sites for dams and reservoirs were chosen eventually, one at Kundala and other at Madupetty, both being on the upper reaches of the Palar river, a tributary of Mudirapuzha. The Kundala dam site was comparatively better, but the storage was poor compared to the Madupetty reservoir. Hence it was decided to construct a small dam across the Kundala gorge and a major dam at the Madupetty gorge.

Preliminary investigations of Madupetty dam site was started in 1941.

1.4 Salient Features of the Dam

General		
1	Location	River : Palar River basin : Periyar Sub River basin : Mudirapuzha District : Idukki Panchayat : Devikulam Latitude : 10° 06'23" N Longitude : 77°07'26"E
2	Means of Access	The nearest Railway station is Aluva. Nearest Air Port is Cochin International Airport, Nedumbassery, Kochi. Nearest City is Kochi.
Geophysical Features		
1	Catchment area at dam site (Free)	60.50 sq. km
2	Mean annual precipitation	2000 mm

3	Geological features at dam site	Rock type granite gneiss and charnockite gneiss
Technical Details of reservoir		
1	Gross Storage Capacity	55.23 Mm^3
2	Live Storage	54.77Mm^3
3	Dead Storage	0.46 Mm^3
4	Minimum Draw Down Level (MDDL)	+1568 m
5	Full Reservoir Level (FRL)	+1599.59 m
6	Maximum Water Level (MWL)	+1599.59 m
7	Reservoir spread area at FRL	3.24 Sq. km
Dam		
1	Type	Concrete
2	Deepest Foundation Level	+1514.85 m
3	Nominal Bed Level	+1553.87 m
4	Crest level	+1594.71 m
5	Top Level of Dam	+1600.20 m
6	Length of dam at top	237.74m
7	Height above bed level	46.33m
8	Height above deepest foundation	85.35m
9	Width of Dam at top	6 m
10	Maximum Width of Dam at bottom	42.36m
11	Type of spillway	Ogee
12	No. of Bays	3
13	Type & size of gates	Radial gates, 6.70 m (W) X 4.95 m (H)
14	Gate Hoisting Arrangement	Rope - Drum type
15	Spillway capacity	453 m3/s
16	Energy Dissipation arrangement	Hydraulic Jump type stilling basin
Outlet		
1	No. and Size	1 No. 1.22m dia.
2	Outlet Sill level	+1554.50m
3	Size of emergency gate	3.2m x 2.5m
4	Type of Hoist	Screw operated
Intake Gate for Dam Toe Power House		
1	Size of Intake gate	2.44m x 2.34m
2	Sill level of Intake gate	+1565.24m
3	Hoisting Arrangement	Rope - Drum type

Table 1.1 Salient Features of Madupetty Dam

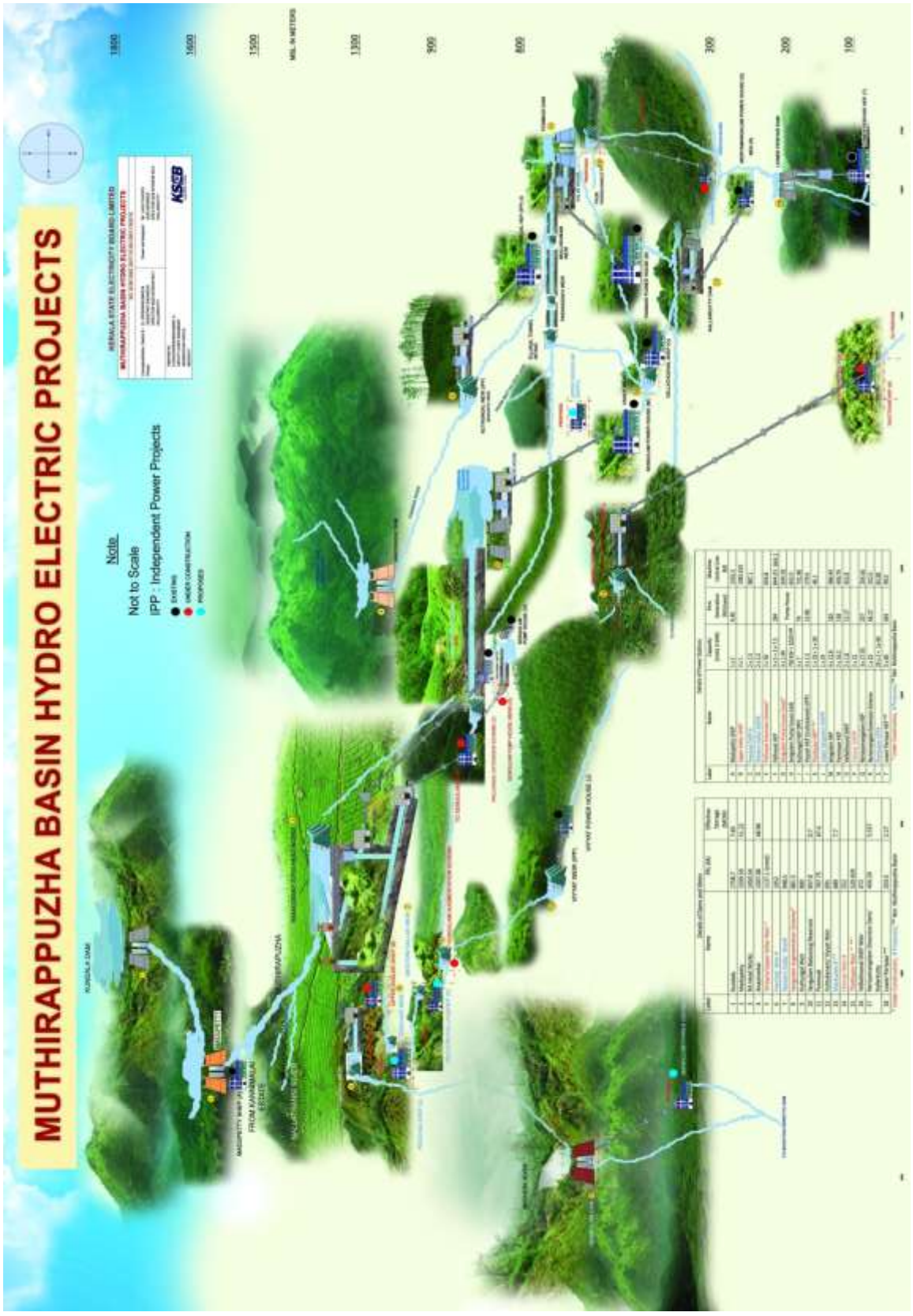

Fig 1.7 Schematic Diagram

1.5 Assignment of Responsibility

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 the staff personnel are required to perform. The same are 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).
3	Authority of operation of Spillway 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 / Operation Officer at dam site	Executive Engineer, Research & Dam Safety Division No. IV, Pambla.
6	Dam Health Engineer and for Reservoir Operations, inspection & maintenance	Executive Engineer, Research & Dam Safety Division No. IV, Pambla.
7	Dam Maintenance Engineer. Recording reservoir data, inspection, monitoring and maintenance at site	Assistant Executive Engineer, Dam Safety Sub Division, Kallarkutty
8	Handling Dam operations, inspection, monitoring and performing duties as Maintenance Officer at dam	Assistant Engineer, Dam Safety Section, Munnar

Table 1.2 – Overall Responsibilities for Madupetty Dam.

1.5.1 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 and record the seepages and to immediately bring to the notice of the EE/ Dy CE /CE in case of excessive seepage/leakage
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, bellies 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, its appurtenants & embankment, 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 Pallivasal Power House 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 1.3 – Roles & Responsibilities of AEE & AE

1.5.2 Roles and Responsibilities of the DyCE 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 for the smooth operation. 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 and to immediately bring to the notice of the CE in case of excessive seepage, leakage
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 dam, approach roads are well maintained by housekeeping personnel
11	Observe the performance of the Dam and its appurtenant structures / Gates and Hoists during flood water releases and to report to the CE in case of any untoward incidents or malfunctioning of the gates or excessive seepages, leakages etc.

Table 1.4 – Roles & Responsibilities of Dy. CE& EE

1.5.3 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 DyCE/EE
5	Coordinate with the Generation wing of KSEBL regarding the power generation requirement.
6	To review and submit the report of Pre and Post Monsoon inspections of the Dam to State Dam Safety Organization with a copy to CWC.

Table 1.5 – Roles & Responsibilities of the Chief Engineer

1.6 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.
- Hydropower releases.
- Weather related data
- Instrumentation data
- Water quality

Sl. No.	Parameter	Frequency of measurement
1	Reservoir water surface elevation	Hourly during monsoon Daily during non-monsoon
2	Reservoir inflow	Hourly during monsoon Daily during non-monsoon
3	Spillway outflow	Hourly during spill
4	River releases	Hourly during monsoon Daily during non-monsoon
5	Hydropower releases	Hourly during monsoon Daily during non-monsoon
6	Weather related data	Daily basis normally During heavy rains at required intervals

Day is defined as from 7 hrs. of the morning of one day to 7 hrs. of morning of the next day.

