Operation and Maintenance Manual for KALLAR Dam State of Kerala

Doc. No. DSO_O&M_KALLAR_DAM
KSEBL_13_v1.0

DRIP
Dam Rehabilitation & Improvement Project

KSEB

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

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Government of Kerala

Operation and Maintenance Manual

Kallar Dam
Of
Idukki HEP-Stage III

KSEB

Prepared

Sd/-

Deputy Chief Engineer (Civil)
Dam Safety & DRIP

Approved

Sd/-

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Kerala State Electricity Board Ltd
Pallom, Kottayam.

December 2019

Government of Kerala
Kerala State Electricity Board Ltd
Dam Safety Organisation

Disclaimer

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

The Manual is developed for the purposes of organization and managing the operation, inspection and maintenance of the dam for reducing risk and optimizing performance of the dam as a general guide.

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Message

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

For managing a dam in a sustainable and scientific manner, it is very crucial for each dam owner to have dam specific Operation and Maintenance Manual that lays down procedures for the daily upkeep of the dam. An Operation and Maintenance Manual for a dam is essential for ensuring its safe functioning and for deriving continued benefits. This Operation and Maintenance Manual for Dam has been prepared following the "Guidelines for preparing, Operation and Maintenance Manuals for dams" 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),
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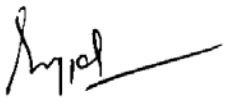
Foreword

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

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

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

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



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PREFACE

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

Central Water Commission has published the Guidelines for the development of New Manual and Updating of Existing Manual vide CDSO_GUD_DS_03_v1.0 Page xii January 2018. Accordingly KSEB Ltd is developing and updating the Operation and Maintenance Manual of Dams under their ownership for a healthy dam safety management system.

Idukki Hydro Electric Project is the largest hydroelectric project of Kerala State located in Idukki District. This project, on Periyar river basin, envisages creation of a reservoir by constructing three dams viz. Idukki Arch dam, Cheruthoni dam and Kulamavu dam. Water from the reservoir is diverted to an underground power house with an installed capacity 780 MW (under stage I & II) located at Moolamattom through tunnel/penstock etc. Idukki reservoir is augmented under Idukki HE Project – Stage III for additional energy generation, by Creation of two fore bays by means of diversion dams, one in river Kallar and another in river Erattayar together commanding a catchment area of 255.8 Sq km in the upper reaches of river Perinjankutty, a tributary of Periyar.

A flow chart of Idukki HEP Stage III is given in the next page for reference.

This Operation and Maintenance Manual is prepared for Kallar dam of Idukki HEP Stage III

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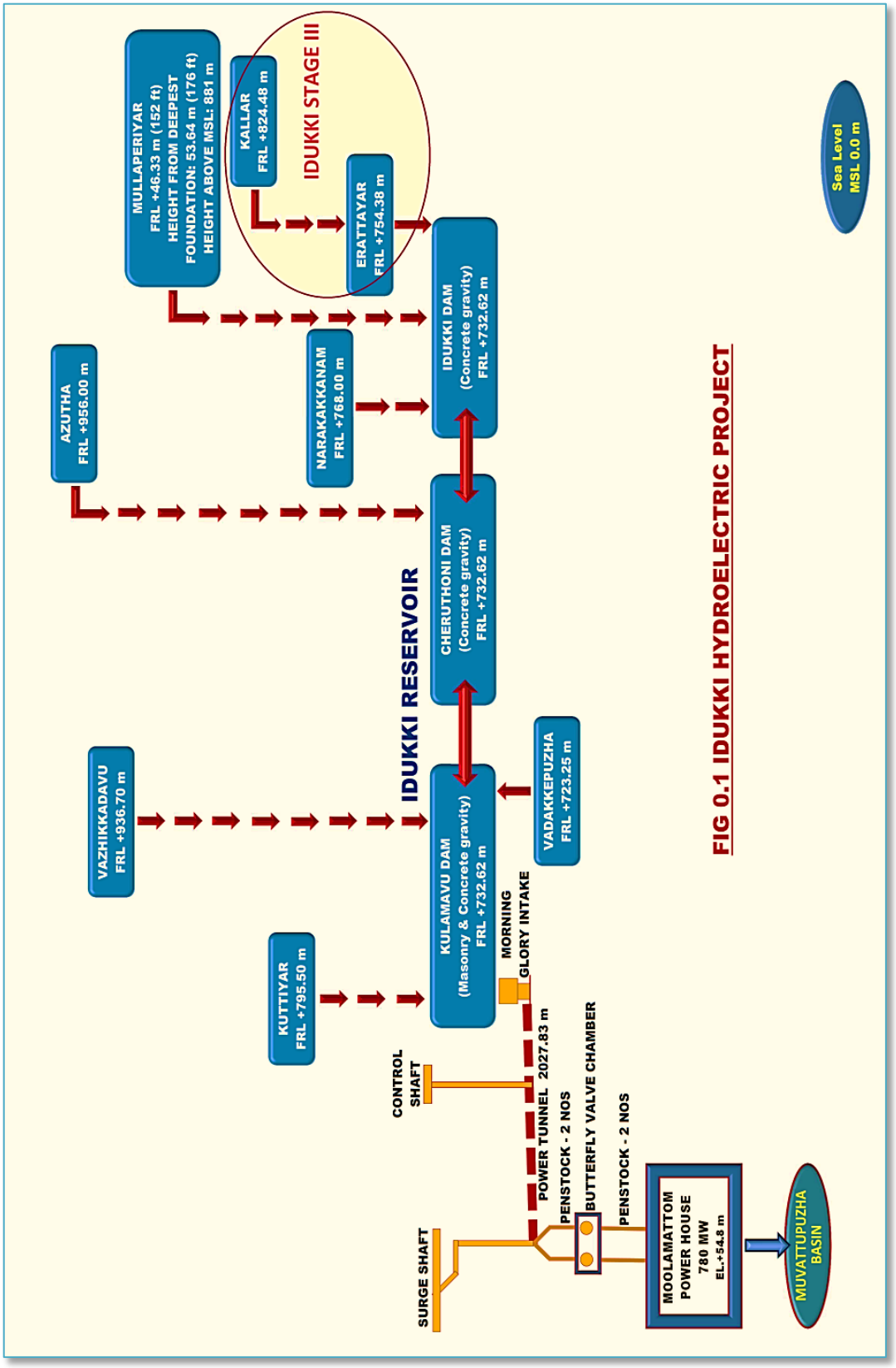
IDUKKI STAGE III
MULLAPERIYAR
FRL +46.33 m (152 ft)
HEIGHT FROM DEEPEST FOUNDATION: 53.64 m (176 ft)
HEIGHT ABOVE MSL: 881 m
KALLAR
FRL +824.48 m
ERATTAYAR
FRL +754.38 m
IDUKKI DAM
(Concrete gravity)
FRL +732.62 m
AZUTHA
FRL +956.00 m
NARAKAKKANAM
FRL +768.00 m
CHERUTHONI DAM
(Concrete gravity)
FRL +732.62 m
IDUKKI RESERVOIR
VAZHIKKADAVU
FRL +936.70 m
KULAMAVU DAM
(Masonry & Concrete gravity)
FRL +732.62 m
VADAKKEPUZHA
FRL +723.25 m
KUTTIYAR
FRL +795.50 m
MORNING GLORY INTAKE
CONTROL SHAFT
POWER TUNNEL 2027.83 m
PENSTOCK - 2 NOS
BUTTERFLY VALVE CHAMBER
PENSTOCK - 2 NOS
SURGE SHAFT
MOOLAMATTOM POWER HOUSE
780 MW
EL.+54.8 m
MUVATTUPUZHA BASIN
Sea Level
MSL 0.0 m
FIG 0.1 IDUKKI HYDROELECTRIC PROJECT

LIST OF ACRONYMS

The following acronyms are used in this publication:

AAR	**Alkali-Aggregate Reaction**
ACI	**American Concrete Institute**
ASTM	**American Society for Testing Materials**
CDSO	**Central Dam Safety Organization**
CWC	**Central Water Commission**
CWPRS	**Central Water and Power Research Station**
DDMA	**District Disaster Management Authority**
DHARMA	**Dam Health and Rehabilitation Monitoring Application**
DRIP	**Dam Rehabilitation and Improvement Project**
EAP	**Emergency Action Plan**
FSCT	**Federation of Societies for Coatings Technology**
HCC	**Hindustan Construction Corporation Ltd**
IS	**Indian Standard**
KERI	**Kerala Engineering Research Institute**
KDSA	**Kerala Dam Safety Authority**
KSEB Ltd	**Kerala State Electricity Board Ltd**
KWA	**Kerala Water Authority**
NCDS	**National Committee on Dam Safety**
NCSDP	**National Committee on Seismic Design Parameters**
PMF	**Probable Maximum Flood**
PMP	**Probable Maximum Precipitation**
RCC	**Reinforced Cement Concrete**
ROUV	**Remotely Operated Underwater Vehicle**
ROV	**Remotely Operated Vehicle**
SDSO	**State Dam Safety Organization**
SISF	**State Industrial Security Force**
UAV	**Unmanned Aerial Vehicle**
USBR	**United States Bureau of Reclamation**
USACE	**United States Army Corps of Engineers**

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF BASIC DRAWINGS IN ANNEXURE 1

LIST OF ANNEXURES

REFERENCES

Central Water Commission (2018): Guidelines for Preparing Operation and Maintenance Manual for Dams, Doc. No. CDSO_GUD_DS_03_v1.0 published under DRIP

Central Water Commission (1987): Guidelines for Safety Inspection of Dams, Doc. No. CDSO_GUD_DS_07_v1.0 Published under DRIP

Central Water Commission (2016): Guidelines for Developing Emergency Action Plan (EAP) for Dams, Doc. No. CDSO_GUD_DS_01_v1.0

IS: 10096, Part 3 (2002): Recommendations for Inspection, Testing and Maintenance of Radial Gates and Rope Drum Hoists- Part 3 After Erection

IS: 14177, Part-II (1994): Guidelines for Painting System for Hydraulic Gates and Hoists

IS: 2339 (1963): Specifications for Aluminium Paint for General Purposes in dual container

IS: 11223 (1985): Guidelines for Fixing Spillway Capacity

Chapter 1

General Information

1.1 Introduction

Idukki Hydro Electric Project is the largest hydroelectric project of Kerala State located in Idukki District. The project is aimed for power generation. This project, on Periyar river basin, envisaged creation of a reservoir by constructing three dams viz. Idukki Arch dam, Cheruthoni dam and Kulamavu dam. Water from the reservoir is diverted to an underground power house with an installed capacity 780 MW located at Moolamattom through tunnel/penstock etc. The reservoir is augmented by diverting water from adjacent streams viz. Kallar and Erattayar under Idukki HEP – Stage III. These five dams together are known to be Idukki dam complex. The Idukki reservoir was further augmented later by diversion from adjacent basins like Azhutha, Vazhikkadavu, Narakakkanam, Vadakkeppuzha etc.

1.2 Purpose, Location, Description of the Project

Idukki Hydro Electric Project

Idukki Hydro-Electric Project is located in the Western Ghats, 80 km from the Cochin Port, in the Southernmost Indian State of Kerala. The project is in Periyar River Basin. Three major dams viz. Idukki, Cheruthoni and Kulamavu are constructed as a part of this project to impound about 1995 Mm^3 of water in Idukki reservoir. Idukki reservoir is the largest man made reservoir of Kerala. In addition to the inflow from own catchment, the Idukki reservoir is augmented from adjacent tributaries by diversion arrangements. Kallar & Erattayar are augmentation schemes of Idukki reservoir which comes under Idukki – Stage III. Kallar dam is located in Idukki district Latitude 9^0 49' 32" N and Longitude 77^0 09' 23" E in Nedunkandam Panchayat, Udumbanchola Taluk of Idukki district.

The nearest city is Kochi, nearest railway station is Aluva about 116 km from dam site and nearest airport is CIAL, Nedumbasserry about 119 km from dam site. The index map and route map of Kallar and Erattayar dams are given in **Fig 1.1** and **Fig 1.2**.

