Operation and Maintenance Manual for VELUTHODU Dam State of Kerala

Doc. No. DSO_O&M_VELUTHODU_DAM
KSEBL_12_v1.0

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

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Government of Kerala

Operation and Maintenance Manual

Veluthode Dam

KSEB

Prepared

Sd/-

Deputy Chief Engineer (Civil)
Dam Safety & DRIP

Approved

Sd/-

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Kerala State Electricity Board Ltd
Pallom, Kottayam.

November 2019

Government of Kerala
Kerala State Electricity Board Ltd
Dam Safety Organisation

Disclaimer

This *Operation and Maintenance Manual for Veluthode 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 working of the dam and appurtenant structures.

The manual is developed for the purposes of organizing 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. The health and safety of these valuable assets is of paramount importance in order to derive benefits from them continuously on a sustainable basis, besides providing protection to the people and property in the downstream areas. The Ministry of Water Resources, River Development & Ganga Rejuvenation through the Central Water Commission (CWC), with financial assistance from the World Bank, started the Dam Rehabilitation and Improvement Project (DRIP) to rehabilitate 198 large dam projects in seven states. Kerala State Electricity Board Ltd, through Government of Kerala participated in DRIP to rehabilitate 37 dams under 12 Hydro Electric Projects in the state.

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

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

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

Bibin Joseph,
Director Generation (Civil),
KSEB Ltd,
Kerala.

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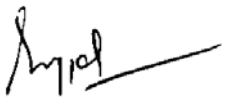
Foreword

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 contains a detailed 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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Team Involved in preparing this O & M Manual of Veluthode dam

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PREFACE

Operation and Maintenance (O & M) Manual contains detailed 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.

Veluthode dam under KSEB Ltd do not have a comprehensive Operation and Maintenance Manual. Hence an attempt is made here to prepare the manual as per the new guidelines by CWC. Sabarigiri HEP is the major hydro power project implemented in Pamba basin. Kakkad HEP with an installed capacity of 50 MW is also a power project in Pamba basin. The tail waters of Sabarigiri HEP discharges to Moozhiyar stream, a tributary of Kakkad River. At the downstream of the confluence of tail race of Sabarigiri HEP, a dam is constructed across Moozhiyar stream to divert the tail water of Sabarigiri HEP to Kakkad Power Station. In addition to the tail water from Sabarigiri, the yield from own catchment of Moozhiyar and yield of Veluthode stream by creating a Forebay dam across Veluthode stream and connecting with the tunnel from Moozhiyar to Kakkad Power Station are utilized in Kakkad HEP for power generation. The project was commissioned in 1999.

A flow chart of Kakkad HEP is given in the next page for reference.

This Operation and Maintenance Manual is prepared for Veluthode dam of Kakkad HEP.