MWL (m)	FRL (m)	Crest Level (m)	Present Water Level (m)	Previous Year Water Level (m)	Storage (Mm3)	Rainfall (mm)	Generation (Mu)	Spill (Mm^3)	Gate Operation Details

Table 1.6 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 1.6** 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 1.7.**

Date	Water Level (m)	Previous Year Same day Water Level (m)	Rainfall (mm)	Previous Year Rainfall (mm)	Storage (Mm^3)	Gross Inflow (Mm^3)	Release of water to R A Head works (Mm^3)	Spill (Mm^3)	Net Inflow (Mm^3)	Remarks

Table 1.7 Daily Reservoir Status

Records/Logbooks of the operations of the following activities at Madupetty Dam are maintained in a chronological manner for reference. These records are also 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.
- 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 during non-monsoon and hourly during monsoon

Reservoir inflow:	This is calculated daily during non-monsoon and hourly during monsoon
Spillway outflow:	This is calculated during spill
Hydropower releases:	The reservoir water is used for power generation
Weather related data:	Collected and reported daily during non-monsoon and during heavy rains at required intervals
Security arrangements:	Provided in dam and premises round the Clock. CCTV surveillance will be provided soon covering the dam and premises.
Water quality:	The quality of water including pH value is to be tested.
Attendance statement during normal operations	Both during monsoon and non-monsoon period maintained at field office
Operations of the spillway gates and outlet works	Take record of actual operations
Operating hours of mechanical equipments	Maintained at field office
Testing/Operation of spillway gates and associated controls	The testing and operation are being carried out as per the manual and maintenance schedule. Other details are maintained at field office
Testing/operation of Outlet gates, valves and associated controls	Maintained at field office
Maintenance activities carried out	Details maintained at field office
Reservoir and dam inspections	Periodically inspected and details maintained at field office
Unusual conditions or occurrences, including acts of vandalism	Details maintained at field office
Attendance statement at dam during emergency operations	Details maintained at field office
Changes to normal operating procedure	Details maintained at field office

Communication network checks:	Regularly checked and maintained
Safety and special instructions:	Safety equipment provided
Names and addresses of official visitors:	Record of inspections maintained at office.

1.7 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

Madupetty dam is about 11km from Munnar. The dam is accessible from Munnar – Top Station highway. The nearest Railway station is Aluva which is at a distance of 118.50km and can be reached via NH85.Nearest Air Port is Cochin International Airport, Nedumbassery which is at a distance of 117km and can be reached via NH85.Nearest City is Kochi which is at a distance of 138km via NH85. .

Location of public utilities / conveniences

Inspection Bungalow is located at Munnar, about 11km from Madupetty dam. Police station is located at Devikulam, 5km away from the dam. A Primary Health Care Centre is located at Devikulam, 18 km away from dam and can be reached via Munnar – Top Station highway.

Safety equipment available at the dam : First aid kit and fire extinguishers are available.

1.8 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. Restricted areas will include the following:

- Spillway approach areas, chutes, energy dissipation arrangements, Power Intake area, trash rack area, spillway & Intake gates and hoists etc.

Sign boards are displayed at the prohibited areas of the dam.

1.8.1 Details of the Security arrangements at Madupetty Dam Site

Security arrangements are provided through private agency (Ex – Servicemen) in dam and premises round the clock. One security personnel per shift is posted in 3 shifts. Also CCTV surveillance will be provided soon covering the dam and premises.

1.9 Staff Position, Communication & Warning System

An engineering organizational chart for the control and safety of Madupetty dam is shown in **Figure 1.8** 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.

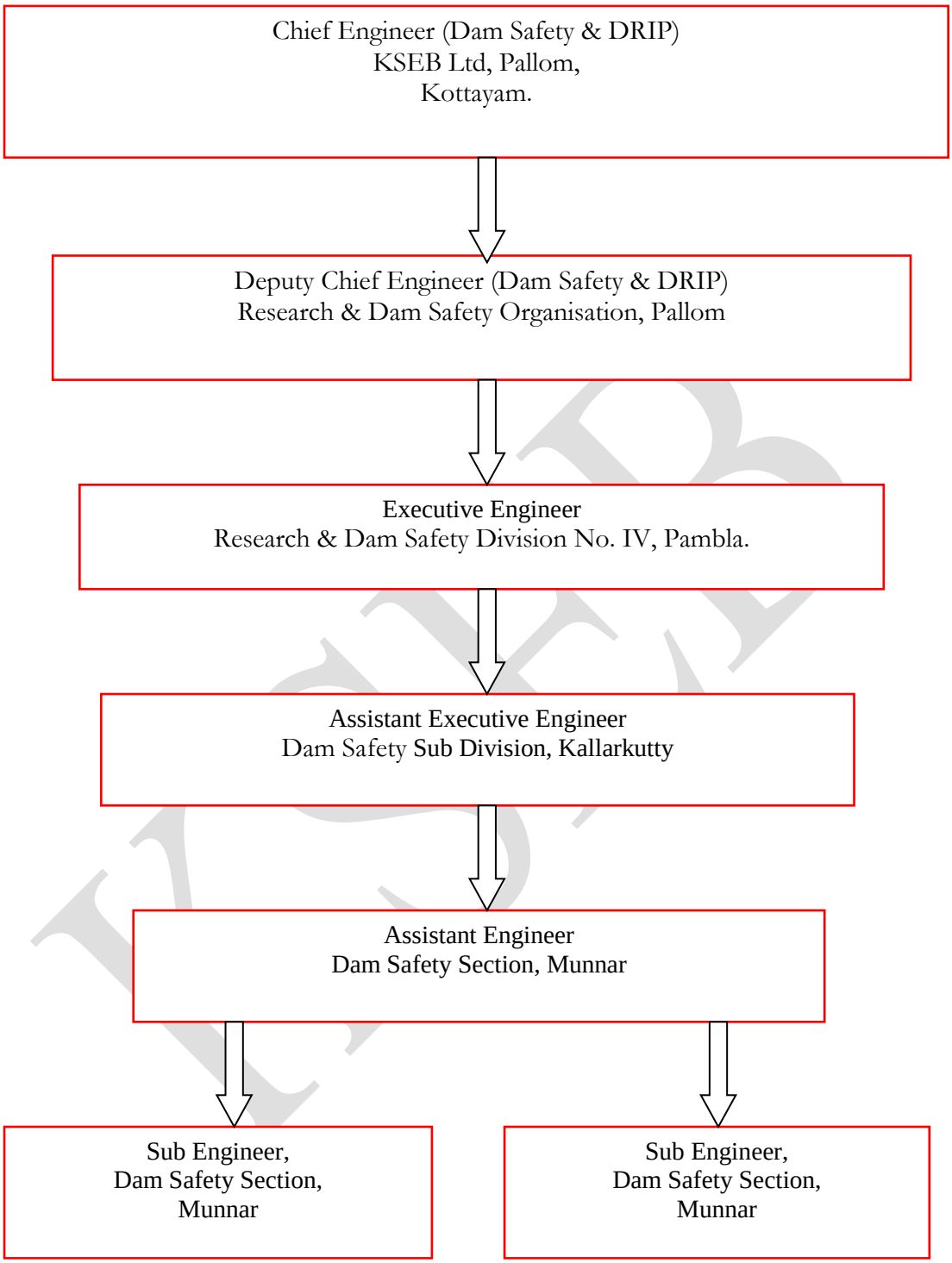

Fig 1.8 – Dam Safety Organisation Structure for Madupetty Dam

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. IV, Pambla	9446008421	eerdspambla@gmail.com
Assistant Executive Engineer, Dam Safety Sub Division, Kallarkutty	9496011963	aeedskty@gmail.com
Assistant Engineer, Dam Safety Section, Munnar	9496011964	

Spillway flood releases

As per the guidelines issued by the Central Water Commission for developing Emergency Action Plan for Dams issued in February, 2016 (Doc. No. CDSO_GUD_DS_01_v2.0), a three colour alert system (Blue, Orange and Red) shall be issued by the dam owner on detecting a distress in the dam according to the nature of the emergency level, to the various statutory authorities in charge of District Administration, Disaster Management etc. in order to take appropriate action to reduce the risk to lives and property from the consequences of potential dam failures. The above guidelines also envisage using the alerts in the case of a large controlled release from the dam due to severe weather and emergency conditions.

The first warning (Blue Alert) is given as water level reaches +1596m. The second warning (Orange Alert) as water level reaches +1597m and third warning (Red Alert) as water level reaches +1598m 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 +1599.59m level. Also, intimations are given to Disaster Management, District

Administration, and Police Department etc. Spillway gates are to be normally opened as per the rule curve attached in Chapter 2.