The main components structures of Idukki HEP – Stage III are:

1. A concrete gravity diversion weir constructed across stream Kallar.
2. Diversion Tunnel from Kallar to Erattayar
3. A concrete gravity diversion dam constructed across stream Erattayar
4. Diversion Tunnel from Erattayar to Idukki reservoir

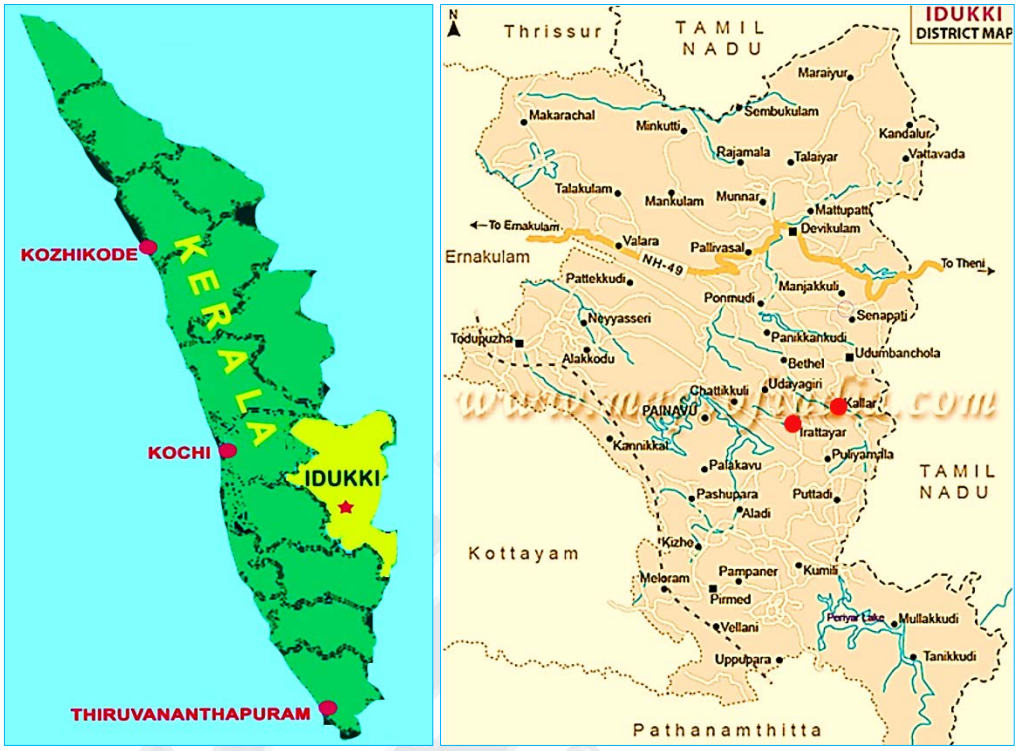

Fig 1.1 Kallar Erattayar Index Map

A schematic diagram of the project Idukki Stage III is outlined below in **Fig 1.3**. The project in general and salient features of its component structures are given below in **Table 1.1** for Idukki HEP Stage I & II and **Table 1.2** for Idukki Stage III. Due to the diversion of Kallar and Erattayar waters to Idukki reservoir, the firm power draft of Idukki power station will be augmented by 9.2 cumec. The additional power generation at Moolamattom power station will be 48 MW at 100% load factor.

A schematic diagram of the project is shown in **Fig 1.4**.

Fig 1.2 Kallar Erattayar Google Route Map

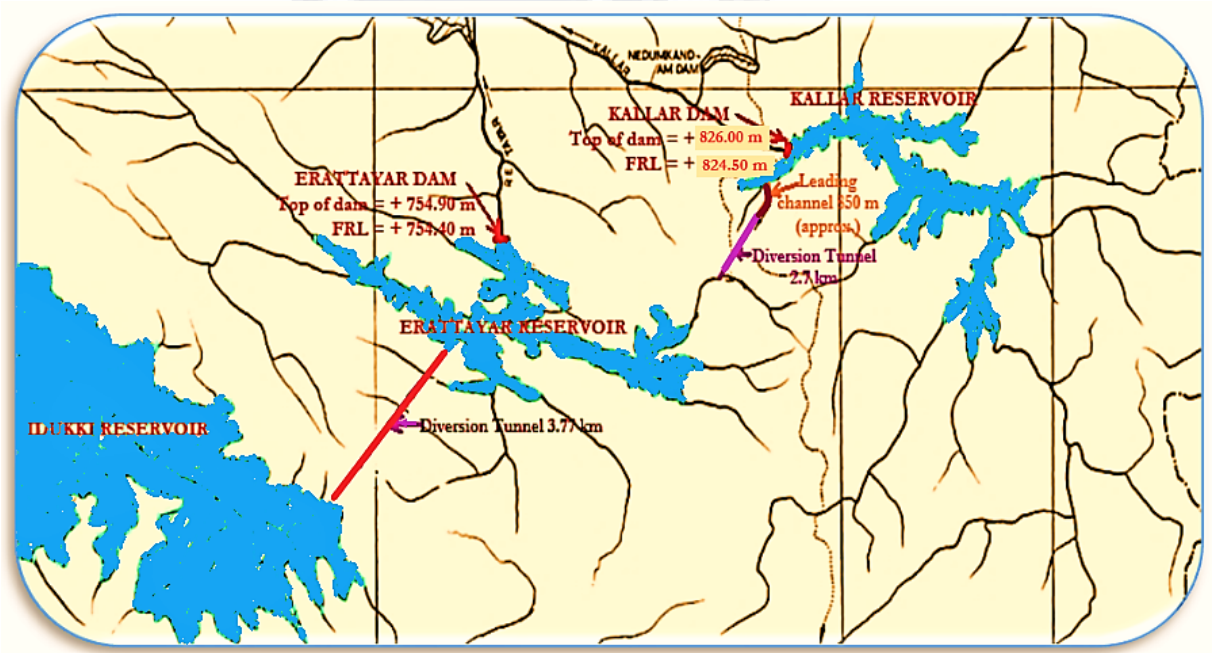

Fig 1.3 Idukki Stage III Layout

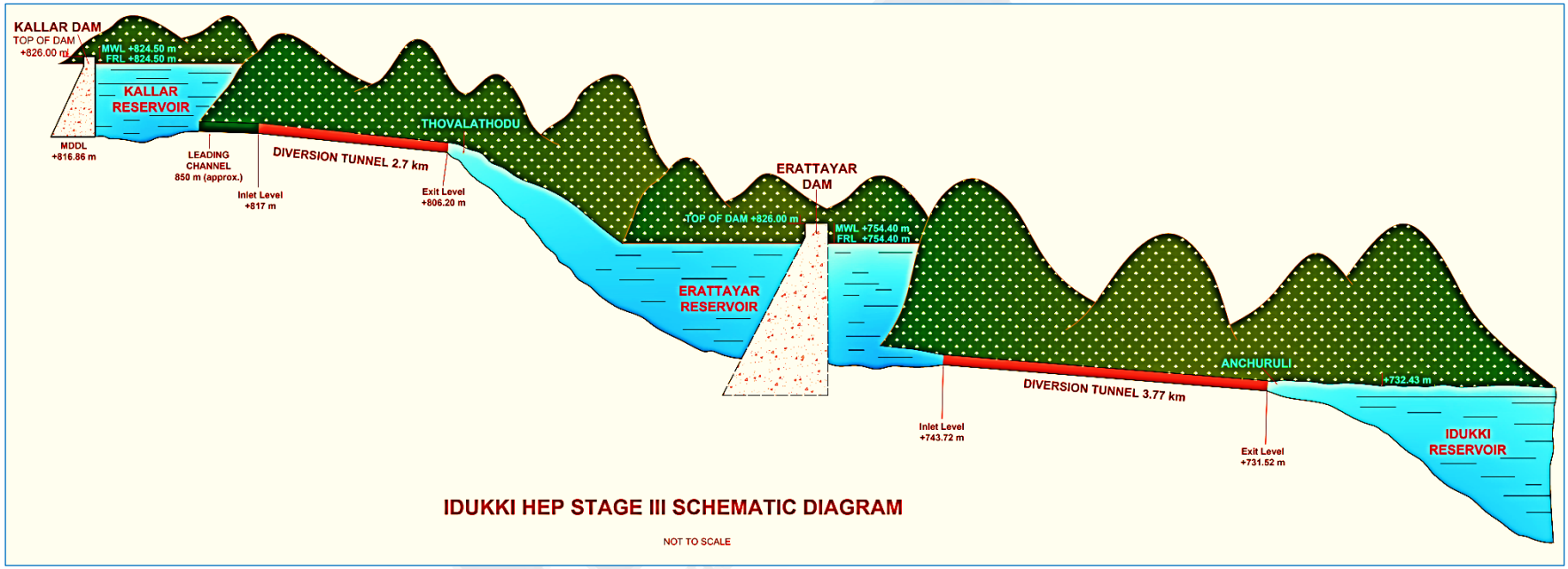

Fig 1.4 Schematic diagram of the project

MAIN FEATURES OF IDUKKI HE PROJECT (Stage I & II)		
A	**Hydrology and Power Potential**	
1	Total Catchment Area	649.30 sq km (526.28 sq km for Idukki-Cheruthoni +123.02 sq km for Kulamavu)
2	Average net effective head available	660 m
3	Firm power at 100% L.F	280.20 MW
4	Annual Average Power generation	2398 MU
5	Maximum rate of diversion to power station	147 m^3/s
B	**Idukki Dam**	
1	Type	Concrete double curvature, Parabolic, thin arch
2	F.R.L	+2403' (732.62 m)
3	M.W.L	+2408.5' (734.3 m)
4	Top of dam	+2415' (736.09 m)
5	Height of dam above deepest foundation	555' (169.16 m)
6	Length of dam at top	1200' (365.85m)
7	Effective Storage above MDDL+2280.0'	51543 Mcft (1459.5 Mm^3)
8	Dead storage below MDDL of +2280'	18957 Mcft (536.79Mm^3)
C	**Cheruthoni Dam**	
1	Type	Straight gravity concrete
2	F.R.L	+2403' (732.62 m)
3	M.W.L	+2408.5' (734.3 m)
4	Top of Dam	+2415' (736.09 m)
5	Length of Dam at Top	+2135' (650.75 m)
6	Height of Dam above deepest foundation	454' (138.38 m)
7	No. and size of radial gates	5 Nos 40' x 34' (12.19 m wide & 10.36 m high)
8	Crest level of spillway	2373.00' (723.29 m)
9	Spillway Capacity at FRL	3875 m^3/s
D	**Kulamavu Dam**	
1	Type	Masonry, Straight gravity
2	F.R.L	+2403' (732.62 m)

3	M.W.L	+2408.5' (734.3 m)
4	Length of Dam at Top	1263' (384.96 m)
5	Top of Dam	+736.28 m
6	Height of Dam above deepest foundation	328' (99.97 m)
7	Kulamavu H B Valve	1.83 m dia outlet
E	**Spillway for Idukki Reservoir at Cheruthoni Dam**	
1	Original design Flood (1974)	8019.83 m^3/s
2	Revised design Flood approved by CWC	9402 m^3/s including the flood contribution of 90.3 m^3/s from diversion schemes
3	Width of Spillway	240' (73.2 m)
4	Length of Spillway	149.35 m
5	No. and size of radial gates	5 Nos. 40' x 34' (12.19 m wide and 10.36 m high)
6	Spillway Discharge Capacity	3875 m^3/s at FRL
7	El. of Spillway Crest	2373.00' (723.29 m)
8	Clear roadway at Spillway bridge	4.572 m
9	El. of the top of Hoist Bridge	+986.49 m
F	**Powerhouse**	
1	Type	Underground single main chamber, excavated in solid rock.
2	Length	460 ft (140.21 m)
3	Width	65 ft (19.81 m)
4	Height	115 ft (from crown of roof to bottom of turbine pit) (35.05 m)
5	Valves	6 spherical valves, 63 in (1.60 m) diameter
6	Turbines	6 vertical Pelton turbines with 6 jets, 375 rpm, 130 HP each. **(3 Turbines in 1st stage and another 3 Turbines in 2nd stage)**

Table 1.1 Main Features of Idukki HE Project (Stage I & II)

The salient features of **Idukki Stage III** are tabulated below.

	DIVERSION SCHEMES	
1.	**KALLAR**	
a.	**Diversion Weir**	
1	Type	Concrete Gravity
2	Length of Dam at Top	57.91 m
3	Width of Dam at Top	3.50 m
4	Height above deepest foundation	12.19 m
5	Main Spillway Arrangement**:**	
	(i) Type of Spillway	Ogee
	(ii) No. of Bays	4
	(iii) Type of Gate	Radial
	(iv) Size of Gate**:**	
	Height	6.10 m
	Width	7.62 m
	(v) Total Spillway Capacity of all bays	1014 m^3/s
	(vi) Gate Hoisting Arrangement	Rope-Drum Type
6	Catchment Area at Dam site	187 sq km
7	Maximum Water Level	824.5 m
8	Full Reservoir Level	824.5 m
9	Minimum Draw Down Level	816.86 m
10	Live Storage Capacity	0.76 Mm^3
11	Gross Storage Capacity at FRL	0.79 Mm^3
12	Reservoir Spread Area at FRL	0.25 sq km
b.	**Diversion Tunnel**	
1	No of tunnel	One
2	Length	8975 ft (2735.58 m)
3	Type & Size	Unlined circular 5.03 m dia
4	Sill level at intake	2680 ft (816.86 m)
5	Slope	1 in 250
6	Maximum velocity	8 ft/sec (2.44 m/s)
7	Maximum flow	1712 cusecs (48.48 cumec) at FRL

2.	**ERATTAYAR**	
a.	**Diversion Weir**	
1	Type	Concrete Gravity
2	Length of Dam at Top	146.30 m
3	Width of Dam at Top	4.70 m
4	Height above deepest foundation	23.50 m
5	Volume Content of Dam	465000 m^3
6	Main Spillway Arrangement:	
	(i) Type of Spillway	Ogee
	(ii) No. of Bays	2
	(iii) Type of Gate	Radial
	(iv) Size of Gate:	
	Height	6.10 m
	Width	7.62 m
	(v) Total Spillway Capacity of all bays	507 m^3/s
	(vi) Gate Hoisting Arrangement	Rope Drum Type
	(viii) Energy Dissipation Arrangement	Ski jump
6	Catchment Area at Dam site :	68.80 sq km
7	Maximum Water Level	754.40 m
8	Full Reservoir Level	754.40 m
9	Outlet Levels (Centre line of river sluice at entrance)	741.00 m
10	Gross Storage Capacity at FRL	5.35 Mm^3
11	Reservoir Spread Area at FRL	0.96 sq km
b.	**Diversion Tunnel**	
1	No of tunnel	One
2	Length	12375 ft (3771.90 m)
3	Type & Size	Unlined circular 5.94 m dia
4	Sill level at intake	2440 ft (743.71 m)
5	Slope	1 in 315
6	Maximum velocity	8 ft/sec (2.44m/s)
7	Maximum flow	2400 cusecs (67.96 cumec) at FRL

Table 1.2 Main Features of Idukki HE Project (Stage III)

The Reservoirs

The Idukki reservoir is formed in Periyar River basin by constructing three dams viz. Idukki, Cheruthoni & Kulamavu. There are two diversion dams/weirs across Kallar and Erattayar streams. A gated weir is constructed across Kallar stream near Nedumkandam town. From Kallar, water is diverted to Erattayar stream through a channel and tunnel with exit at Mannakudy near Valiya Thovala. In Erattayar also there is diversion structure which diverts the water diverted from Kallar plus the inflow from its own catchment to Idukki reservoir through a tunnel which exit to Idukki reservoir at Anchuruli. The layout map of the reservoirs under the project is shown in **Fig 1.5**. Google map view of the reservoir is given in **Fig 1.6**.