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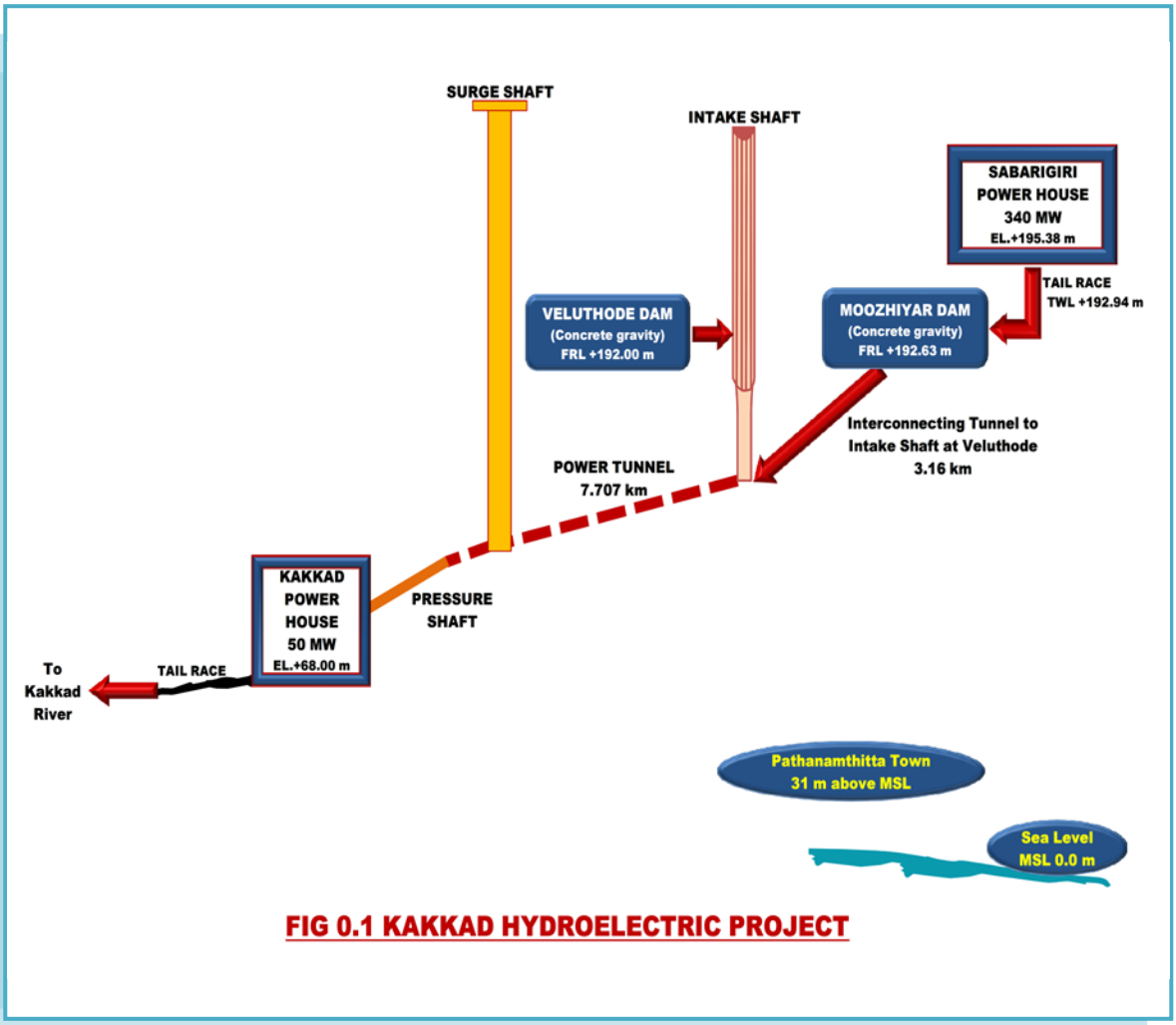

FIG 0.1 KAKKAD HYDROELECTRIC PROJECT

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**

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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 Safey 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 7.

IS: 15472 (2004): Guidelines for Planning & Design of Low Level Outlets for Evacuating Storage Reservoirs

Project Screening Template of Kakkad HEP under DRIP I

Dam Safety Review Panel Report under DRIP I

Hydrology Review Report under DRIP I

Chapter 1

General Information

1.1 Introduction

Kakkad Hydroelectric Project is the second stage development of Pamba river basin. This scheme utilises the tail race water from Sabarigiri power station and flow received from the tributaries of Kakkad river viz. Moozhiyar and Veluthode Rivers. Moozhiyar and Veluthode dams feed water to the powerhouse. Moozhiyar Dam creates the main reservoir of this project. The second reservoir is formed by the Veluthode dam, constructed across Veluthode River and is a Forebay dam. After power generation, water from Kakkad power station is released to the Kakkad River.

Kakkad and Sabarigiri Power stations will be operated integrally such that the releases from Pamba Kakki Reservoirs regulated together with the waters of Moozhiyar catchment are utilized for maximum generation of power in the system. Own catchment area of Moozhiyar reservoir is approximately 28.75 sq km and that part bisected by the construction of Upper Moozhiyar Earth dam is 7.77 sq km which diverts the water up to its FRL (+983 m) into Kakki-Anathode Reservoir. The bed level of the Moozhiyar stream at the Diversion Dam site is 164.46 m. The maximum tail water level of the Sabarigiri Power station with Pelton installation is +192.94 m. To avoid tail race encroachment the FRL is restricted to +192.63 m and the live storage is 1.16 Mm^3. The peak discharge from Sabarigiri alone is at the rate of 54.368 cumec.

Veluthode dam is a diversion dam which diverts the water to the Kakkad Power House through the water conductor system of Kakkad HEP. The tunnel from Moozhiyar Reservoir to Kakkad Power House passes under the Veluthode stream just upstream of the dam. Water from the Veluthode reservoir is led to the power tunnel of Kakkad HEP through a vertical intake shaft through a trash rack arrangement with no gate control.