The Alert level is fixed considering the normal rainfall intensity and for general guidance. 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, Idukki for spilling the water. Release from the dam will be contained in the river course and no evacuation is required in normal course.

Release for hydropower

The water stored in the Madupetty reservoir plus the water released from Kundala is released to downstream through a Dam Toe Power Station having a capacity of 2 MW. R A Head Works, a gated diversion structure, constructed downstream of Madupetty dam enables to divert the water released from the upstream reservoir as well as the inflow from own catchment to Pallivasal Power Station with installed capacity 37.5MW for generating power.

The outlet in the dam is provided with an emergency gate. A Howell - Bunger (HB) valve is provided for the outlet and emergency gate at the upstream side. The valve is manually operated and is located close to the dam toe Power house. Normally release of water from the dam to RA Head works for power generation at Pallivasal Power House is done by operating the dam toe power house, as Madupetty dam is the only source, after the inflow from the own catchment of Head works subsides. However, when the dam toe power house is not operational, the water requirement of Pallivasal Power House is met by opening the HB valve and the upstream emergency gate for release of water to the R A Head Works. The HB valve is also used for depleting the reservoir.

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 are supplied 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, sluice gate as part of routine maintenance before the onset of monsoon. Details are given under the Chapter, Project Maintenance.

1.10 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 1.8.**

Sl. No.	Component/ Duty	Frequency	Personnel
1	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	Daily	Sub Engineer/Dam operators on contract
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	Fort nightly	Assistant Executive Engineer

	foundation and abutments, Spillway and its energy dissipation arrangements		
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 dissipation arrangements	Monthly	Executive Engineer
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, 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	Quarterly	Executive Engineer

	inside of motor control cabinet.		
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 Pre and Post Monsoon Inspection report to State DSO, CWC and uploading into DHARMA.	Half yearly	Chief Engineer/Deputy Chief Engineer
23	Comprehensive inspections of Dam Safety Authority of KSEB.	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).	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 by DSRP.	Ten Yearly	DSRP
26	Review O&M Manual and EAP and update as necessary	Ten Yearly	Executive Engineer

Table 1.8 Schedule of duties/inspections

1.11 Hydro-Mechanical Inspections / Checks

Special duties required to be performed by H-M operating personnel are given in this section. Frequency of inspections / checks for hydro-mechanical components and necessary actions to be taken up during maintenance are as under:

1. Gates

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

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	Quarterly

	and rectify the defects	
4	Clean all drain holes 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 &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 1.9 Frequency of inspection of Hydro Mechanical components

1.12 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

- Gate Manufacturer's instructions and drawings
- Regional communication directory
- Instrumentation reports / results
- Latest dam design flood review and flood routing study report
- All drawings of dam (Civil, Mechanical & Electrical)

1.13 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, Vydyuthi 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, Dam Safety Division No. IV, Pambla	1
5	Assistant Executive Engineer, Dam Safety Sub Division, Kallarkutty	1
6	Assistant Engineer, Dam Safety Section, Munnar	1
7	Officer at dam site	1

Table 1.10 Distribution of O & M Manual and revisions

CHAPTER 2

PROJECT OPERATION

2.1 Basic Data

The Madupetty operation plan contains instructions for operating the dam and reservoir during routine (normal) and emergency conditions. The operating procedures for normal operations are discussed in this chapter including operating criteria for the reservoir, spillway and outlets. The operation of a dam involves regulation of its reservoir as per rule curve/ project specific requirements.

2.1.1 Elevation Capacity curve

The Elevation - Capacity Curve for Madupetty Reservoir in tabular and graphical form are shown in **Fig. 2.1** and **Table 2.1**.

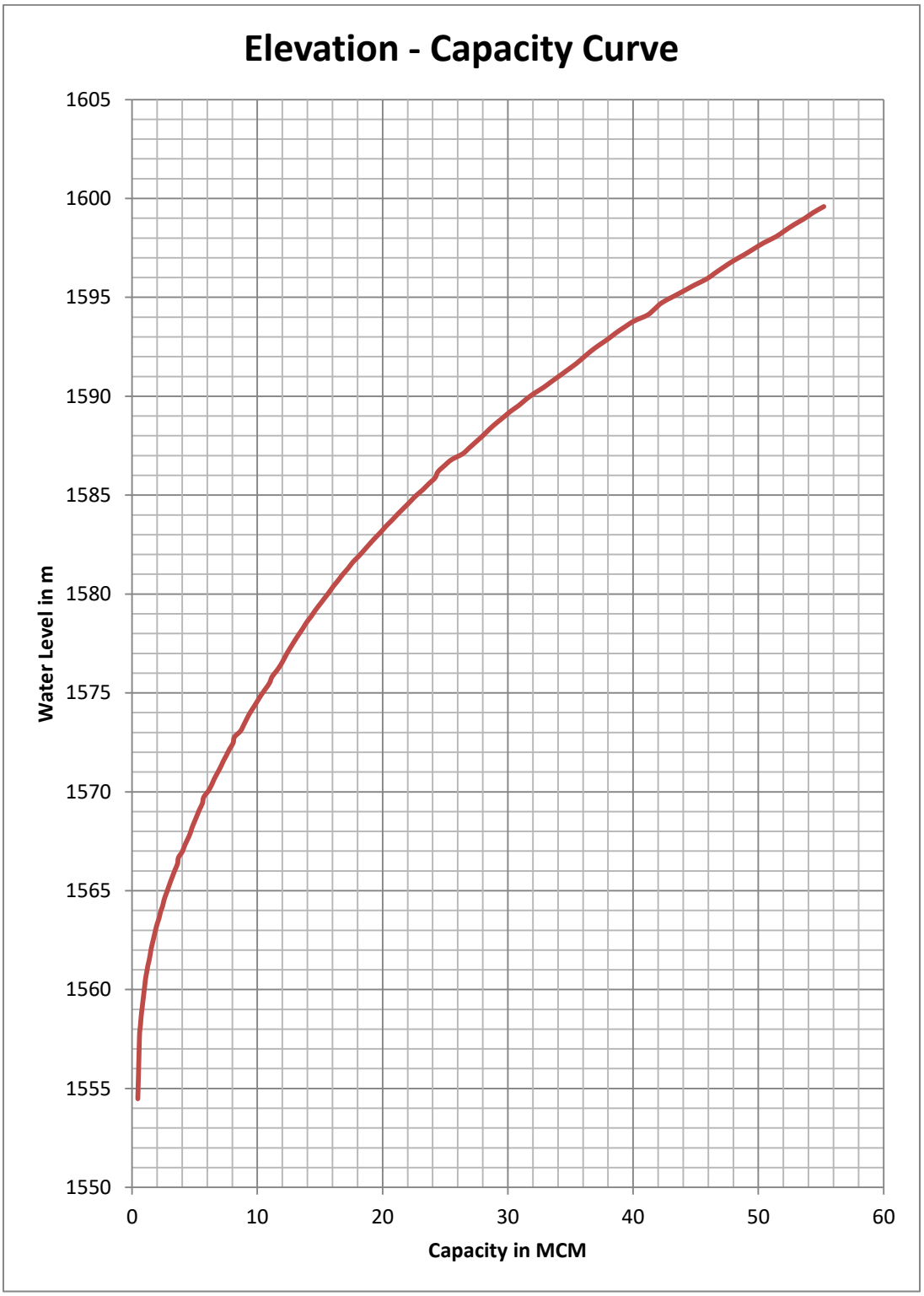

Fig 2.1 Elevation capacity curve for Madupetty reservoir

ELEVATION - CAPACITY OF MADUPETTY RESERVOIR					
Water level in m	**Gross Storage in MCM**	**Water level in m**	**Gross Storage in MCM**	**Water level in m**	**Gross Storage in MCM**
1554.48	0.46	1565.76	3.25	1574.29	9.72
1557.53	0.59	1566.06	3.43	1574.60	10.02
1557.83	0.60	1566.37	3.63	1574.90	10.31
1558.14	0.66	1566.67	3.70	1575.21	10.65
1558.44	0.70	1566.98	4.01	1575.51	10.98
1558.75	0.74	1567.28	4.20	1575.82	11.18
1559.05	0.80	1567.59	4.42	1576.12	11.55
1559.36	0.86	1567.89	4.64	1576.43	11.87
1559.66	0.91	1568.20	4.79	1576.73	12.14
1559.97	0.97	1568.50	4.99	1577.04	12.40
1560.27	1.03	1568.81	5.19	1577.34	12.69
1560.58	1.08	1569.11	5.39	1577.64	12.99
1560.88	1.17	1569.42	5.61	1577.95	13.30
1561.19	1.25	1569.72	5.72	1578.25	13.63
1561.49	1.37	1570.02	6.07	1578.56	13.92
1561.80	1.45	1570.33	6.34	1578.86	14.29
1562.10	1.54	1570.63	6.55	1579.17	14.62
1562.40	1.65	1570.94	6.80	1579.47	14.99
1562.71	1.76	1571.24	7.06	1579.78	15.35
1563.01	1.88	1571.55	7.28	1580.08	15.72
1563.32	2.00	1571.85	7.54	1580.39	16.06
1563.62	2.16	1572.16	7.78	1580.69	16.46
1563.93	2.27	1572.46	8.06	1581.00	16.83
1564.23	2.44	1572.77	8.17	1581.30	17.25
1564.54	2.56	1573.07	8.66	1581.61	17.62
1564.84	2.73	1573.38	8.91	1581.91	18.10
1565.15	2.90	1573.68	9.15	1582.22	18.53
1565.45	3.07	1573.99	9.41	1582.52	18.95