In addition, the following Augmentations schemes are diverting more waters from neighboring streams to increase the power potential of the project.

Project	**Energy addition**
Idukki Stage III	376 MU
Narakakkanam	7 MU
Vazhikkadavu	25 MU
Vadakkepuzha	12 MU
Kuttiyar	44 MU
Azhutha	57 MU
Total addition	**521 MU**

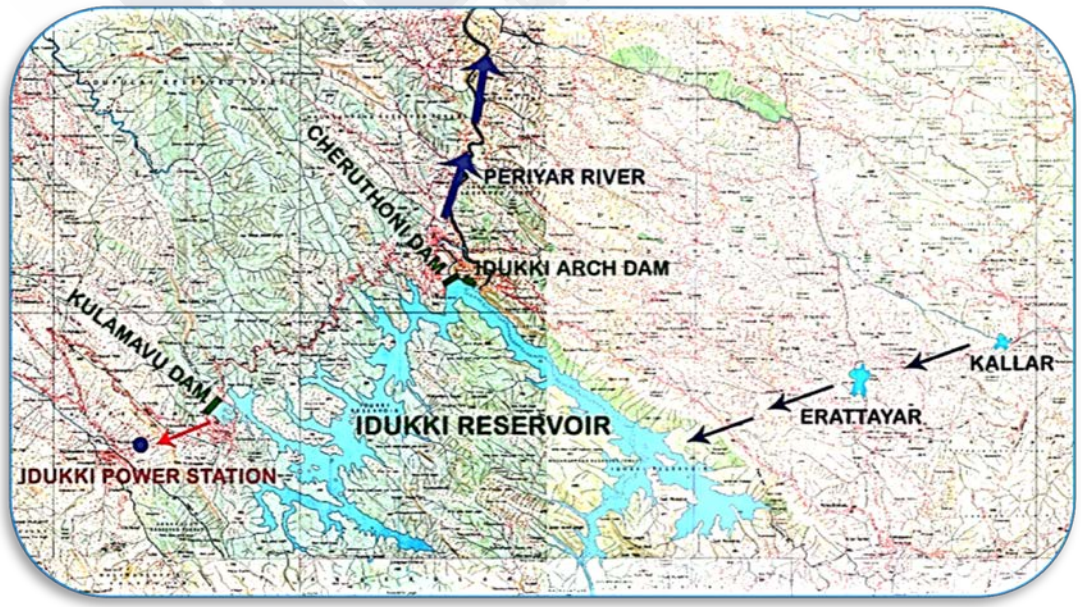

Fig 1.5 Reservoir Layout of IHEP

Fig 1.6a Google map view of Kallar Dam

Fig 1.6b Google map view of Kallar Dam

1.3 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 are identified by their designation and, in particular, the responsibilities of operating personnel are specifically identified in below and include regularly scheduled duties which staff personnel are required to perform as outlined.

Project Administration Officer	-	Chairman& Managing Director, KSEB Ltd
Chief Controlling Officer (Dam Safety &Operation)	-	Chief Engineer (Civil–DS & DRIP), KSEB Ltd, Pallom, Kottayam
Authority of Spillway and Flood releases	-	Deputy Chief Engineer, Research & Dam Safety Organization, Pallom, KSEB Ltd.
Controlling Operations of equipment at the dam	-	Executive Engineer, Dam Safety Division No. II, Vazhathoppe
Authorizing spillway flood releases	-	Executive Engineer, Dam Safety Division No. II, Vazhathoppe, Idukki
Authorizing releases from Dam	-	Executive Engineer, Dam Safety Division No. II, Vazhathoppe, Idukki.
Reservoir inflow and flood forecasting	-	Assistant Executive Engineer, Dam Safety Sub Division I, Vazhathoppe, Idukki
Recording reservoir data, Routine inspection	-	Assistant Executive Engineer, Dam Safety Sub Division I, Vazhathoppe, Idukki
Maintenance, Dam safety surveillance including instrumentation	-	Assistant Engineer, Dam Safety Sub Division I, Vazhathoppe, Idukki

1.3.1 Roles and Responsibilities of the AEE and AE during Monsoon

Flood condition assessment, warning, flood mitigation, and other responsibilities

1. Coordinate with the Asst. Exe. Engineers of other Sub Divisions and get the information on inflow status, reservoir level and to bring it to the notice of the EE/Dy.CE.

2. Assist the EE to issue notification to the inhabitants downstream in Newspapers, Radio and TV News channel to alert regarding the flood situation.

3. Assist the EE/ Dy.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. Maintain the reservoir water level gauge register and to update on hourly basis during floods and report to EE/ Dy.CE.

5. Submit to the EE/ Dy.CE /CE on the inflows and releases from the reservoir and status of the reservoir twice in the day.

6. Maintain the spillway crest gate operation log book.

7. Operate the Spillway crest gates for flood mitigation as per the instructions of the EE/ Dy.CE and to update the Gate operation Log book

8. Observe the seepages in the drainage Gallery with respect to the reservoir head and bring to the notice of the EE in case of excessive seepage/leakage in any specific portion.

9. Observe the gates and to see that the drain holes are not clogged and floating debris is not deposited in the gate components

10. 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

11. Observe the dam top, ensure that embankment, catwalk, approach roads are well maintained by housekeeping personnel

12. 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 in case of any untoward incidents or malfunctioning of the gates of excessive seepages, leakages etc.

13. Assist EE/Dy.CE to coordinate with the Generating staff of Moolamattom Powerhouse downstream in the operation and power generation.

1.3.2 Roles and Responsibilities of the Executive Engineer during Monsoon

1. Conduct Periodical inspections to assess the health of the Dam and to direct the Asst. Executive Engineer for the immediate repair and maintenance for the smooth operation.

2. Conduct Pre and Post Monsoon inspections of the Dam and submit the report to Dy.CE and upload in DHARMA web site.

3. Observe the performance of the Dam and its appurtenant structures / Gates and Hoists before and after monsoon and to issue necessary instructions to the Asst. Executive Engineer

4. Coordinate with the Engineers of the sub divisions & to get the information in the rainfall and inflow status and to bring to the notice of the Dy.CE.

5. Coordinate with the Generating staff of Moolamattom Powerhouse downstream in the operation and power generation.

6. To issue notification to the inhabitants downstream in Newspapers, Radio, TV News channel to alert them regarding the flood situation

7. Submit to the Dy.CE the daily inflows and releases/Gate operation from the reservoir and status.

8. Observe the seepages in the Drainage Gallery with respect to the reservoir head and bring to the notice of the Dy.CE in case of excessive seepage, leakage in any specific portion.

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 embankment, catwalk, 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 Dy.CE in case of malfunctioning of the gates of excessive seepages, leakages etc.

1.3.3 Roles and Responsibilities of the Deputy Chief Engineer during Monsoon

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, releases etc.

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 EE/AEE.

5. Coordinate with the Generation wing of KSEB Ltd regarding the power generation requirement.

1.4 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 (On hourly basis during monsoon and daily basis during non-monsoon)
- Spillway outflow (On hourly basis during monsoon)
- Weather related data

Date	MWL (m)	FRL (m)	Crest Level (m)	Present Water Level at 8.00 am	Previous Year Water Level at 8.00 am	Percentage Storage	Rainfall (mm)	Generation (MU) of the day	Spill of the day	Gate Operation Details

Table 1.3a Daily Reservoir Data

Date	Time (hourly)	MWL (m)	FRL (m)	Crest Level (m)	Present Water Level	Previous Hour Water Level	Percentage Storage	Storage of the hour	Spill of the hour	Gate Operation Details

Table 1.3b Hourly Reservoir Data

Instruction is given to the Executive Engineer for daily collection and reporting of inflow and outflow data in a standard proforma as in **Table 1.3** above to the Deputy Chief Engineer.

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

- Date and Time
- 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 on hourly basis in monsoon and on daily basis during non-monsoon.
Reservoir inflow	This is calculated on hourly basis in monsoon and on daily basis during non-monsoon.
Spillway outflow	This is calculated on hourly basis in monsoon and on daily basis during non-monsoon.
Irrigation, water supply and hydropower releases	The reservoir water is diverted to Erattayar reservoir with no control gate and from there to Idukki reservoir for power generation at Moolamattom power house. There is no arrangement of measuring the discharge diverted to Erattayar.
Weather related data	Collected and reported daily
Surveillance/Security arrangements	Provided security check posts near dams. The watch and ward of the dam structure and premises is arranged with private security agencies.
Attendance statement during normal operations	Both during monsoon and non-monsoon period maintained at field office.
Operations of the spillway gates and outlet works	The spillway is designed for a safe discharge of 1014 m^3/s at FRL. There are 4 no's of radial gates for spillway operation. The spillway operations are recorded in the gate operation log book.

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.
Maintenance activities carried out	Details maintained at field office
Reservoir and dam inspections	Periodically inspected and details maintained at field office as well as forwarded to higher offices and upload in DHARMA
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	Network available at Dam site but not with full band strength at some locations.
Safety and special instructions	Safety equipments are provided
Names and addresses of official visitors	Record of inspections maintained at office

1.5 Public Utilities 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. Inspection Bungalow is provided near Cheruthoni and Idukki Dams. Dam is located in Nedumkandam Panchayat of Idukki District. Directional display boards are erected all along the road by state PWD and KSEB Ltd. The project site is accessible from Kumili – Munnar Road. The approximate distance to the project site from Kumili is 42 km.

Location of public conveniences:

Nearest Airport: CIAL, Cochin 119 km.

Nearest Railway Station: Aluva, 116 km.

Nearest Police Station: Kumily, 42 km.

Nearest Hospital: Medical College Idukki, 34 km.

1.6 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 include: confined spaces such as Control room, Gate operation area, Adits, galleries, spillway approach, chute, energy dissipation arrangements, intake, tunnel etc. Warning boards showing the restricted area are placed at the dam premises.

Lighting of Dams

General lighting on dam top and dam premises are provided.

Dam safety surveillance

Security arrangements with private agencies are provided near dam at security check post. Security Arrangement Existing**:** Kerala Ex-servicemen security @ 3 shifts per day

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

1.7 Staff position, Communication & Warning System

The number & description of operating unit personnel posted/placed at different locations of the dam are noted in supporting documents and referenced in this Manual. Means of communications both in normal and emergency situations are identified in the Communication Directory.

A hierarchy of organizational structure for the control and safety of Kallar and Erattayar dams is outlined below in **Fig 1.7**. Kallar and Erattayar dams are under the control of Dam Safety Sub Division No.I, Vazhathoppe, Idukki. Means of communications both in normal and emergency situations are identified in the Communication Directory. Available communication means including landline, mobile and satellite phones, wireless sets are provided. Basic warning facilities like mike announcement is provided.