The investigation works were taken up after the completion of the Sabarigiri HE Project. So, the roads and buildings constructed for Sabarigiri provided access and accommodation facilities to this Investigation team. The project was commissioned in 1999.

1.2 Purpose, Location, Description of the Project

Kakkad Hydro Electric Project

The Kakkad (Sabarigiri Tail Race) scheme is formed by the formation of two small reservoirs at Moozhiyar and Veluthode, having a total storage capacity of 2.856 Mm^3, connected by an Inter connecting tunnel of length 3168.01 m. A lined power tunnel 7925.10 m long, internal diameter 4.15 m takes off from the Forebay reservoir and leads the waters to the Pressure shaft which bifurcate near the power House feeding the two machines with a total 50 MW (2 x 25 MW) installed capacity to generate a firm power 30 MW corresponding to 262 MU per year.

Location:

The Project is situated in Seethathode Panchayath of Pathanamthitta District of Kerala State and is accessible by road from the District head quarter via Vadasserikkara - Chittar. The index map and Google map of Kakkad HEP are given in **Fig 1.1** and **Fig 1.2.**

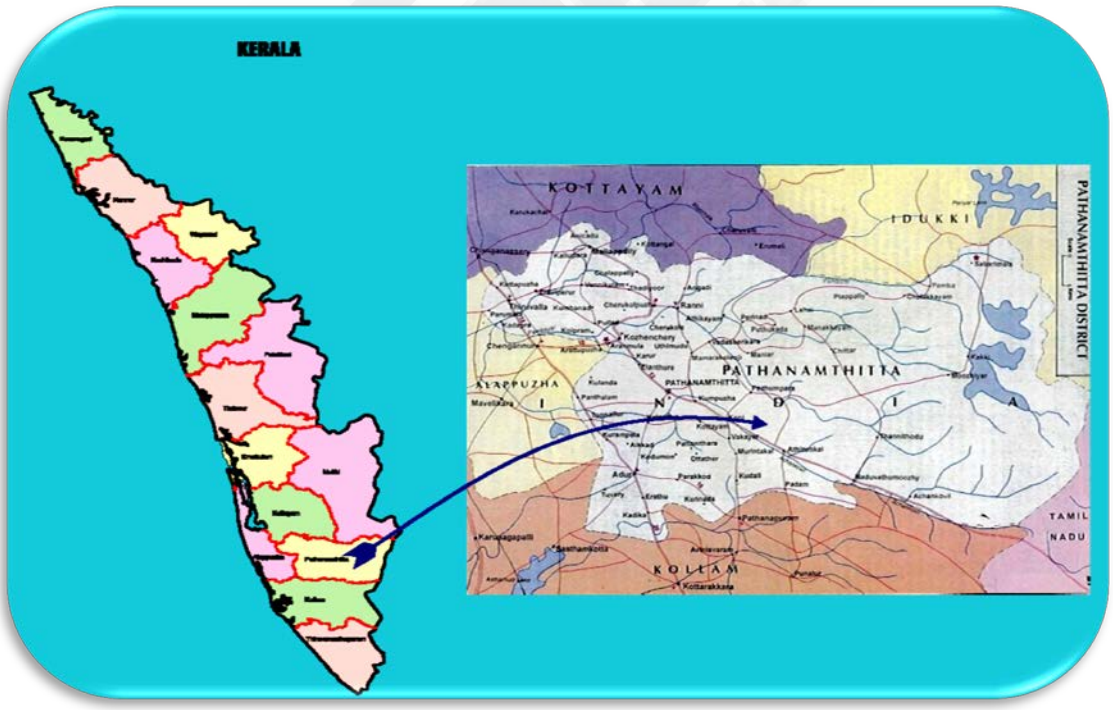

Fig 1.1a Index Map

Fig 1.1b Google Map showing the Project

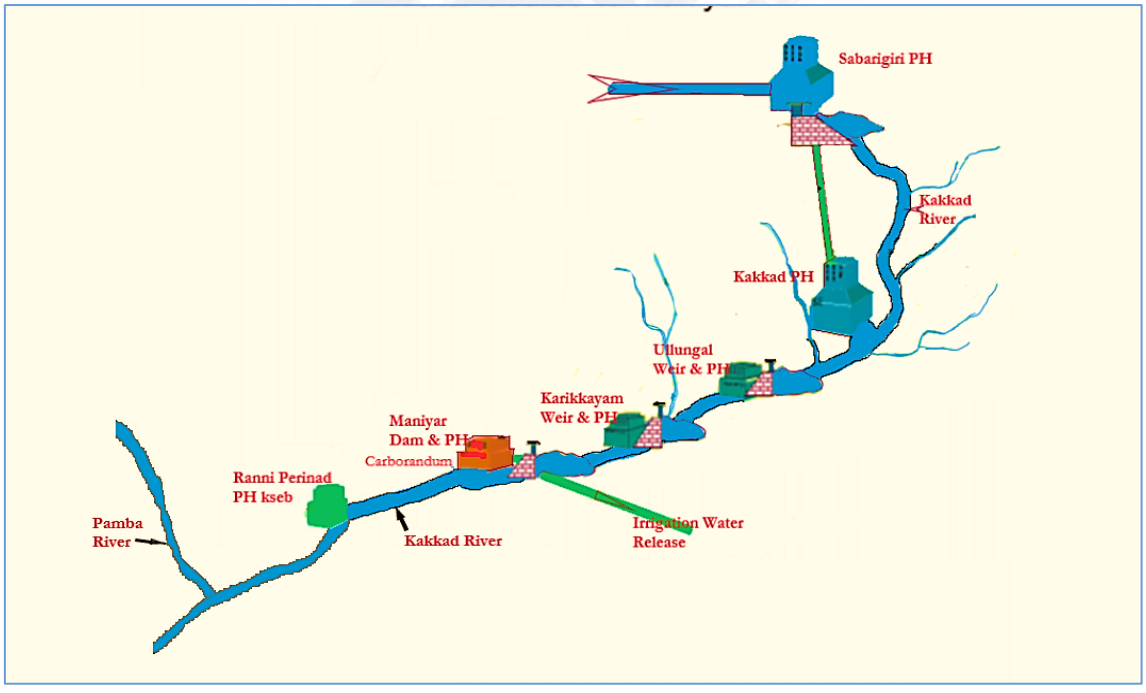

Fig 1.2 Kakkad HEP - Flow Chart Downstream Schemes

Project Benefits:

The installed capacity of the Kakkad project is 50 MW (2 x 25MW) with firm power of 30 MW corresponding to 262 MU per year. The water released from Kakkad Power station flows to Kakkad River and is used for power generation at Ullumkal Power station (IPP) & Karikkayam Power station. The tail race flows to the Maniyar reservoir for power generation at the Maniyar power station, operated by M/s Carborandum Universal Ltd. Flow Chart showing the above schemes is given in **Fig 1.2.**

Kakkad project includes the following**:**

1. A Concrete straight gravity dam 30.04 m high above the deepest river bed and 176.50 m long with gated spillway having 3 spans of 7.62 m each across River Moozhiyar, about 1.6 km downstream of Sabarigiri Power station.
2. A concrete straight gravity ungated diversion dam 20.50 m high above the deepest river bed and 107 m long across Veluthode which diverts its catchment waters through the water conductor system of Kakkad HEP.
3. The water conductor system consists of an intake from Moozhiyar reservoir, a lined interconnecting tunnel 3.168 km long with 4.15 m finished diameter, a vertical ungated intake from Veluthode reservoir, a lined power tunnel 7.925 km long and 4.15 m finished diameter, a restricted orifice surge shaft of 16 m finished diameter, a lined pressure shaft 687.57 m long with bifurcation at Power House end.
4. A surface Power House with two machines each of 25 MW capacity located on the left bank of Kakkad River at Seethathode.

A schematic diagram of the project is outlined below in **Fig 1.3**.