Water level in m	Gross Storage in MCM	Water level in m	Gross Storage in MCM	Water level in m	Gross Storage in MCM
1582.83	19.39	1588.62	29.03	1594.41	41.72
1583.13	19.86	1588.92	29.63	1594.71	42.26
1583.44	20.28	1589.23	30.19	1595.02	43.13
1583.74	20.76	1589.53	30.87	1595.32	44.04
1584.05	21.22	1589.84	31.44	1595.63	44.92
1584.35	21.70	1590.14	32.09	1595.93	45.88
1584.66	22.18	1590.45	32.85	1596.24	46.56
1584.96	22.64	1590.75	33.51	1596.54	47.27
1585.26	23.20	1591.06	34.18	1596.85	48.00
1585.57	23.68	1591.36	34.84	1597.15	48.86
1585.87	24.19	1591.67	35.49	1597.46	49.65
1586.18	24.42	1591.97	36.05	1597.76	50.44
1586.48	24.93	1592.28	36.62	1598.07	51.40
1586.79	25.49	1592.58	37.27	1598.37	52.11
1587.09	26.40	1592.88	37.98	1598.68	52.85
1587.40	26.94	1593.19	38.60	1598.98	53.67
1587.70	27.47	1593.49	39.31	1599.29	54.38
1588.01	28.01	1593.80	40.06	1599.59	55.23
1588.31	28.49	1594.10	41.14		

Table 2.1 Elevation – Capacity of Madupetty Reservoir

2.2 Operation Plan

The project operation plan will be based the rule curve/ requirements of the project. The rule curve is covered at para 2.4.1. Salient features of the reservoir are given below.

Salient features

Original Maximum Water Level (MWL) - +1599.59 m

Full Reservoir Level (FRL) - +1599.59 m

Minimum Draw Down Level (MDDL) - +1568.00 m

Gross storage - 55.23 Mm^3

Live storage	-	54.77 Mm^3
Water spread area at FRL	-	3.24 sq. km

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 was 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 15-17August 2018 at Madupetty Dam site was 580 mm.

Spill details of 2018 are tabulated below in **Table 2.2**.

Date	Water Level m	Gross Inflow MCM	Spill MCM
14-Aug-18	1599.40	3.257	1.820
15-Aug-18	1599.60	3.440	2.840
16-Aug-18	1599.30	2.050	2.950
17-Aug-18	1599.20	2.230	2.530
18-Aug-18	1598.50	-0.160	1.940
19-Aug-18	1598.30	0.690	1.290
21-Aug-18	1598.50	0.220	0.220
22-Aug-18	1598.50	0.220	0.220
23-Aug-18	1599.00	1.880	0.380
24-Aug-18	1598.80	-0.492	0.108
25-Aug-18	1598.60	0.370	0.970
26-Aug-18	1598.30	0.070	0.970
27-Aug-18	1598.00	0.070	0.970
28-Aug-18	1598.30	1.870	0.970

29-Aug-18	1597.80	-0.430	0.970
30-Aug-18	1597.50	0.070	0.820
31-Aug-18	1597.30	0.230	0.730
Total for August 2018			**20.698**
1-Sep-18	1597.00	-0.020	0.730
2-Sep-18	1596.90	0.480	0.730
3-Sep-18	1596.80	0.339	0.589
4-Sep-18	1596.60	0.040	0.540
5-Sep-18	1596.60	0.540	0.540
6-Sep-18	1596.50	0.120	0.370
7-Sep-18	1596.60	0.390	0.140
Total for September 2018			**3.639**
1-Oct-18	1598.85	0.730	0.730
2-Oct-18	1598.80	0.580	0.730
3-Oct-18	1598.70	0.289	0.589
4-Oct-18	1598.70	0.540	0.540
5-Oct-18	1598.60	0.240	0.540
6-Oct-18	1598.20	-0.830	0.370
7-Oct-18	1597.85	-0.835	0.140
Total for October 2018			**3.639**
1-Nov-18	1596.05	0.730	0.730
2-Nov-18	1596.05	0.730	0.730
3-Nov-18	1596.00	0.464	0.589
4-Nov-18	1595.90	0.290	0.540
5-Nov-18	1595.90	0.540	0.540
6-Nov-18	1595.85	0.245	0.370
7-Nov-18	1595.80	0.015	0.140
Total for November 2018			**3.639**
1-Dec-18	1596.80	0.730	0.730
2-Dec-18	1596.85	0.855	0.730
3-Dec-18	1596.90	0.714	0.589
4-Dec-18	1596.90	0.540	0.540
5-Dec-18	1596.90	0.540	0.540
6-Dec-18	1596.90	0.370	0.370
7-Dec-18	1596.85	0.015	0.140
Total for December 2018			**3.639**

Table 2.2 – Spill details

2.2.2 Design Flood and Features Related to Safety

Hydrology

Madupetty dam is constructed on river Mudirapuzha about 12kmdownstream of Kundala dam. The catchment area of the dam site is 60.50 sq. km. The average rainfall in this catchment is reported to be in the vicinity of 2000 mm. The gross storage capacity of the reservoir is 55.23 $Mm^3$and its hydraulic head from FRL to deepest river bed level is about 46.33 m. The dam is classified as a large dam as per BIS code 11223 and qualifies for Probable Maximum Flood (PMF).

The existing design flood is 453 m^3/s. FRL and the original MWL of the dam is the same at 1599.59 m. The top level of the dam is at +1600.20 m which is 0.61 m above MWL.

Climate

The Madupetty climate is very healthy, elevation being around +1585 m. Generally, the North East monsoon is heavier than the South West monsoon. Heaviest rainfalls are generally from October to December.

Water Spread:

Water spread area of Madupetty reservoir at F.R.L is 3.24 sq. km.

Hydrology Review

The unit hydrograph for the revised design flood of Madupetty reservoir (Pallivasal HEP) has been estimated as per FER 5 (a) & (b) published by Central Water Commission. The Central Water Commission has approved a revised design flood with peak discharge as 1131 m^3/s.

The original spillway capacity is 453 m^3/sat El.1599.59 m. The revised design flood peak has now become more than two times that of the spillway capacity. The revised flood PMF is estimated from a PMP value derived after transposing 1-day storm occurred at Devikulam in 1924. So far, the reservoir was never required to tackle a flood more than its original design flood since the project was completed in 1956.

As the revised design flood is greater than the original spillway capacity, flood routing studies were carried out. It was observed that the dam will get overtopped for the revised design flood. Presently there are no structural/non-structural arrangements in place to take care of this revised design flood. Hence it has been proposed to conduct dam break analysis and evolve Emergency Action Plan to take care of extreme scenario resulting from an abnormal flood situation.

2.3 Madupetty Dam

Madupetty Dam is a concrete gravity dam. Elevation at top of dam is +1600.20 m. Nominal bed level is + 1553.87 m. Length of dam is 237.74 m. Top width of dam is 6 m. Width at bottom of the maximum dam section is 42.36 m. Height of dam above lowest bed level is 46.33 m. The downstream slope varies from 0.48 H : 1 V to 0.788 H : 1V and the upstream slope is 1 in 20.

The dam is a straight massive concrete gravity structure except at the flanks. On the left flank from chainage 0 to 68.58 m, the dam is aligned 25^0 to the centre line of the dam to the downstream side. On the right flank too, from chainage 234.70 to 262.13 m, the alignment is 26^0 to the centre line of the dam on the downstream side.

The spillway structure has three bays. The spillway crest level is +1594.71 m. MWL and FRL is same and is +1599.59 m. There is one lower level outlet provided in the dam and another outlet which serves as power intake.

Fig 2.2 Madupetty Dam

Fig 2.3 Madupetty dam – downstream view

2.3.1 Components

Spillway

Spillway is ogee type with 3 bays. Radial Gates of size 6.70 m x 4.95 m are installed for controlling the flood discharge. Rope-Drum type gate hoisting arrangement is

provided. Crest level of spillway is +1594.71 m. The Spillway is designed for a maximum discharge of 453 cumec. Dissipation of energy of the water falling from the ogee crested spillway is effected by a bucket kind of arrangement with splitters followed by stepped falls towards the river.