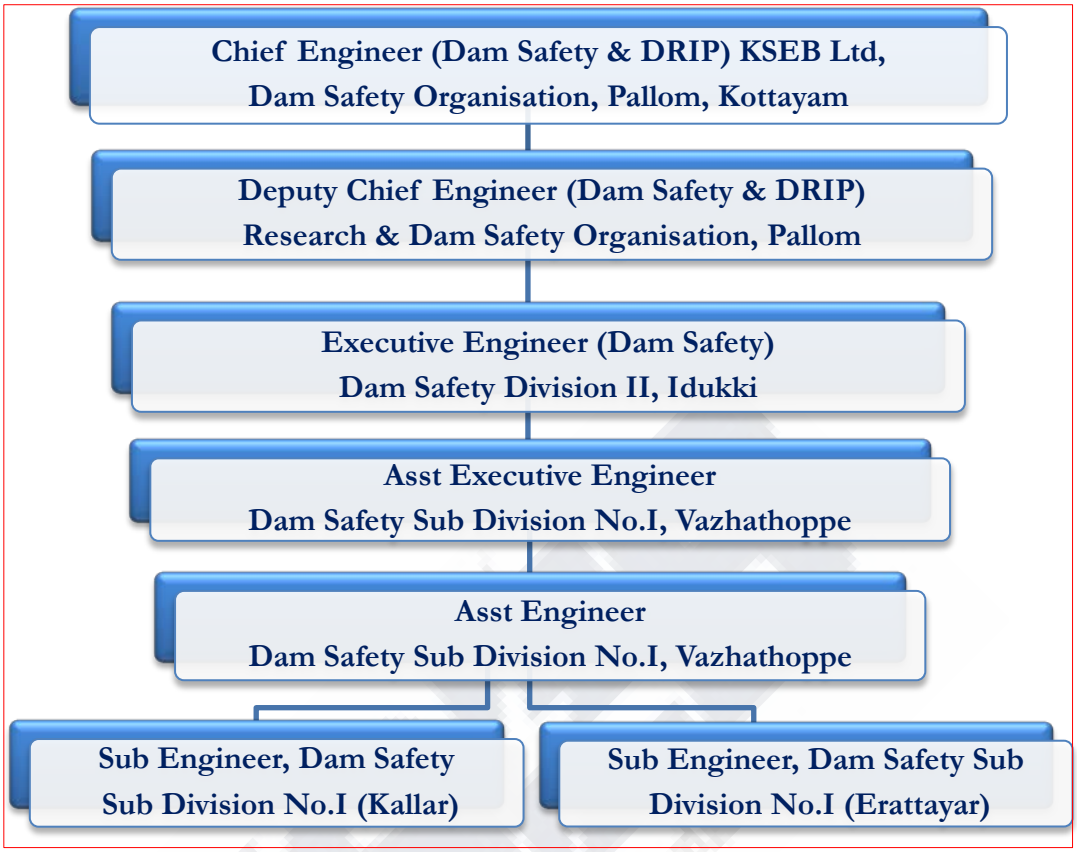

Fig. 1.7 Dam Safety Organisation Structure for Kallar and Erattayar dams

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

Designation and office address	Contact number and e-mail
Chief Engineer Civil (Dam safety & DRIP), KSEB Ltd, Dam Safety Organisation, Pallom, Kottayam	Ph: 9496018719, 9446008964 e-mail: cedamsafety@kseb.in, cedamsafety@gmail.com
Deputy Chief Engineer, Research & Dam Safety Organization, Pallom, Kottayam	Ph: 9446008492, 0481-2432290, 9496011540 e-mail: dirroplm2@gmail.com
Executive Engineer, Dam Safety Division No. II, Vazhathoppe	Ph: 9446008425 e-mail: ddrdskkds@gmail.com
Assistant Executive Engineer, Dam Safety Sub Division No. I, Vazhathoppe	Ph: 9446011961 e-mail: aee1dssd@gmail.com
Assistant Engineer, Dam Safety Sub Division No. I, Vazhathoppe	e-mail: aee1dssd@gmail.com

Spillway flood releases

Spillway gates at Kallar are being opened during flood season, as the inflow to the reservoir increases and reservoir reaches to FRL. Since this is a very small reservoir of capacity 0.79 Mm^3, no alerts are fixed for opening of spillway gates. No special warning is given as the discharge through spillway can be easily managed with the widened river course downstream.

Releases for various purposes like irrigation, water supply and hydropower

This is an augmentation reservoir for diversion to Idukki. The water from Kallar reservoir is diverted to the Erattayar reservoir and from there to Idukki reservoir for additional power generation at Moolamattom underground power house of KSEB Ltd. The tail-race system of tunnels and channels carry the Idukki waters after power generation to Valiar, a tributary of Thodupuzha River in the Muvattupuzha basin.

Warning system: Mike announcement, Newspaper and Television are used for providing warning to the downstream areas in case of heavy floods.

Routine inspection

Usually monthly inspection and quarterly inspections are carried out by the operating/controlling officers. Pre-monsoon inspection and Post monsoon inspection as per CWC are carried out and reports intimated to CWC. These reports are to be updated in DHARMA web site. Details are given under the **Chapter 'Project Inspection'**.

Maintenance

Routine maintenance is carried out for spillway gates and hoisting mechanism as part of routine maintenance before the onset of monsoon. Details are given under the **Chapter 'Project Maintenance'**.

1.8 Distribution of Operation & Maintenance Manual

The following officers/ field staff at different levels in the Division under the supervision of Deputy Chief Engineer, Research & Dam Safety Organization, KSEB Ltd, Pallom and administrative control of Chief Engineer, Dam Safety Organization, KSEB Ltd, Pallom are entrusted with the specific responsibility for carrying out O & M activities for Kallar and Erattayar dams.

1) Executive Engineer, Dam Safety Division No. II, Vazhathoppe
2) Asst. Executive Engineer, Dam Safety Sub Division No. I, Vazhathoppe
3) Assistant Engineer, Dam Safety Sub Division No. I, Vazhathoppe
4) Personnel in charge of works of the Dam

The offices/officers to which the O & M Manual of Kallar dam is to be distributed are:

1. Dam Safety Division No. II, Vazhathoppe
2. Dam Safety Sub Division No. I, Vazhathoppe
3. Assistant Engineer, Dam Safety Sub Division No. I, Vazhathoppe
4. Office of Deputy Chief Engineer, Research & Dam Safety Organization, KSEB Ltd, Pallom
5. Office of Chief Engineer, Dam Safety Organization, KSEB Ltd, Pallom
6. Central Project Monitoring Unit, CWC, New Delhi

1.9 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.

- Detailed drawings of the Project
- Emergency Action Plan (EAP)
- Latest Hydrology Review Report and flood routing study
- Latest DSRP Report
- Flood forecasting and operating criteria of the reservoir
- Operating criteria of the spillway and outlets
- Administrative procedures
- Maintenance Procedure
- Gate Manufacturer's manual and drawings
- Regional communication directory
- Instrumentation reports / results

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 1.4**.

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.	Hourly in monsoon & Daily in non-monsoon	Sub Engineer/Dam operators on contract
3	Record meteorological data and seepage from drainage systems	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	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, diversion tunnel intake structure etc.	Weekly	Assistant Engineer
6	Check stand by generator (DG Sets), Drainage systems etc.	Weekly	Assistant Engineer
7	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, diversion tunnel intake structure etc.	Fort nightly	Assistant Executive Engineer

8	Check security and safety devices, logbook and site register which include the above information.	Fort nightly	Assistant Executive Engineer
9	Check stand by generator (DG Sets), Drainage systems etc.	Fort nightly	Assistant Executive Engineer
10	Measuring devices, communication devices, status of instruments, vegetation growth	Fort nightly	Assistant Executive Engineer
11	Check Sign/Warning display boards near vulnerable locations	Fort nightly	Assistant Executive Engineer
12	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, diversion tunnel intake structure etc.	Monthly	Executive Engineer
13	Check measuring devices/instruments, Communication devices, Status of vegetation growth, rectification, if needed.	Monthly	Executive Engineer
14	Check Sign/Warning display boards near vulnerable locations	Monthly	Assistant Executive Engineer
15	Replace fuse light bulbs, Inspect to maintain ventilation system, cleaning of control panel boards.	Monthly	Assistant Engineer
16	Check operation of gates, gate air vents, clean gate control switchboxes, clean inside of motor control cabinet, grease gate hanger/dogging etc.	Quarterly	Executive Engineer
17	Check condition of spillway, energy dissipation arrangement, d/s area etc. Check and clear spillway bridge drains,	Quarterly	Executive Engineer
18	Check hydro mechanical components for spillway	Quarterly	Executive Engineer

19	Inspection of Spillway, 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 rubber seals and seal clamp bar.	Half yearly (Pre and Post Monsoon)	Executive Engineer along with Asst. Executive Engineer & Asst. Engineer in charge of dam
20	Submission of Pre-Monsoon and Post-Monsoon Inspection reports to State Govt., CWC and uploading into DHARMA.	Half yearly	Executive Engineer
21	Comprehensive inspections	Annually	Dam Safety Authority along with Dam Owners
22	Inspect dam and gate structures, trash racks under water by de-watering and stilling basin/energy dissipation arrangement, Diversion tunnel in dry condition etc.	Five Yearly	Chief Engineer/ Deputy Chief Engineer
23	Review Dam operation procedures, O & M Manual & update	Ten Years	Executive Engineer
24	Comprehensive inspection of performance of the dam and gate structures and reservoirs, trash racks and stilling basin /energy dissipation arrangement.	Ten Yearly	DSRP

Table 1.4 Schedule of duties/inspections

1.11 Hydro-Mechanical Inspections / Checks

Frequent inspections/checks of hydro-mechanical components in spillway are to be conducted and necessary action to be taken up during maintenance. Routine maintenance is carried out for Spillway gates and hoisting machinery as part of routine maintenance before the onset of monsoon. Details are given under the Chapter **'Project Maintenance'**.

Chapter 2

Project Operation

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

2.1 Basic Data

Kallar and Erattayar dams operation plan contains step-by-step instructions for operating the dams and reservoir during routine (normal) and emergency conditions. The operating procedures for normal operations (for both monsoon and non-monsoon period) are discussed in this chapter including operating criteria for the reservoir and spillway. The operation of the dam will involve regulation of its reservoir as per project specific requirements.

The emergency conditions are outlined in **Cl 4.2.1** on Maintenance. Emergency Action Plan is required to be invoked during emergency conditions.

2.1.1 Kallar Dam

Kallar diversion structure is constructed, as part of Idukki Stage III development, across Kallar stream near Nedumkandam town with a catchment area of about 187 km^2. Kallar is a concrete gravity diversion weir having 4 blocks constructed across stream Kallar. The entire width of the channel is blocked by four bays of spillway structure. Length of overflow portion is 30.48 m. Bed level at weir site varies from +815.00 m to +826.00 m. The dam is abutted with solid rock abutments on either side by small portion of non-overflow blocks. A sloping apron from the downstream slope of spillway forms the energy dissipation arrangement terminating in river bed comprising of solid rock.

A typical non overflow section of Kallar dam is given in **Fig 2.1**. Photographs showing downstream and upstream elevation of spillway at Kallar dam are given in **Fig 2.2a** and **Fig 2.2b.**

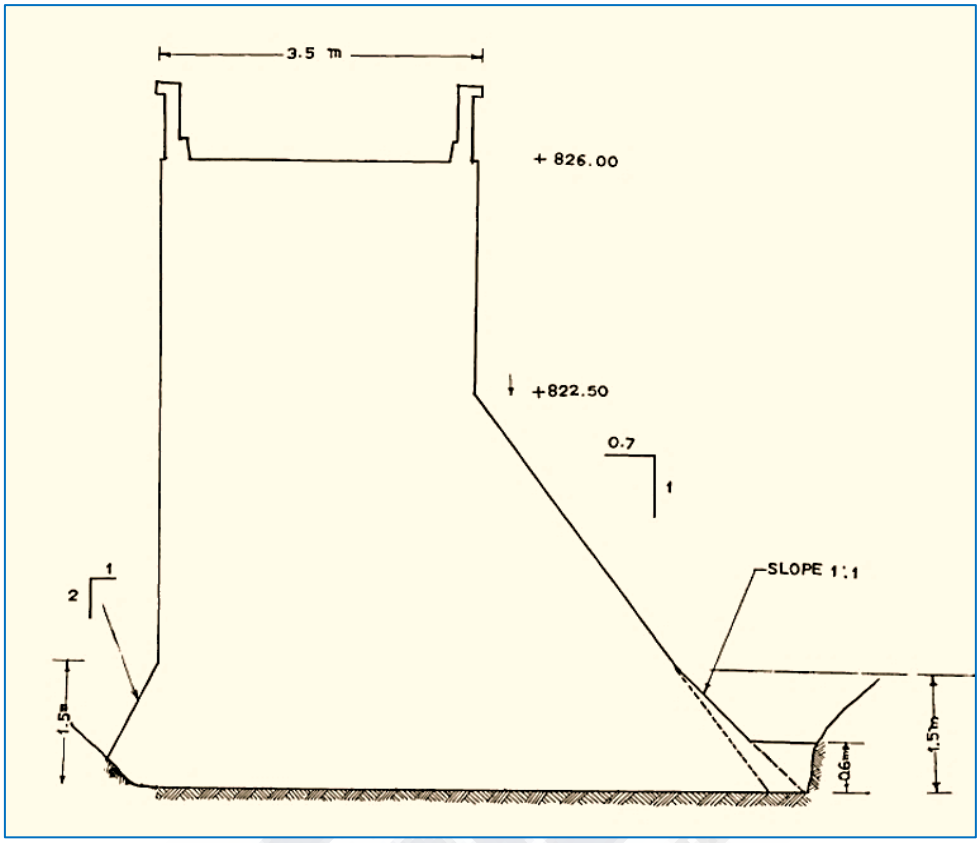

Fig 2.1 Typical non overflow section of Kallar dam

Fig 2.2a Downstream Elevation of Kallar Dam

Fig 2.2b Upstream Elevation of Kallar Dam

2.1.2 Kallar Spillway

The diversion of flow is mainly done by radial gates 4 Nos (7.62 m width and 6.10 m height) erected over the weir. The gross storage capacity is only 0.79 Mm^3. The overflow arrangements span over the total width of stream after enlarging the cross section of the stream at weir site. The stream in the downstream portion of the weir is also widened. The design flood of the project is 982 m^3/s at FRL. The discharge capacity of this structure is 1014 m^3/s at FRL. The entire width of the channel is blocked by four bays of spillway structure. The spillway is of Ogee type and hoist is of rope drum type. Clear length of overflow portion is 30.48 m (4 x 7.62 m) excluding piers. The maximum overflow section of the spillway at Kallar dam is given in **Fig 2.3**. The upstream elevation showing spillway and plan of spillway are given in **Fig 2.4** and **Drg 2.1 & 2.3 of Annexure 1** respectively.