Fig 2.4 Spillway of Madupetty dam

Fig 2.5 Spillway bucket

Fig 2.6 Gate hoisting arrangements

Outlet Arrangements

One outlet conduit of dia. 2.4 m is provided in the dam. It is provided at a centre line elevation of EL 1555.72 m (5104 ft). An emergency gate of size 3.2 m x 2.5 m, operated by screw hoist is provided for the outlet with sill level at EL 1554.50 m (5100 ft). A Howell - Bunger (HB) valve of Glenfield make with 1.22 m diameter is provided at the downstream end of the outlet pipe. An air release/ filler valve is provided for the outlet conduit with the outlet leading to the downstream side and the end closed with a valve. The HB valve is manually operated and is housed in a valve house located close to the dam toe Power house. A dial gauge with a maximum indication up to 8 inches is provided which indicates the opening of the valve when the operating lever is turned in anticlockwise direction. The emergency gate is opened and the HB valve is operated for release of water to the R A Head Works for generation of power at Pallivasal Power House during shutdown of dam toe power house at Madupetty/depletion of reservoir. Normally the downstream release through the dam toe power house is sufficient to meet the water requirements of Pallivasal Power House. Discharge Tables of the HB valve are not available. The maximum opening of the HB valve is 8 inches. Normally opening the valve above 2 ½ inches will lead to spill at RA Head works with Pallivasal Power House running at full load. The opening of the HB

valve is regulated so as to meet the requirements of Pallivasal Power House without resulting in a spill at RA Head works.

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Fig 2.7 Disperser valve

Fig 2.8 Disperser valve house

Fig 2.9 Emergency gate screw hoist

Fig 2.10 HB valve hoist and dial

Fig 2.11 HB valve discharge

Gallery

A gallery is provided in the dam. A Gallery Access Room is provided on the downstream side of the dam at the rear side of the Power house. A walkway is provided at the right bank through the downstream slope of the dam to provide approach to the Gallery Access Room and Valve house. The access to the gallery is through an access well provided inside the Gallery Access Room through a ladder. One V-notch is installed for taking seepage measurements. The seepage water is collected in a sump pit from where it drains naturally to the Power house peripheral drain and from there it is drained to the tail race channel.

Fig 2.12 Gallery

Fig 2.13 Gallery room

Fig 2.14 Access to gallery

Fig 2.15 Gallery outlet and entry well

2.4 Operation of the Reservoir

The Gross Storage of Madupetty Dam is 55.23 Mm^3 and live storage 54.77 Mm^3. FRL &the original MWL of the reservoir are 1599.59 m. Top level of dam is 1600.20 m. There are three nos. of radial gates each of size 6.70 m x 4.95 m. Crest level of spillway is 1594.71 m. One lower level outlet of 1.22 m dia. is also provided at elevation +1565.15 m. Spillway capacity is 453 m^3/s.

The water stored in the Madupetty reservoir plus the water released from Kundala is further released to downstream through a Dam Toe Power Station having a capacity of 2MW. The controlled release from Madupetty Dam reaches R A Head Works, a gated diversion structure, constructed downstream of Madupetty and from there, the water is diverted through a water conducting system to the 37.5MW Power house of Pallivasal HEP located on the right bank of Mudirapuzha river for power generation. Following inputs/information is used to support the reservoir operation.

a) Satellite images of cloud formation.
b) India Meteorological Department (IMD) forecast.
c) Advance information on release from upstream reservoir.

c) Daily rainfall detail of the nearby rain gauge stations.

Discharge through single spillway bay for different reservoir levels with different gate openings is tabulated in **Table 2.3**. Discharge (Rating) curve showing discharge through one gate at various reservoir levels is given in **Fig. 2.15**.

Discharge through a single spillway gate for different gate openings and reservoir levels									
Reservoir Level (m)	**Gate opening (m)/Bottom level of gate (+m)**								
	0.01	**0.3**	**0.6**	**0.75**	**0.9**	**1.2**	**1.5**	**1.8**	**2.1**
1594.71 (Crest level)	**1594.72**	**1595.01**	**1595.31**	**1595.46**	**1595.61**	**1595.91**	**1596.21**	**1596.51**	**1596.81**
1599.20	0.42	12.26	24.09	29.85	35.49	46.43	56.91	66.91	79.83
1599.25	0.42	12.33	24.23	30.02	35.70	46.72	57.28	67.36	80.40
1599.30	0.42	12.40	24.37	30.20	35.91	47.01	57.65	67.81	80.96
1599.35	0.42	12.47	24.51	30.37	36.12	47.30	58.01	68.26	81.51
1599.40	0.42	12.53	24.65	30.54	36.33	47.58	58.37	68.70	82.07
1599.45	0.42	12.60	24.78	30.72	36.54	47.86	58.73	69.14	82.62
1599.50	0.42	12.67	24.92	30.89	36.75	48.14	59.09	69.58	83.16
1599.55	0.42	12.73	25.05	31.06	36.95	48.42	59.45	70.02	83.70
1599.59	0.42	12.78	25.16	31.19	37.12	48.64	59.73	70.36	84.13
1599.60	0.42	12.80	25.19	31.23	37.16	48.70	59.80	70.45	84.24
1599.65	0.42	12.86	25.32	31.39	37.36	48.98	60.15	70.88	84.77
1599.70	0.42	12.93	25.45	31.56	37.56	49.25	60.50	71.30	85.31
1599.75	0.42	12.99	25.58	31.73	37.76	49.52	60.85	71.73	85.83
1599.80	0.42	13.06	25.71	31.89	37.96	49.79	61.19	72.15	86.35

Reservoir Level (m)	**Gate opening (m)/Bottom level of gate (+m)**							
	2.4	**2.7**	**3**	**3.5**	**4**	**4.5**	**4.7**	**4.95**
1594.71 (Crest level)	**1597.11**	**1597.41**	**1597.71**	**1598.21**	**1598.71**	**1599.21**	**1599.41**	**1599.66**
1599.20	89.22	98.06	109.36	122.14	133.06			
1599.25	89.88	98.82	110.25	123.23	134.37	143.54		

1599.30	90.54	99.58	111.14	124.31	135.67	145.07		
1599.35	91.19	100.33	112.02	125.38	136.95	146.59		
1599.40	91.84	101.07	112.89	126.44	138.22	148.10		
1599.45	92.48	101.81	113.75	127.49	139.48	149.58	153.06	
1599.50	93.12	102.54	114.61	128.53	140.72	151.05	154.63	
1599.55	93.75	103.27	115.46	129.56	141.96	152.51	156.18	
1599.59	94.25	103.85	116.14	130.38	142.94	153.67	157.41	
1599.60	94.38	103.99	116.30	130.59	143.18	153.95	157.72	
1599.65	95.00	104.71	117.14	131.60	144.39	155.38	159.24	
1599.70	95.62	105.42	117.97	132.61	145.59	156.79	160.75	162.31
1599.75	96.23	106.13	118.79	133.61	146.78	158.19	162.24	164.94
1599.80	96.84	106.83	119.61	134.60	147.96			