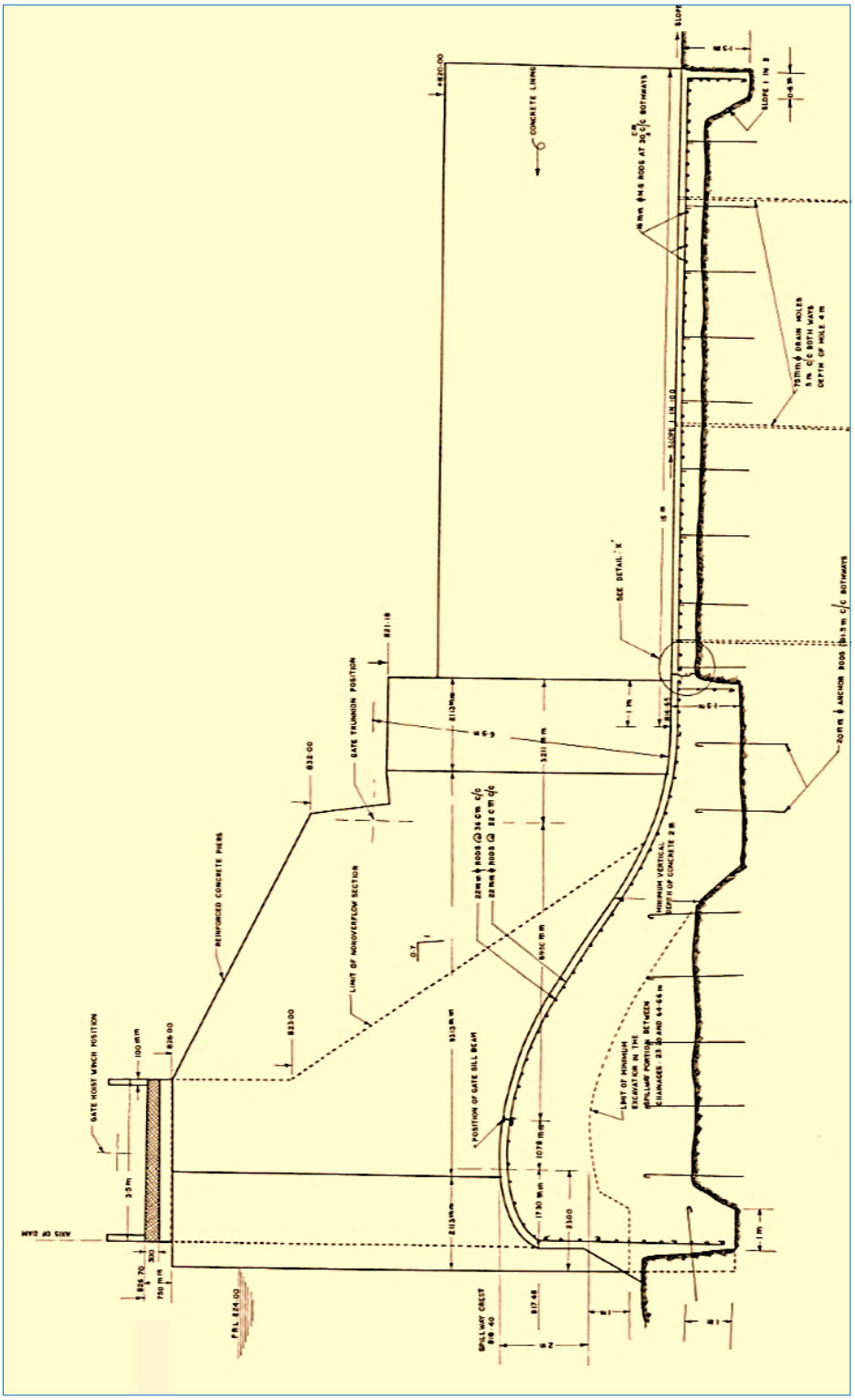

Fig 2.3 Overflow Section of the spillway at Kallar dam

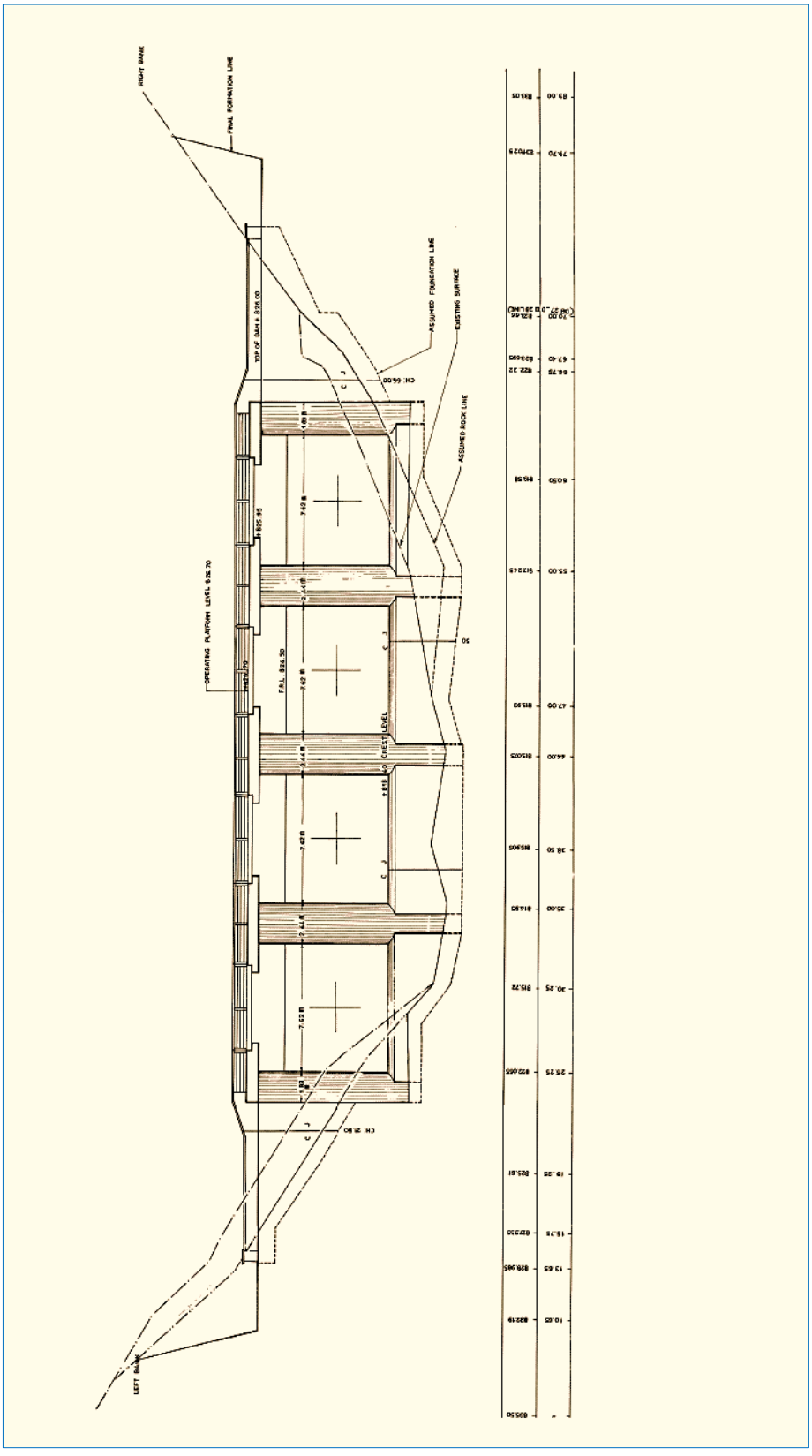

Fig 2.4 Upstream Elevation of the spillway at Kallar dam

2.1.3 Spillway operation schedule

There is no specific spillway operation schedule as this is a small diversion weir of gross storage 0.79 Mm^3. As reservoir approaches FRL, the gates are opened for regulating the water to downstream. The original design flood estimated based on Ryves formula was 982 m^3/s. The spillway capacity provided is 1014 m^3/s at FRL.

A register with the following details is to be maintained to give the details of gate operation.

- Date, Hour
- Reservoir level at the end of the hour (m)
- Rise or fall in reservoir level (m)
- Change in storage (m^3/s)
- Release from the reservoir during the hour (m^3/s)
- Details of Gate opening during the hour.

2.1.4 Elevation Capacity Curve

The area and capacity curves for Kallar Reservoir used during design stage are given in **Drg 2.2 of Annexure 1**. The Elevation & Capacity (Storage) tabulated based on **Drg 2.2** for Kallar Reservoir are given in **Table 2.1.**

Water level in feet	Water level in metre	Storage in Mcft	Storage in Mm^3	Remarks
2675	815.34	0.00	0.0000	
2680	816.86	0.086	0.0024	
2690	819.91	6.47	0.1832	
2700	822.96	10.53	0.2982	
2705	**824.50**	**28.00**	**0.7929**	**FRL**
2710	826.01	41.00	1.1610	
2720	829.06	85.45	2.4197	

Table 2.1 Kallar Reservoir Elevation Vs Capacity

2.2 Operation Plan

An effective operation plan and schedule is required for the safe project operation for which the project specific features shall be known. The salient features of the dam and reservoir are detailed in **Chapter 1**. Since this is only a small diversion structure, the reservoir is operated based on requirement.

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 rainfall of 484 mm and 751 mm respectively was recorded.

The second historical flood which occurred during August 14 to 17 in the year 2018 is the highest flood recorded in the catchment. The SW monsoon of the year 2018 in the State was similar to that of 1924 Devikulam storm. Kerala experienced 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 in Pamba, Periyar and Bharathapuzha sub-basins are almost comparable to the Devikulam storm of 16-18, July 1924. For the entire Kerala, out of 758.6 mm rainfall from 1 August 2018 to 19 August 2018, about 414 mm rainfall (Kerala average) 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 (Kerala average). The 3-day rainfall of 15-17, August 2018 at Idukki dam site was 812 mm. The 4–day rainfall of 15-18, August 2018 at Idukki dam site was 1032 mm which is one of the highest in the State.

Kallar spillway shutters are opened frequently during monsoons for flood control.

2.2.2 Design Flood and Features Related to Safety

Details regarding Hydrology as available is given below.

Hydrology (Original)

The catchment area at Kallar Diversion site is approximately 187 km^2. The gross storage of the structure is 0.79 Mm^3. The original flood was estimated using Ryves equation with a C

value 2000 in FPS units. The design flood of the project is 982 m^3/s. The discharge capacity of the spillway is 1014 m^3/s at FRL.

Hydrology review carried out in DRIP

The estimation of the revised design flood of Kallar has been done as per the FER 5 (a) & (b) published by Central Water Commission. As per the qualifying criteria, the design flood of this diversion structure is to be estimated with a storm of return period 100 years. The point rainfall with 100 year return period as per PMP Atlas at this catchment is 20 cm and the catchment area at the diversion site is 187 km^2. The revised design flood is estimated as 939 m^3/s. The spillway capacity provided is 1014 m^3/s. Hence the existing spillway can easily negotiate the design flood.

2.2.3 Hoisting Arrangements for Radial Crest Gates

As detailed in **Cl 2.1.2,** Kallar spillway has 4 No's radial gates of size 7.62 m (width) x 6.10 m (height) erected over the weir**.** The details of spillway radial crest gates are given in **Drg 2.4** and a longitudinal section in **Drg 2.5** of **Annexure 1**. The platform of the gate hoist structure is located at El.826.7 m (**Drg 2.4** of **Annexure 1**). Photograph showing hoist platform is given in **Fig 2.5**. Photograph of the downstream side of spillway is given in **Fig 2.6 & Fig 2.7** and Radial Gates hoist mechanism in **Fig 2.8**. These gates are operated **electrically and manually**. Three phase electric supply is available at site and a 30 KVA DG set is also provided. Salient features of gates and hoists are tabulated below:

Fig 2.5 Kallar dam hoist platform

Fig 2.6 View of Radial Gates hoisting Mechanism from downstream

Fig 2.7 View of Spillway Gate Operation Bridge from downstream

Fig 2.8 Radial Gates hoist mechanism

Radial crest gates		
• **Gate structure**		
Type of gate	:	Spillway radial crest gates
Size of gate		
a. Clear span	:	7.62 m
b. Height	:	6.10 m
c. Radius	:	7.62 m
Elevations		
a. Crest	:	818.40 m
b. Trunnion	:	821.448 m
• **Hoist**		
Motor		
a. Speed	:	966 rpm
b. HP	:	5 HP
c. Supply	:	414 Volts, 3 phase
Electro-magnetic brake	:	414 V, single phase type
Wire rope	:	28 mm dia fibre core
Seal	:	Bronze cladded rubber seal

2.3 Normal Operation of the Reservoir

2.3.1 Operation of the Reservoir

Kallar reservoir is augmenting the Idukki reservoir. The reservoir capacity is only 0.793 Mm^3. The reservoir water is diverted through a tunnel and a leading channel from tunnel exit to Erattayar reservoir. The river section is widened at the weir site to accommodate the flood due to monsoon. There is no specific operating schedule for this reservoir. As water level rises and reaches FRL, the spillway gates are opened for releasing the excess water. There is no alert system for operating this spillway.