Table 2.3 Spill way Discharge

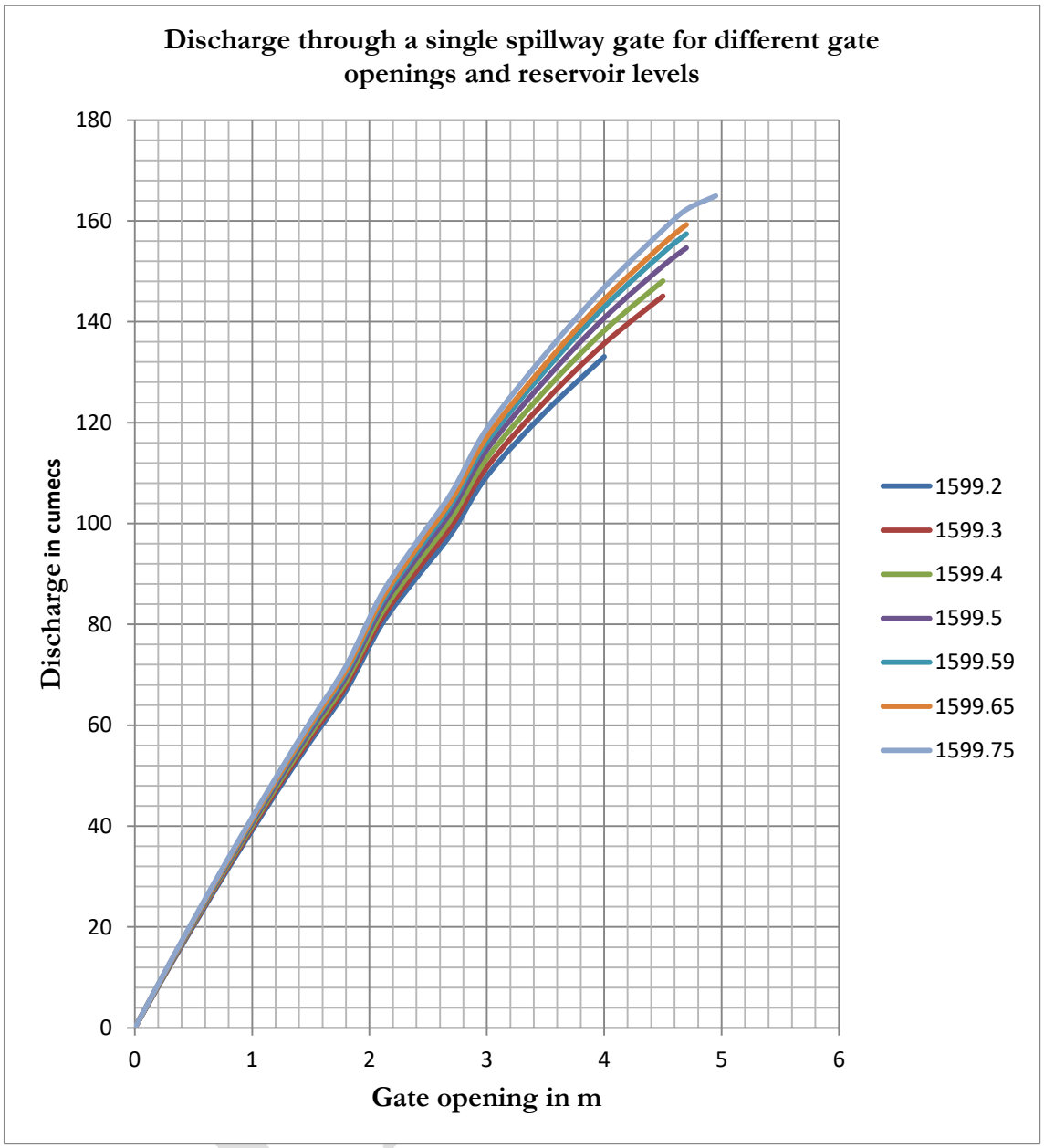

Fig 2.17 Discharge curve

2.4.1 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 in order to create some dynamic flood cushion for moderating the floods of lower return periods. 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 release from Kundala dam, rainfall, inflow, release to R A Head works, power generation, an average reservoir water level pattern is arrived as shown in **Table 2.4**. The peak level is proposed at FRL 1599.59m during January 15th. A rule curve is arrived as shown in **Fig 2.16**. The reservoir water exceeding the rule curve level will be spilled or adjusted with power generation. This can be used till further revision.

MADUPPETTY DAM - WL FROM 2012 to 2018												
Month/ Year	June		July		August		September		October		November	
	1F	2F	1F	2F	1F	2F	1F	2F	1F	2F	1F	2F
2012-13	1583.48	1582.15	1582.45	1583.08	1583.08	1584.03	1586.00	1587.45	1588.40	1589.58	1590.88	1591.55
2013-14	1577.95	1580.65	1585.13	1589.43	1595.65	1598.70	1599.45	1599.30	1598.83	1597.15	1596.18	1596.78
2014-15	1579.65	1577.90	1577.35	1580.65	1585.65	1589.05	1592.50	1594.65	1596.10	1597.80	1599.25	1599.43
2015-16	1587.85	1588.75	1590.75	1592.10	1593.25	1594.10	1595.10	1596.20	1597.45	1598.38	1599.08	1599.33
2016-17	1583.75	1583.90	1585.30	1587.75	1589.40	1590.10	1590.60	1590.90	1591.23	1591.30	1591.28	1591.38
2017-18	1576.55	1576.35	1576.50	1577.25	1578.65	1581.00	1584.05	1587.55	1590.45	1591.65	1592.98	1593.83
2018-19	1584.05	1586.03	1588.25	1592.65	1597.78	1598.00	1597.03	1597.95	1597.73	1596.35	1595.83	1596.20
Average	1581.90	1582.25	1583.68	1586.13	1589.06	1590.71	1592.10	1593.43	1594.31	1594.60	1595.06	1595.50
Rule curve	1585.44	1585.79	1587.22	1589.68	1592.61	1594.26	1595.65	1596.98	1597.86	1598.15	1598.61	1599.04

Month/ Year	December		January		February		March		April		May	
	1F	2F	1F	2F	1F	2F	1F	2F	1F	2F	1F	2F
2012-13	1592.03	1592.30	1592.53	1592.65	1592.75	1592.65	1591.80	1589.65	1587.85	1586.80	1584.45	1581.15
2013-14	1597.20	1597.23	1596.78	1595.61	1593.93	1592.00	1590.00	1587.60	1584.65	1583.08	1583.05	1582.30
2014-15	1599.55	1599.55	1599.55	1599.03	1597.95	1596.45	1594.80	1593.00	1590.65	1594.10	1588.70	1588.70
2015-16	1599.40	1599.40	1599.28	1598.60	1597.95	1595.90	1594.05	1591.95	1589.70	1588.65	1588.40	1586.40
2016-17	1591.40	1591.43	1592.95	1591.28	1591.13	1590.90	1590.00	1587.65	1584.60	1583.50	1583.00	1579.63
2017-18	1595.05	1595.00	1595.18	1594.63	1593.90	1592.95	1591.60	1589.60	1587.00	1586.15	1585.90	1584.63
2018-19	1596.83	1596.53										
Average	1595.92	1595.92	1596.04	1595.30	1594.60	1593.48	1592.04	1589.91	1587.41	1587.05	1585.58	1583.80
Rule curve	1599.47	1599.47	1599.59	1598.84	1598.15	1597.02	1595.59	1593.46	1590.96	1590.59	1589.13	1587.35

Table 2.4 Reservoir Water Levels

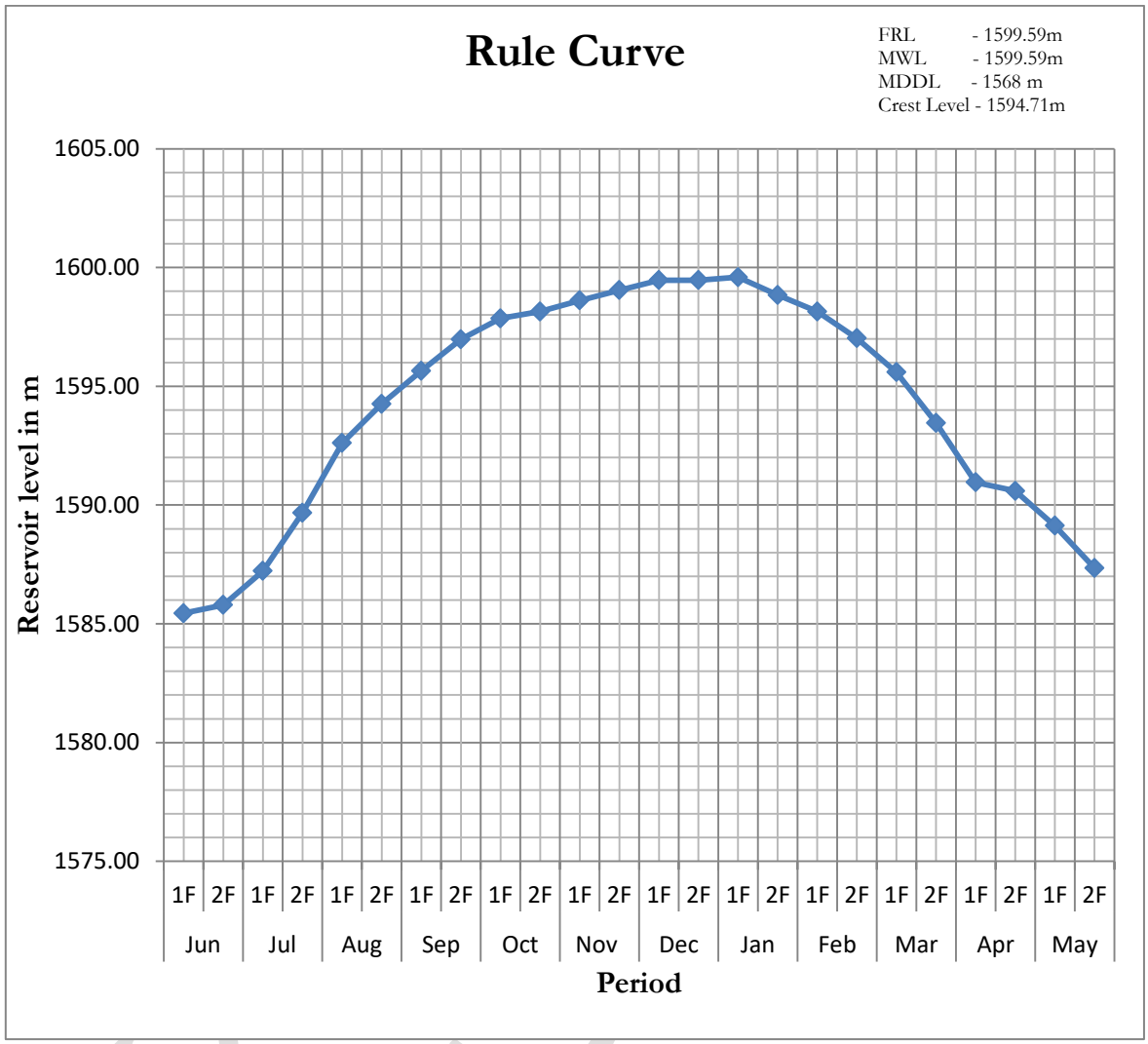

Fig 2.18 Rule curve

2.4.2 Safety Aspects

The spillway gates are operated step by step after assessing the reservoir water level and inflow and the sequencing is defined in **2.4.3.**