Spillway Rating Curve

During flood season, the reservoir water is released through spillway gates. The Full Reservoir Level is **824.50 m** and spillway crest level is **818.40 m**. The total spillway discharge (free discharge) through spillway gates (4 No's) for different reservoir levels under full opened condition is tabulated in **Table 2.2** and is given in **Fig 2.9**. Discharge (Rating) curve through single spillway for different reservoir levels with different gate openings is given in **Fig 2.10** and tabulated in **Table 2.3**.

Water Level in m	Spillway discharge through one gate in m^3/s	Total Spillway discharge (4 gates) in m^3/s
818.40	0.00	0.00
819.00	11.77	47.10
820.00	38.91	155.63
821.00	74.19	296.74
822.00	121.15	484.59
823.00	168.86	675.44
824.00	221.38	885.53
824.50	253.50	1014.01

Table 2.2 Free Discharge Table for Spillway Gates

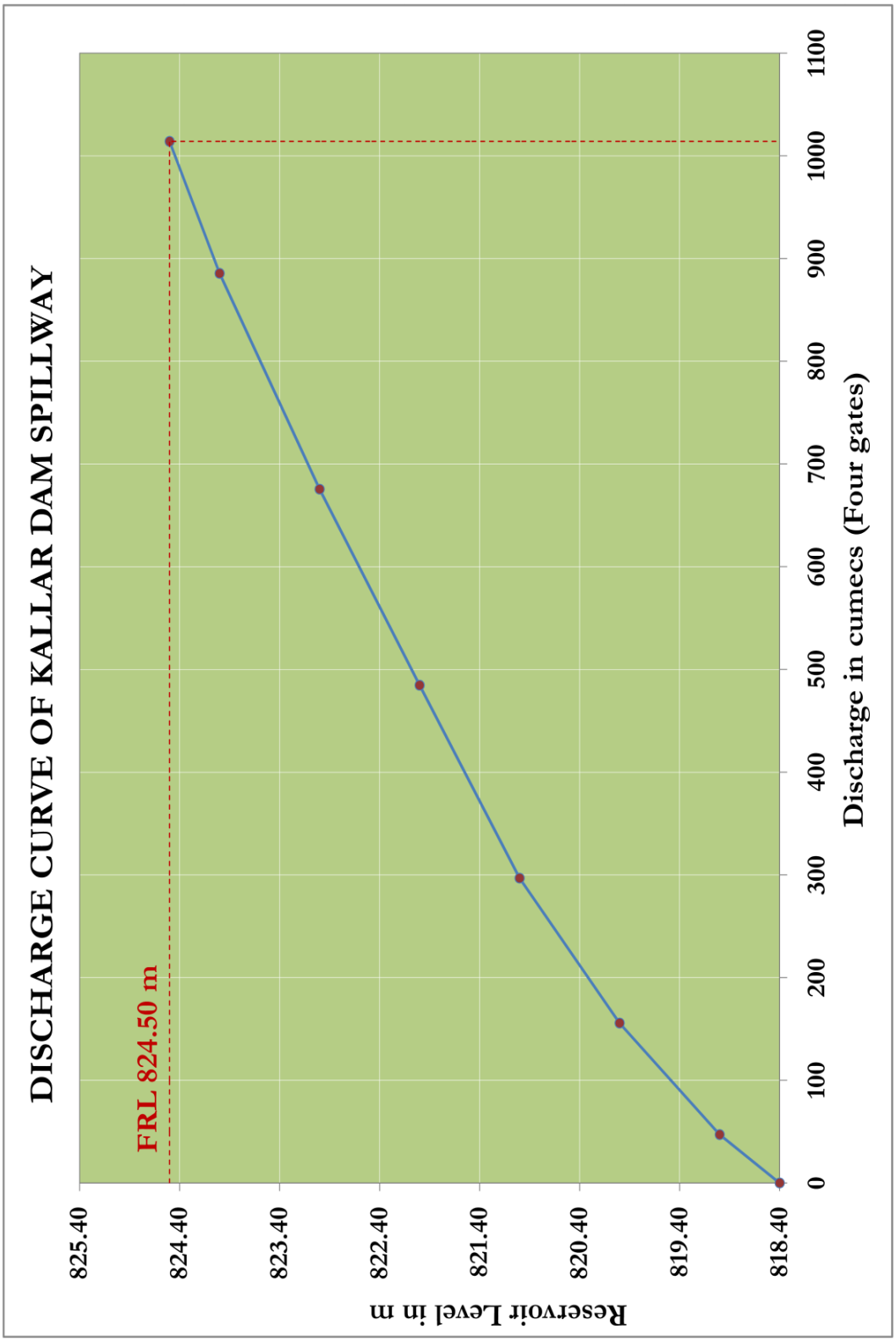

Fig 2.9 Free Discharge curve for Spillway Gates

Kallar-Discharge through a single spillway gate for different gate openings and reservoir levels										
Reservoir Level (m)	Gate opening (m)/Bottom level of gate (+m)									
	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
	818.7	819.0	819.3	819.6	819.9	820.2	820.5	820.8	821.1	821.4
818.4 (Crest level)	0.0									
819.0	6.5	11.8								
819.5	8.2	15.5	21.6							
820.0	9.6	18.4	26.3	33.2	38.9					
820.5	10.8	20.9	30.3	38.8	46.4	52.9	58.1			
821.0	11.9	23.2	33.8	43.6	52.7	60.9	68.1	74.2		
821.5	12.9	25.2	36.9	47.9	58.2	67.8	76.6	84.5	91.3	97.0
822.0	13.8	27.1	39.7	51.8	63.3	74.1	84.1	93.5	101.9	109.5
822.5	14.7	28.8	42.4	55.5	67.9	79.8	91.0	101.6	111.4	120.4
823.0	15.5	30.4	44.9	58.8	72.2	85.1	97.4	109.0	120.0	130.3
823.5	16.2	32.0	47.2	62.0	76.3	90.1	103.3	115.9	127.9	139.3
824.0	16.9	33.4	49.5	65.0	80.1	94.7	108.8	122.4	135.4	147.8
824.5	17.6	34.8	51.6	67.9	83.8	99.1	114.1	128.5	142.4	155.7

Kallar-Discharge through a single spillway gate for different gate openings and reservoir levels										
Reservoir Level (m)	Gate opening (m)/Bottom level of gate (+m)									
	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.1
	821.7	822.0	822.3	822.6	822.9	823.2	823.5	823.8	824.1	824.5
818.4 (Crest level)										
819.0										
819.5										
820.0										
820.5										
821.0										
821.5										
822.0	115.9	121.1								
822.5	128.6	135.7	141.8							
823.0	139.8	148.5	156.4	163.2	168.9					
823.5	150.1	160.1	169.4	177.8	185.3	191.8	197.0			
824.0	159.6	170.8	181.3	191.0	200.0	208.2	215.3	221.4		
824.5	168.5	180.7	192.3	203.2	213.5	223.0	231.7	239.5	246.3	253.5

Table 2.3 Discharge rating table for single spillway

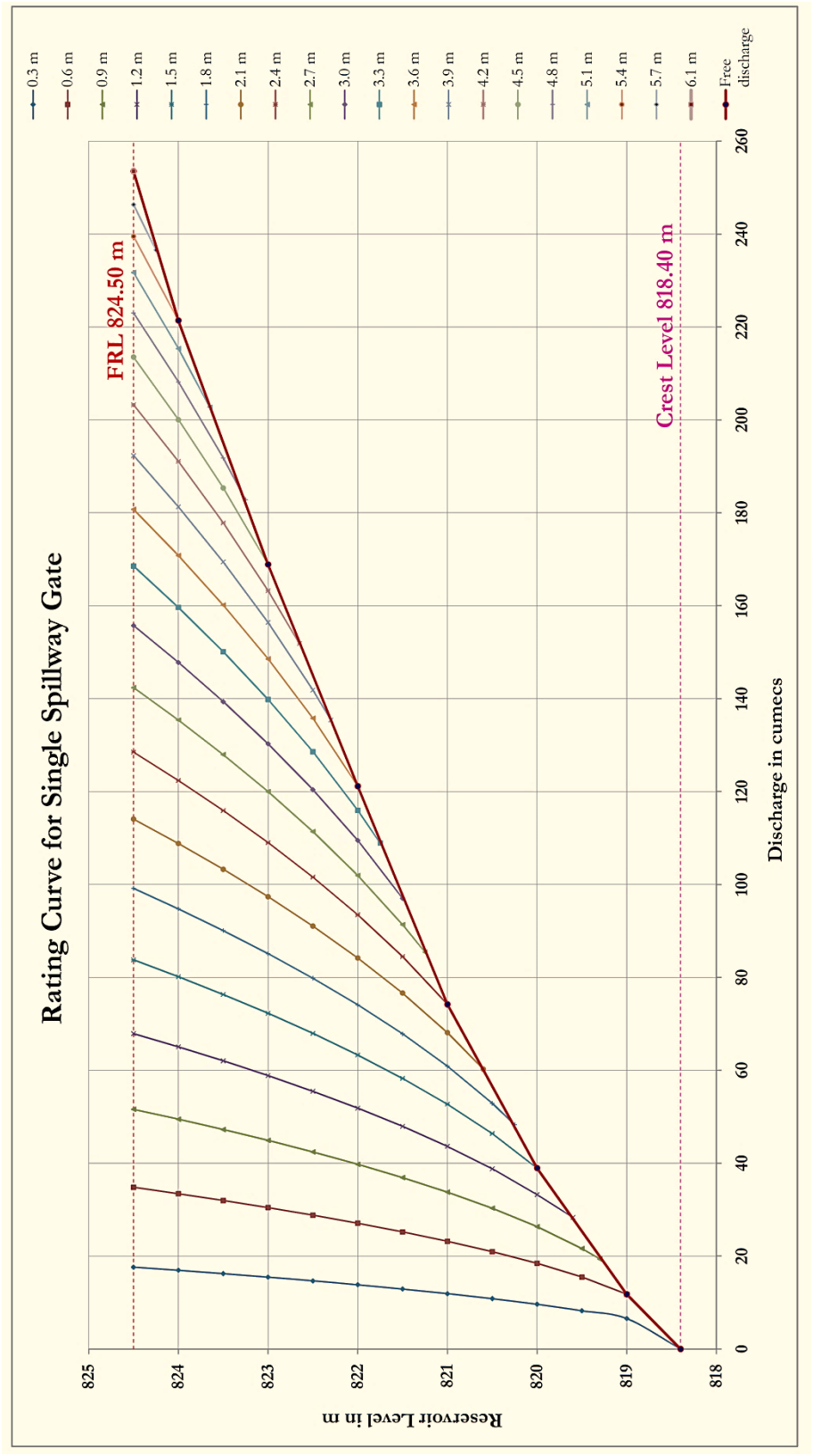

Fig 2.10 Discharge Rating Curve for Single Spillway

2.3.2 Operation of Control Mechanisms

Radial Gate Operations

The radial gates of Kallar dam are operated as explained in **Annexure 2** attached.

2.3.3 Rule Curve

In the Kerala flood study report of August 2018, CWC has recommended for reviewing the rule curves of major reservoirs in Kerala. The rule curves need to be formulated for both conservation as well as operations during the flood, in case of storage reservoirs also, particularly for the reservoirs having the live storage capacity of more than 200 Mm^3 in order to create some dynamic flood cushion for moderating the floods of lower return periods. But Kallar being a very small reservoir, no rule curve is required.

2.3.4 Safety Aspects

The spillway gates are operated after assessing the reservoir water level and inflow. Since downstream river course is wide enough to accommodate the very small flood of the river, no evacuation will be required normally. In case of any exigency, EAP will be activated.

2.3.5 Climate

Kallar catchment receives comparatively good rains during south west monsoon. The basin receives rain during north east monsoon also.

2.3.6 Flood Release Procedure

The flood water is released through the 4 spillway gates. The sequence of operation of spillway gates is Gate no. 2, 3, 1 & 4. Gate No. 2 & 3 are opened to a unit height on the basis of requirement and then Gate No. 1 and Gate No. 4 are opened to the same height. After that as per requirement, the gate opening can be increased or reduced. Closing of the gates is done in a reverse manner i.e. the gates which are opened first are closed last.

2.3.7 Inflow forecasting/Methodology

There is no inflow forecasting system at present in Kallar dam. Normally the reservoir level rises during south west monsoon and north- east monsoon as the inflow from the nearby free catchment increases. A methodology for working out the inflow is not arrived.

2.3.7.1 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 (from spillway and diversion tunnel leading waters from Kallar to Erattayar reservoir) are to be 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.. Expressed as an equation, this will be.

Inflow in Kallar reservoir (cumecs) = 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 Kallar 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. But for Kallar reservoir, the diversion tunnel outflow is not being measured based on the assumption that when the reservoir is at FRL, the diversion tunnel flow is maximum @ 48 cumec.

2.3.8 Emergency Operation

The Emergency operation will be carried out following the Emergency Action Pan (EAP). The EAP together with this Manual will be available at site at all times. Summary of Alert conditions during Emergency are given in **Annexure 8**.