2.4.3 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**. There are three spillway gates. The sequence of operation of spillway gates is Gate no. 2, 1, 3 ie. the spillway gate No. 2 is operated first. Thereafter depending on requirement, gates on either side of the central gate nos. 1 & 3 are opened. Further opening of gates, if required is done in the same

way, keeping the difference in the openings of any two adjacent gates not more than 0.2m. Closing of gates is to be done in reverse order; the gate opened last being closed first.

Fig 2.19 Spillway radial gates

2.4.4 Reservoir Capacities

Fig 2.20 Madupetty Reservoir

The Gross storage of the reservoir is 55.23 Million Cubic Meters and the live storage is 54.77 Million Cubic Meters at FRL of +1599.59 m.

2.4.5 Inflow forecasting

Monsoons are from June to December and incessant rains may cause floods. These 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 in the river during the monsoons.

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, 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, networks of mobile phones are widely available. Advantage of this facility will be taken. Mobile numbers of all officers and staff working in Dam operations wing, District Disaster Management, Revenue authorities will be listed and made available to all the personnel who have been assigned duty of disaster management. A satellite phone is provided at the dam site.

2.4.6 Methodology of Flood Regulation at Madupetty

2.4.6.1 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.

Inflow (cumec) = Total outflow (cumec) + Rate of increase in storage (cumec)

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. For easy computation a table can be developed showing the rate of change of storage in the Madupetty reservoir for a rate of rise in reservoir level of 1 cm/hour. This table can be put to use for easy interpolation. Once the inflow is known the outflow and gate opening required to maintain the water level can be computed.

2.4.7 Summary of Flood Regulation Procedure

The flood regulation procedures at Madupetty can be summarized in the following 5 steps:

1. Observe the reservoir level at 1 hour intervals.
2. Determine the total outflow occurring at all outlets (including river outlet, spillway, release to R A Head works)
3. Estimate the inflow
4. Determine the gate opening as the case maybe.
5. Open the required number of gates to the extent required to maintain constant reservoir level (i.e., release is equal to the inflow).

2.4.8 Emergency Operation

The purpose of Emergency Action Plan is to identify emergency situations that could threaten Madupetty 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 are provided in the detailed EAP document of Madupetty Dam. Summary of Alert Conditions during Emergency are given in **Annexure 7**.

The Emergency operation will be carried out following the Emergency Action Pan (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.

2.5 Power Generation

The Madupetty dam was constructed as a second stage of Pallivasal Hydro Electric Project which was completed in 1940. It was intended as a storage for Pallivasal Power Station which now has a total capacity of 37.5 MW. It has 3 machines of 5 MW capacity and another 3 machines of 7.5 MW. The release from Madupetty dam to RA Head works for diversion to Pallivasal Power Station was done through the river sluice earlier.

Later, a Power House of 2 MW capacity was commissioned in 1998 at the immediate downstream of Madupetty dam. The Power House has one Francis machine of 2 MW with average net effective head of 6.4 m and a firm power of 0.7 MW. The release of water to the RA Head works for power generation is now carried out through the operation of this dam toe power house. During monsoon season, the inflow from the own catchment of RA Head works is sufficient to generate power at Pallivasal Power Station and the water is stored in Madupetty dam. As the inflow at RA Head works is reduced, generation is started at the dam toe power house to maintain the water levels required for power generation at Head works.

Fig 2.21 Dam toe power house

2.5.1 Power Intake and Gate

The power intake is provided with an intake conduit of 1.84 m dia. with centre line at EL 1565.15 m (5135 ft). This conduit is provided with a bend inside the dam body and has downstream exit centreline at EL 1554.50 m (5100 ft). The intake gate sill is at EL 1564.25m (5132 ft). The intake gate is provided with a rope drum hoist operated from a raised platform at dam top.

Fig 2.22 Intake gate hoist

Fig 2.23 Intake rope drum hoist

2.6 Initial Filling of Reservoir

The initial filling of the reservoir was carried out during 1956.

2.7 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 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 on hourly basis during monsoon.
4. Estimated spillway outflows 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.

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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 Madupetty dam envisages that the Deputy Chief Engineer along with Executive Engineer of the project shall 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 of the Project will also conduct quarterly inspections and will prepare health reports as per KDSA. The format to be followed as per CWC has been revised during January 2018 and new guidelines have been issued vide Doc No. CDSO_GUD_DS_07_ v1.0, CWC 2018 for Safety Inspection of Dams. The health reports of the dam are to be prepared in the new format meant for incorporating the data 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 required to be carried out at Madupetty 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.

Guidance for carrying out other inspections is elaborated in the following paras.

3.1 Types of inspections

Four types of dam safety inspections could be carried out at Madupetty 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.

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 Madupetty 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 including.
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 as required.
5. Preparation of a detailed report of the inspection.

3.2.1 Details to be provided to DSRP before inspection.

All relevant details / data / drawings for the dam project to be examined by the DSRP shall be provided at least 3 months in advance of the proposed visit. This will include:

- General information and scope of the project
- Emergency preparedness
- Details of key personnel
- Hydrology original and reviewed
- Reservoir operation and regulation plan
- Basic data and issues related to safety of dam
- Problems, if any, during construction
- Drawings of dam, spillway, gates and appurtenant structures
- Seismicity aspects & details
- Status of the instrumentation
- Construction history
- Geological report including special problems at site and their treatment
- Field Inspection- Observation and recommendation regarding remedial measures
- Dam incidents and reservoir filling details

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 developments that may be detrimental to the dam. These inspections involve assessing operational capability as well as structural stability and detection of any problems 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 and when the same are received and include in the evaluation report of that data. Dam Inspection Report or an inspection brief should be prepared following the field visit.
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 report should be filed in the dam owner's project files

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

Detailed checklists are to be followed to ensure evaluation of 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)**.

The information in regard to above inspection would be supplied to the Chief Engineer of the Project for further co-ordination with the concerned departments and district Authorities.

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 relevant files or data, 2) visual inspection, and 3) report preparation.

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

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 especially to keep an eye on the proper operation and maintenance of the dam. These inspections 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 Madupetty 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 for inspection / surveillance, 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 case may be, or they may cover the entire dam and its appurtenant structures in one go. 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, other features etc.

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 based on manual of operating parts, frequent inspections, priority, and interval is attached as **Annexure 6**. 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 clarified 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.
- The dam is about to be breached by erosion, slope failure etc.
- A dam showing signs of failure due to aging/cracking, sliding, overturning 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 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 any concrete or metal components that have deteriorated.
- Cleaning of the choked drainage holes in the dam body/ foundations.
- Repair any damages on spillway glacis, piers, energy dissipaters, training/divide walls, downstream areas etc.
- Repairs on the upstream face of masonry dams, in case the pointing is damaged, due to which there is increased seepage.
- Controlling any heavy seepage in the foundation/ inspection galleries in Concrete/Masonry dams from drainage holes.
- Repairs of any cracks/cavities/joints in concrete/masonry 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:

- Any routine repair to concrete or metal component.
- Observation of any springs or seepage areas, comparing the 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 & Hydro-Mechanical equipment and systems e. g. Servicing of spillway gates, hoisting arrangements and gates/hoist of outlet works & stand by generator.
- Maintaining proper lighting at dam top etc.