2.4 Power Generation

Idukki Hydro Electric Project is the largest hydroelectric project of Kerala State with installed capacity 780 MW. There are six machines with capacity 130 MW. The planned annual generation from this plant is 2398 MU. Due to the diversion of Kallar and Erattayar waters to Idukki reservoir, the firm power draft of Idukki power station will be augmented by 9.2 cumecs. The additional power generation at Moolamattom power station will be 48 MW at 100% load factor.

2.4.1 Diversion Tunnel

The diversion tunnel from Kallar to Erattayar reservoir has a length of 2905 m and diameter of 5 m. Rate of diversion is 48 m^3/s. There is no control gate for the tunnel. A concrete trash rack is provided to prevent the entry of floating debris to the tunnel. **Fig 2.11** shows the entry to the tunnel from the leading channel from Kallar reservoir.

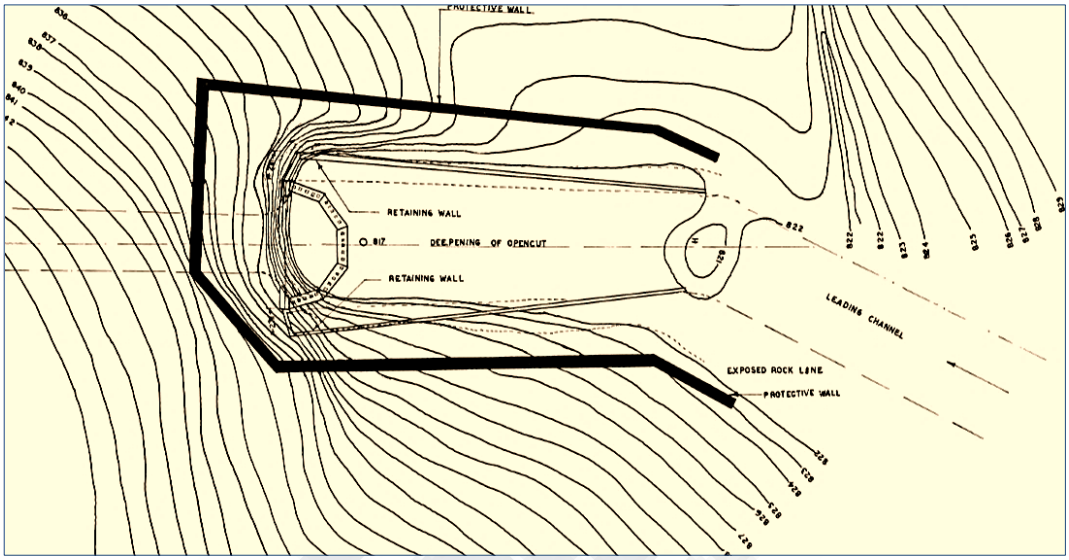

Fig 2.11 Entry to the tunnel from the leading channel

A photograph showing the entrance to tunnel is shown below in **Fig 2.12**. Alignment giving leading channel and diversion tunnel to Erattayar reservoir is given in **Drg 2.6** of **Annexure 1** and trash rack to tunnel entry in **Drg 2.7** of **Annexure 1.**

Fig 2.12 Entrance of Diversion Tunnel

2.4.2 Initial Filling of Reservoir

The construction of the project was started in 1964 and commissioned in 1975.

2.5 Geology at dam site

The project area and its environment form a part of southern granolithic terrain belonging to Archean age. Charnockite gneiss occasionally injected with pegmatite is the main rock type present in the project area. Fresh rock is exposed in the river bed as well as both the flanks of the dam area on both upstream and downstream. General foliation trend is NW-SE with moderately steep dips. These rocks are generally cut across by 3 to 4 sets of joints and are classified to blocky to massive. Slicken sides are present along the low to moderately dipping joints.

2.5.1 Seismic Factor

Dam is located in Zone III of seismic zoning map BIS of India. No major earthquakes have occurred in the project area. Earth quake factor of 0.05g for horizontal and 0.025 g for vertical forces are taken in to account in the design.

2.6 Record Keeping

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

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. Estimated spillway outflows during monsoon on hourly basis.
4. All operating procedures

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 send to higher offices. The current practice of Inspection at Kallar reservoir includes the Executive Engineer at site to carryout pre-monsoon and post-monsoon inspections along with the Assistant Executive Engineer and Assistant Engineer as per CWC guidelines in the format issued by CWC (**Annexure 3)**. The Executive Engineer will submit the inspection report to the Deputy Chief Engineer. The format followed as per CWC is now revised during January 2018 and new guidelines issued vide Doc No. CDSO_GUD_DS_07_v1.0, CWC 2018 for Safety Inspection of Dams. Now since the health reports are to be uploaded in DHARMA, the inspection reports are prepared in the new format. Detailed description on project inspections is available in the Guideline for Safety Inspection of dams. However an overview of the various types of inspections to be carried out at Kallar dam is given below.

3.1 Types of inspections

Four different types of dam safety inspections are to be carried out at Kallar 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 (Un scheduled) inspections
4. Informal inspections.

The frequency of each type of inspection depends on the condition of the dam and State DSO regulations, etc. Typical inspection elements and the detail of the safety inspections are provided below. More detailed descriptions are given in the 'Guideline for Safety Inspection of Dams' (CWC 2018). A comprehensive health checklist **(Annexure 4)** 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 required 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 Kallar 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.
4. Review of design studies, review of design flood, checking of the adequacy of Spillway capacity, freeboard requirements, dam stability and any special study.
5. Preparation of a detailed report of the inspection.

3.2.1 Details to be provided to DSRP before inspection

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 Revised,
- Reservoir operation and regulation plan are to be handed over in detail.
- Basic data and issues related to safety of dam
- Problems if any during construction
- Drawings of dam, spillway, gates and appurtenant structures
- Seismicity
- Geological Report including special problems at site and their treatment
- Field Inspection- Observation & recommendation regarding remedial measures
- Dam Incidents and Reservoir filling

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 Organisation/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. Dam Inspection Report or an inspection brief should be prepared following the field visit as per the approved format of CWC as in **Annexure 3.**

Scheduled inspections include the following four 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.

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

Detailed checklists are required to ensure the health of the dam and to ensure that it continues to operate in satisfactory and safe condition. The proforma to be used for inspection should be the one enclosed in the Doc No. CDSO_GUD_DS_07_ v1.0, CWC 2018 on the Guidelines for Safety Inspection of Dams.

Pre-monsoon Inspection to be carried out during	:	April - May
Post-monsoon Inspection to be carried out during	:	December - January
Inspecting Officers	:	Executive Engineer Field, Concerned field Assistant Executive Engineer and Assistant Engineer
Preparation of Inspection Report	:	Executive Engineer, Field (Dam Health Engineer)
Submission of Pre-monsoon Inspection Report	:	Before June 30th
Submission of Post-monsoon Inspection Report	:	Before January 15th
Checking and approval of report	:	Deputy Chief Engineer, SPMU
Uploading corrected document in DHARMA	:	Executive Engineer, Field

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

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

Operators, maintenance crews, or other staffs who are posted at dam sites conduct informal inspections. These people are the 'first-line of defense' in assuring safe dam conditions, and it is their responsibility to be familiar with all aspects of the dam. Their vigilance in walking the dam, checking the operating equipment, and noting changes in conditions may prevent serious mishaps or even dam failures.

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

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 and litigation.

4.1 Maintenance Plan

A basic maintenance schedule for various components shall be prepared for Kallar dam based on Manual of operating parts, inspections carried out etc. as in **Annexure 5**.

4.2 Maintenance Priorities

Maintenance activities need to be prioritized. In order of priority they need to be clarified under the heads immediate maintenance and 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 showing signs of piping or internal erosion along faults, weak zone etc., indicated by increasingly cloudy seepage or other symptoms.
- The spillway being blocked or with some gates become in operative.

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 from the dam and restoring any eroded areas.
- Repair of defective gates, and other hydro-mechanical equipment.
- Repair any concrete or metal components that have deteriorated.
- Repair any damages on spillway glacis, piers, energy dissipaters, training/divide walls, downstream areas etc.
- Repairs of any cracks/cavities/joints in concrete 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 quantity and quality (clarity) with prior 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 eg. Servicing of spillway gates, hoisting arrangements, gates/hoist and stand by generator.
- Maintaining proper lighting at dam top.
- 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 fences or barricades. Any damages are repaired as soon as possible**.** Also vehicles were permitted after security checking at check posts.

4.3.2 Controlling Vegetation

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

4.3.3 Masonry / Concrete Dams and Spillways

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

- Vegetation growth in dam, spillways, spill channel, approach channel etc.
- Minor repairs to concrete as per standard specifications for repair of concrete surfaces.

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

4.3.4 Trash Racks

Trash racks are provided at the entrance to the diversion tunnel starting from the leading channel. This trash rack is manually cleaned as per site requirements and the accumulated debris/trash removed.

4.3.5 Spillway Radial Gates & Hoisting Equipment

The safe and satisfactory operation of a dam depends on proper operation of its Gates & Hoisting Equipment. Maintaining spillway gates in working condition is critical for dam safety and is to be assigned the highest priority. If routine inspection reports of the Hydro-Mechanical Equipment recommend 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). Because 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 spillway gates in general are given below. The O&M manuals of the gates manufacturer's would however govern the overall maintenance of Gates & Hoists whenever there is any contradiction with the instructions given in the Manual.

4.3.5.1 Radial Gates

The main components of these gates are as under;

a) Embedded Parts:

- Common Anchorages (Bonded Anchorages)
  - Sill beam Assembly
  - Wall plate Assembly
  - Horizontal Anchor Rods
  - Trunnion Girder
  - Trunnion girder chairs
  - Vertical rods
  - Thrust block (If tie between trunnion is not used)
- Independent Anchorages (Unbonded Anchorages)
  - Sill beam assembly
  - Wall plate assembly
  - Anchor girders
  - Load Anchors / Tie flats
  - Yoke girders
  - Rest plate
  - Vertical rods etc.
  - Thrust block (If tie between trunnion is not used)

b) Radial Gate Leaf:

- **Common** Anchorages (Bonded Anchorages)
  - Skin plate

- Side guide and seal assembly
- Vertical stiffeners
- Horizontal Girders
- Horizontal Girder Bracings
- Arm Assembly
- Trunnion
- Trunnion pin
- Trunnion Bush
- Trunnion Bracket
- Tie between trunnion and thrust Block

➢ Independent Anchorages (Un bonded Anchorages)

- Lifting Bracket
- Skin plate
- Side guide and seal assembly
- Vertical stiffeners
- Horizontal Girders
- Horizontal Girder Bracings
- Arm Assembly
- Trunnion
- Trunnion pin
- Trunnion Bush
- Trunnion Bracket
- Tie between trunnion or Thrust block

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

a) **Rubber Seals**:

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

a) **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.

b) **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.

c) **Embedded Parts:**

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

d) **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.

4.3.6 Maintenance of Electrically operated fixed hoists

1. General Instructions:

a. Operation of fixed hoist without lifting the gate is not possible and need not therefore be attempted. It will be possible to operate the unit and observe operation of load carrying hoist component when gate is being lifted or lowered.

b. Never open any bolt or nut on motor, gear boxes, rope drums and other load carrying hoist components when the gate is in raised position. The gate should be fully closed or rested on the gate latches before carrying out any work on hoist components including motor brake and other electrical equipment.

c. The aspects to be inspected and maintained periodically for ensuring proper operation of Rope drum hoists are as under;

i. Entrance to all hoist platforms shall be kept locked. All keys shall remain with the shift supervisor.

ii. A cursory daily inspection shall be made of hoist and gate to ensure that there is no unusual happening.

iii. Clean all hoisting equipment and hoist platform.

iv. Check oil level in gearboxes and replenish as and when required with oil of proper grade.

v. Apply grease of suitable grade by grease gun.

vi. Lubricate all bearings, bushings, pins, linkages etc.

vii. Check all the fuses on the power lines.

viii. All bolts and nuts on gear boxes, hoist drum and shaft couplings should be checked for tightness.

ix. Check the supply voltage.

x. Drain sample gear oil from each of the gear boxes. If excessive foreign particles or sludge is found, the gear box shall be drained, flushed and filled with new oil.

xi. All the geared couplings shall be greased.

xii. Raise and lower the gate by hoist motor and check for smooth, and trouble free operation of gate without excessive vibration.

xiii. Observe current drawn by motor at the time of lifting and check if it is more than normal. If so, stop the hoist and investigate the cause and rectify.

xiv. Check the condition of painting of various components and remove rust wherever noticed and repaint the portion after proper cleaning as per painting schedule.

xv. All trash, sediments and any other foreign material shall be cleared off the lifting rope and lifting attachment.

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

xviii. Check the overload relays for proper functioning.

xix. Check all the nuts, bolts, rivets, welds and structural components for hoisting platform and its supporting structure for wear, tear and damage. All damages shall be rectified. All bolts shall be tightened. The portion with damaged painting shall be touched up.

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

xxi. Raise and lower the gate for its full lift several times (at least three to four) and observe the following:

a) Check the limit switches and adjust for design limits.

b) The effectiveness and slip of the breaks shall be checked by stopping the gate in raising and lowering operations. The brakes shall be adjusted if needed.

c) When the gate is operated, there should not be any noise or chatter in the gears.

xxii. Adjust the rope tension of wires if unequal. Check for all gears and pinions for uneven wear and adjust for proper contact. Grease the gears.