- Monitoring of seepage in masonry/ concrete dams.
- Monitoring/ cleaning & removal of leached deposits in porous concrete / formed drains in dam body and foundation drainage holes of masonry/ concrete dams.
- Maintenance of all dam roads & access roads.
- Operation of electrical and mechanical equipment and systems including exercising gates & 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 fencing 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

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

4.3.3 Masonry / Concrete dams & spillways

The following important issues / aspects need to addressed while undertaking the periodic maintenance, but are not be limited to:

- Cracking in concrete (potential causes are alkali – aggregate reaction, thermal stresses because of heat of hydration or temperature variations, foundation problems).
- Damages on spillway glacis, spillway piers, training/divide walls, energy dissipaters, downstream areas (probable causes are cavitation, abrasion, unsymmetrical flows, unfavourable down-stream conditions)

- Vegetation growth in spillways, spill channel, approach channel etc.
- Seepage on d/s face of the dam.
- Cleaning and removal of leached deposits from choked drainage holes in the dam body/foundations.
- Repair to upstream face of masonry dams in case the pointing is damaged, leading to increased seepage.
- Status of rectification works undertaken from time to time need to be assessed during periodic maintenance.
- To ensure that the dam is behaving as designed based on instrumentation programs.
- Periodic maintenance should be performed on all concrete surfaces to repair deteriorated areas. Repair of deteriorated concrete at the earliest following the standard specifications for repair of concrete surfaces and re-pointing of masonry joints etc. it is most easily repaired in its initial stages. Deterioration can accelerate and, if left unattended, can result in serious problems or dam failure.

For remedial measures of problems of special nature advice of experienced engineers/ Panel of Experts needs to be obtained.

4.3.4 Gates & Hoisting Equipment

The safe and satisfactory operation of Spillway 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 Gate and Hoists whenever there is any contradiction with the inspections 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. Recommended and approved oils and grease only should be used.

viii) 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.

ix) The guide-assemblies, wheel-assemblies and sealing-assemblies shall be cleared off grit, sand or any other foreign material.

x) The wheel pin shall be coated with corrosion resistant compound.

xi) All nuts and bolts shall be tightened.

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

a) **Rubber Seals**:

Seals shall be inspected for leakages. Locations of excessive leakages shall be recorded for taking remedial measures. Appropriate action to replace the damaged seal needs to be taken immediately after monsoon. 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.

a) 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.

xiv) 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.

4.3.5 Maintenance of Electrically operated fixed hoists

i) 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.

Inspection and Maintenance

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.

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.

xviii. All wire ropes shall be greased with cardium compound.

xix. Check the overload relays for proper functioning.

xx. 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.

xxi. Check the pulleys, sheaves and turn-buckles.

xxii. 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 brakes 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.

xxiii. Adjust the rope tension of wires if unequal.

xxiv. Check for all gears and pinions for uneven wear and adjust for proper contact. Grease the gears.

xxv. Repaint the hoist components, hoisting platform and its supporting structures as per requirement.

xxvi. The periodic maintenance of commercial equipment like motors, brakes, thrusts etc. shall be carried out as per manufacturers operation and maintenance manual.

4.3.6 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 smoothening 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.

xii) Examine earth connections and motor leads.

xiii) Examine motor windings for overheating

xiv) Examine control equipment

xv) Examine starting equipment for burnt contacts

xvi) Check and tighten all nuts and bolts

xvii) Clean and tighten all terminals and screw connections all contact surfaces shall be made clean and smooth.

xviii) 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.

viii) Brake drum shall be cleaned to remove any dust or grease.

4.3.7 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 the motors, brake system, control panel and limit switches shall be overhauled once in every year preferably before monsoon, and after monsoon. All the components shall be checked in detail for the electrical parameters. If any components are seen damaged shall be repaired/ replaced so as to ensure smooth operation of the equipments. The bearings of electric motor should be grease lubricated once in six months.

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/repaired where needed. The recommendations of the manufacturer should also be referred to.

4.3.8 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.

4.3.9 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 / slope failure etc. develop, assistance of experienced Engineers/Expert Panels should be arranged 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.

4.3.10 General Cleaning

As already suggested, for proper operation of spillways, sluiceways, approach channels, 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 is also 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.

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

At Madupetty 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.

4.5 Preparation of O&M budget

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

ii) Establishment Cost of Regular Staff – Salaries and allowances, Bonus, Medical Reimbursement, LTC, Leave Encashment, Pension benefits etc. (As applicable)

iii) Establishment Cost of Work charged – Salaries and allowances, Bonus, Medical Reimbursement, LTC, Leave Encashment, Pension benefits, TA and DA etc. (As applicable)

iv) Establishment Cost of Daily Wage Staff – Salaries and allowances, TA and DA etc. (As applicable)

v) Office Expenses – Rent for Office, Telephone/Mobile/ any other Telecommunication bills, Electricity bills, Water bills, Office stationaries Day to day office requirements

vi) Motor Vehicles – Running and Maintenance cost of inspection vehicles, Cost of hiring of vehicles as required

vii) Maintenance of Colony – Maintenance of staff quarters, colony roads, Electricity, Sanitary and Water supply systems etc.

viii) T&P –The T&P requirements for offices, colony, works etc. as applicable

ix) 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	POWER INTAKE			
1.3	OUTLET IN DAM			
1.4	APPROACH / INSPECTION ROADS WITHIN DAM AREA			
2	**HYDRO-MECHANICAL**			
2.1	SPILLWAY GATES & HOISTS			
2.2	INTAKE GATE & HOIST			
2.3	EMERGENCY GATE & HOIST			
2.4	OUTLET GATES VALVE & HOISTS			
3	**ELECTRICAL**			
3.1	ELECTRICAL FITTINGS, MOTORS, CONTROLS FOR ALL GATES VALVES & 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.

5.1 Instrument Types and Usage

The instruments installed in Madupetty dam are appended below.

LIST OF INSTRUMENTATIONS INSTALLED IN MADUPPETTY DAM			
Sl. No.	**Name of Instruments**	**Total No. installed**	**Frequency of measurements**
1	V – notch	1	Weekly

Table 5.1 Instrumentation present status

5.1.1 Parameters monitored

Water Level

Daily water levels are taken. During monsoon, hourly readings are taken and recorded.

Seepage Flow

Seepage is measured with V notch in the foundation gallery on weekly basis.

Seepage assessment

In Madupetty dam, seepage is measured using V-notch fitted in the foundation gallery. Typical Seepage data for the period 01.06.2018 to 31.12.2018 is tabulated below.

Date	Water Level in m	Discharge (lit/sec)	Date	Water Level in m	Discharge (lit/sec)
01-06-2018	1583.75	0.04	16-09-2018	1597.65	0.1
08-06-2018	1583.20	0.04	23-09-2018	1598.25	0.1
15-06-2018	1585.80	0.05	30-09-2018	1598.85	0.1
22-06-2018	1586.80	0.05	07-10-2018	1597.85	0.09
29-06-2018	1587.60	0.055	14-10-2018	1596.55	0.09
06-07-2018	1588.00	0.05	21-10-2018	1596.4	0.085
13-07-2018	1589.90	0.055	28-10-2018	1596.2	0.085
20-07-2018	1593.95	0.055	04-11-2018	1595.9	0.08
27-07-2018	1596.00	0.055	11-11-2018	1595.6	0.08
03-08-2018	1597.05	0.07	18-11-2018	1596.1	0.075
10-08-2018	1598.45	0.095	25-11-2018	1596.6	0.075
17-08-2018	1599.2	0.16	02-12-2018	1596.85	0.07
24-08-2018	1598.8	0.16	09-12-2018	1596.85	0.06
31-08-2018	1597.3	0.155	16-12-2018	1596.9	0.06
07-09-2018	1596.6	0.15	23-12-2018	1596.65	0.055
14-09-2018	1597.5	0.15	30-12-2018	1596.2	0.05

Table 5.2 Seepage Details

Fig 5.1 Drain hole FDH No.7

Fig 5.2 Drain hole BDH No.7

Water Quality

The quality of water including pH value is to be tested.

Seismic Activity

There is no Seismic observatory installed at Madupetty Dam.

Weather Conditions

Now the rainfall data are measured with rain gauges. But a full equipped weather station can sense all weather conditions. Automated weather station is needed.

5.2 Data Processing and Evaluation

The monthly reports are prepared for evaluation done.

5.2.1 Data Collection

On daily, fortnightly / monthly basis as the case may be.

5.2.2 Data Presentation

On monthly basis.

5.2.3 Data Interpretation

As per standard practice & on monthly / six monthly / yearly basis or as decided by design authorities.

CHAPTER 6

REHABILITATION WORKS UNDER DRIP

The rehabilitation works carried out under DRIP include:

1. Protective works on the left bank of Madupetty dam
2. Reaming foundation drain holes and body drain holes
3. Pressure washing dam and painting allied structures
4. Construction of a security guard room/operator' s room
5. Security Fencing
6. Installation of High Mast light

Fig 6.1 Pressure washing of dam

Fig 6.2 Parapet painting and security fencing

Fig 6.3 High mast light on left and right banks

Fig 6.4 Security guard room

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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:

i) Increase/decrease in the frequency of an inspection or the maintenance routine based on additional data/ experience acquired,
ii) Changes in the operation and/or maintenance procedures based on additional data/experience acquired,
iii) 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.