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

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

4.3.7 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) Examine earth connections and motor leads.

xii) Examine motor windings for overheating

xiii) Blow out windings thoroughly by clean and dry air to clear air passage in the stator and the rotor of any accumulated dirt. The air pressure shall not be too high to damage the insulation.

xiv) Examine 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.

4.3.8 Electrical System

Electricity is typically used at a dam for lighting and to operate the gates, hoists, recording equipment, and other miscellaneous equipment. It is important that the Electrical system be well maintained, including a thorough check of fuses and a test of the system to ensure that all parts are properly functioning. The system should be free from moisture and dirt, and wiring should be checked for corrosion and mineral deposits.

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

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

4.3.9 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.

Surface Preparation and Painting of HM Works

i) Protection of painted surfaces is considered essential for protection & enhancement of service life. Gates, their embedded parts, gate leaf, hoists and its supporting structures need to be protected against corrosion due to climatic condition, weathering, biochemical reaction and abrasion etc. This equipment is likely to deteriorate or get damaged to any extent that the replacement of parts may become necessary and such replacement may become difficult and costly.

ii) Surface preparation & Painting requirements:

Painting for hydro-mechanical works is to be carried out as prescribed in IS 14177 for both newly manufactured as well as old & used gates, hoists and associated works after proper surface preparation. The preparation includes thorough cleaning, smoothing irregular surfaces, rusted surfaces, weld spatters, oil, grease, dirt, earlier applied damaged layers of primers/ paint by use of mechanical tools, by use of solvents, wire brush etc. The sand / grit blasting process is used for surface preparation to a level of Sa 2½ of the Swedish standard.

iii) Surfaces not requiring painting & their protection during surface preparation, painting & transportation process:

a) The following surfaces are not to be painted unless or otherwise specified:
   - Machine finished or similar surface
   - Surfaces which will be in contact with concrete
   - Stainless steel overlay surfaces.
   - Surfaces in sliding or rolling contact
   - Galvanized surfaces, brass and bronze surfaces.
   - Aluminum alloy surfaces

b) The Surfaces of stainless steel, nickel, bronze and machined surface adjacent to metal work being cleaned or painted shall be protected by using sticky protective tape or by other suitable means over the surfaces not to be painted.

c) All embedded parts which come in contact with concrete shall be cleaned as detailed above and given two coats of cement latex to prevent rusting during the shipment while awaiting installation.

iv) Application of primer &finish coats on embedded parts and gates:

a) Embedded Parts:

- The prescribed primer shall be applied as soon as the surface preparation is complete and prior to the development of surface rusting and within the specified time prescribed by Indian Standards or the Paint Manufacturer. In case there is lapse of considerable time beyond the prescribed time limit, the surfaces shall be again cleaned prior to priming.
- Two coats of zinc rich primer with epoxy resin shall be applied to all embedded parts surfaces which are not in contact with concrete and shall remain exposed to atmosphere or submerged in water to obtain a dry film thickness of 75 microns.
- This shall be followed by three coats at an interval of 24hours of coal-tar blend epoxy resin so as to get a dry film thickness of 80 microns in each coat. Total dry film thickness of paint shall not be less than 300 microns

b) Gates:

- Primer Coat:

  Over the prepared surface one coat of inorganic zinc silicate primer giving a dry film thickness of 70 ± 5 microns should be applied. Alternatively two coats of zinc rich primer, which should contain not less than 85% zinc on dry film should be applied to give a total dry film thickness of 75 ± 5 microns.

- Finished paint:

  Two coats of solvent less coal tar epoxy paints. These shall be applied at an interval of about 24 hours. Each coat shall give a dry film thickness of 150±5 microns. The total dry film thickness of all the coats including primer coating shall not be less than 350 microns.

v) Hoist and supporting structure:

a) Structural components:

Primer coats of zinc phosphate primer shall be applied to give a dry film thickness of 40±5 microns.

Final Coats: One coat of alkalized based micaceous iron oxide paint to give a dry film thickness of 65 ± 5 microns followed by two coats of synthetic enamel paint confirming to IS 2932 – 1974 to give a dry film thickness of 25 ± 5 microns per coat. The interval between each coat shall be 24hours. The total dry thickness of all coats of paint including the primer coat shall not be less than 175 microns.

b) Machinery: Except machined surfaces all surfaces of machinery including gearing, housing, shafting, bearing pedestals etc., shall be given:

Primer coats: One coat of zinc phosphate primer paint to give minimum film thickness of 50 microns. Motors and other bought out items shall be painted if necessary.

Finished coats: The finished paint shall consists of three coats of aluminum paint confirming to IS2339 – 1963 or synthetic enamel paint confirming to IS 2932 – 1977 to give a dry film thickness of 25±5 microns per coat to obtain a total minimum dry film thickness of 125 microns.

c) Machined surfaces:

All machined surfaces of ferrous metal including screw threads which will be exposed during shipment or installation shall be cleaned by suitable solvent and given a heavy uniform coating of gasoline soluble removable rust preventive compound or equivalent. Machined surfaces shall be protected with the adhesive tapes or other suitable means during the cleaning and painting operation of other components.

vi) Application of paint:

- Mix the contents thoroughly as directed by paint manufacturer before and during use.
- Painting at shop can be done by any of the three methods namely Brush / roller, Conventional spray, Airless spray etc.

The paint can be made to suit the adopted method. But once the gate and equipment is in erected position the general method adopted is only brush / roller. In case of spray lot of precautions are to be taken.

For More details: Refer IS: 14177 Part (II) – 1971.

Appendix A – Brushing of paint

Appendix B – Spraying of paint

Appendix C – Spray painting defects: Causes and remedies.

Removal of old paint / rust and carrying out fresh painting:

The carrying out of fresh painting is to be considered under the following conditions:

- The rusting is noticed all over the surface or
- Rusting is severe or
- Cracking and blistering has damaged the primer coat exposing the metal and is noticed all over the surface or
- The paint film has eroded badly, scrap the entire paint film to the base metal and carry out fresh painting.

Note: In case of maintenance and renovation: Refer IS 14177 (Part II) – 1971 for checking and repainting.

vii) Removal of old paint for repainting:

Caution should be exercised while removing the old paint. The surfaces shall be de-rusted and descaled by either mechanically by one or more of the methods, namely:

a) Wire brushing, Scraping, and chipping. Sand papering or cleaning with steel wool or abrasive paper
b) Power tool cleaning
c) Flame cleaning
d) Sand blasting or shot blasting and
e) Chemical rust removal.

Note: The method of application shall be decided based on conditions existing. After cleaning, painting is to be carried out as originally proposed.

Some are painted without removal of old paint and rusting this will amounts to no painting and deteriorate faster than the original one.

viii) Inspection and testing of painting of H. M works:

a) The following steps are involved in inspection of painting:
   - General inspection before and during painting
   - Viscosity test of paints

- Paint thickness test – using Elco-meter.
- Inspection of general appearance of finished work.

b) General:

The aim of inspection and testing is to ascertain whether the recommended practice is being employed correctly during every stage of application and whether the final results fulfill the object of painting. Any test carried out should be of non – destructive nature or, if it is of destructive nature, it should be either restricted to areas which can be restored without marring the general appearances or be such that it is possible to restore easily without necessitating a complete repetition of the work.

c) Inspection of surfaces prior to painting:

Inspection methods will depend on whether it is to be painted for the first time or is to be repainted.

d) New Works (Not previously painted): The following shall be decided by inspection:

- The method of pre cleaning feasible or recommended;
- The intermediate protective treatments to be applied, if found necessary;
- The final painting schedule and the specifications for the paint for ensuring the particular performance;
- The method of application, whether by brush, roller or spray.

e) Old Work (Which requires repainting):

The following shall be decided by inspection:

- Whether the entire existing paint requires removal; and/or
- Whether repainting without paint removal would be adequate.

4.3.10 Access Roads

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/slopes develop which can lead to blockage of the road, protective works including retaining walls shall be provided as remedial measures. Drains are required to be provided and maintained along roads to remove surface and subsurface drainage. This will prolong the life

of the road. Road surfacing should be repaired or replaced as necessary to maintain the required traffic loadings. The maintenance of all access roads is executed under DRIP.

4.3.11 General Cleaning

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

4.4 Materials and Establishment Requirements during Monsoon

Materials required during monsoon period for both immediate maintenance and preventive maintenance must be stocked in adequate quantities for emergency situations that may arise. At Kallar dam, ex-servicemen security is provided. At the same time if additional requirements arise during monsoon, the same will be provided.

The departmental regular manpower provided for Kallar Dam is as below:

Present Manpower		
Designation	**Kallar Dam**	**Remarks**
Executive Engineer	1	The dam safety officers and staff concentrate fully on monsoon related dam operation & monitoring works during monsoon period. The dam safety O&M works are generally executed during the non - monsoon period.
Assistant Executive Engineer	1	
Assistant Engineer	1	
Sub Engineer	1	
Security Staff	As mentioned in **Cl.1.6**	

Following materials are required for handling the situations during monsoon period:

- Gunny Bags
- Sand
- Boulders/Wire crates
- Bamboos/ Balli's
- Baskets

- Ropes
- Petromax Lamps with Spares
- Torches with spare cells
- Kerosene Oil
- Match Boxes
- Rain Coats
- Gum Boots
- Warning sign indicator
- Danger zone lights

4.5 Preparation of O&M budget

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

i) **Establishment Cost of Regular Staff** - Salaries and allowances, Bonus, Medical Reimbursement, LTC, Leave Encashment, pension benefits etc. (as applicable).

ii) **Establishment Cost of Work charged Staff** - Salaries and allowances, Bonus, Medical Reimbursement, LTC, Leave Encashment, Pension benefits, TA and DA, etc. (as applicable).

iii) **Establishment Cost of Daily Wage Staff** - Salaries and allowances, TA and DA etc. (as applicable)

iv) **Office Expenses**-Telephone/Mobile/any other Telecommunication bills, Electricity bills, water bills, Office stationery, Day to day office requirements.

v) **Motor Vehicles** - Running and Maintenance cost of inspection vehicles, Cost of hiring of vehicles as required

vi) **Maintenance of Colony** - Maintenance of staff quarters, colony roads, Electricity, Sanitary and Water supply systems etc

vii) **T&P**-The T&P requirements for offices, colony, works etc. as applicable.

viii) **Works**-Painting, greasing, overhauling of HM equipments, 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 access roads to dams, provision for flood contingency works during monsoon, unforeseen events/items (about 10% of the cost of works) etc.

ix) **Upkeep and maintenance –** Provision for upkeep and maintenance of all Radial gates and connected works.

x) **Dam monitoring -** Instruments are to be monitored, readings taken for which O & M budget required.

A summary table for the O & M budget is given below in **Table 4.1**.

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	Vehicle expenses			
5	Maintenance of office			
	Sub-total - a			
b.	**Works**			
1	**Civil works**			
1.1	Concrete / masonry dam			
1.2	Approach / inspection roads within dam area			
2	**Hydro-Mechanical works**			
2.1	Spillway gates & hoists			
3	**Electrical works**			
3.1	Electrical fittings, motors, controls for all hoists			
3.2	Power supply lines			
3.3	Electrical fittings on dam top.			
3.4	Standby power / diesel generator			

3.5	Remote control			
4	**Instrumentation and monitoring**			
4.1	Water level reading and rain gauge			
5	**Miscellaneous works**			
6	**Salary of work charged staff including all benefits**			
7	**Materials to be stored before monsoon**			
	Sub-total - b			
c.	**Contingencies**			
1	Contingency (10%) on Sub-total of **a & b**			
2	Tools & Plants			
	Sub-total - c			
	Total Annual Cost			

Table 4.1 Summary Table for Annual O &M Budget

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, and
- 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 may draw information from a wide spectrum of instruments and procedures, ranging from simple to complex. The program must be based on prevailing geotechnical conditions at the dam, and must include consideration of the hydrologic and hydraulic factors present before and after the project is in operation.

5.1.1 Kallar Dam - Instrument Types and Usage

In Kallar Dam, no instrumentation is provided except the water level gauge. Water levels are monitored daily and hourly in monsoon. Certain instruments are proposed under DRIP.

Chapter 6

Previous Rehabilitation Efforts

6.1 Issues with the dam

The dam was commissioned long back and no major rehabilitation works were carried out. The Dam was inspected by experts from CWC and DSRP under DRIP, and certain, recommendations were given for works/remedial measures to be carried out for improving the structural safety and performance of the Dam. Accordingly the following works were carried out under DRIP I.

- Overhauling of radial gates at Kallar
- Maintenance of approach road of Kallar Dam
- Replacing of existing parapet of Kallar dam.
- Providing roof for the hoisting arrangement of radial gate at Kallar dam
- Providing catwalk and access to reach the d/s.
- Supplying and installing of DG set at Kallar dam.

Photographs of works carried under DRIP I are enclosed below.

Kallar dam before & after DRIP 1


Kallar dam hoist bridge before and after roofing

Kallar dam catwalk and access to downstream

Kallar dam Generator room & DG set

Kallar dam hoist mechanism before & after

Chapter 7

Updating the Manual

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

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

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