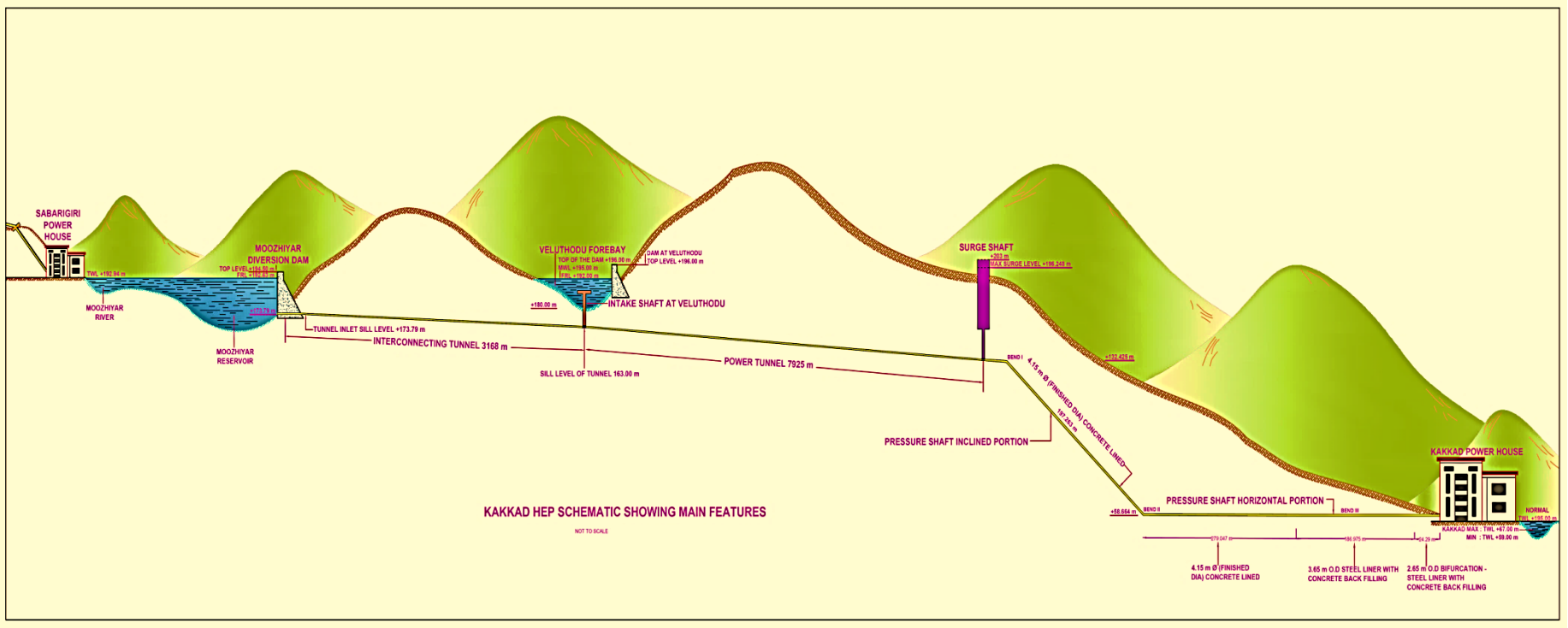

Fig 1.3 Schematic Diagram of the Project

SALIENT FEATURES OF THE PROJECT

A	Name of dam	-	Moozhiyar dam
	Type of dam	-	Concrete gravity
	Name of the river where the dam is built, sub- basin	-	Moozhiyar River
	River basin	-	Pamba River basin
	Catchment area at Dam site	-	28.75 km^2
	Deepest River Bed Level	-	164.46 m
	Top level of dam	-	194.50 m
	Maximum Water Level (MWL)	-	192.94 m
	Full Reservoir Level (FRL)	-	192.63 m
	Minimum Draw Down Level (MDDL)	-	181.36 m
	Height above deepest foundation	-	34.17 m
	Height above deepest river bed	-	30.04 m
	Bottom width at maximum section	-	28.18 m
	Length of Dam at Top	-	176.50 m
	No and size of radial gates	-	3 Nos (H-6.70 m x W-7.62 m)
	Crest level of spillway	-	186.53 m
	Spillway capacity at FRL	-	730.25 m^3/s
	Gross storage at FRL	-	1.50 Mm^3
	Design Flood		500.64 m^3/s
	Live storage at FRL	-	1.16 Mm^3
	Dead storage	-	0.34 Mm^3
	Water spread area at FRL	-	0.15 km^2
	Approximate volume of dam	-	52160 m^3
	Downstream slope	-	0.74 H : 1V from El + 189.00 m
	Upstream slope	-	0.1 H : 1V from El + 170.00 m
	Size of disperser valve	-	1500 mm with 28.03 m^3/s
	Diameter of outlet pipe	-	2000 mm
B	**Name of dam**	**-**	**Veluthode dam**
	Type of dam	-	Concrete gravity

	Deepest River Bed Level	-	175. 50 m
	Top level of dam	-	196.00 m
	Maximum Water Level (MWL)	-	195.00 m
	Full Reservoir Level (FRL)	-	192.00 m
	Crest level of spillway	-	192.00 m
	Spill way length (single bay)	-	20 m
	Maximum spillway discharge at MWL	-	216.6 m^3/s
	Height above deepest foundation	-	22.00 m
	Length of dam at top	-	107.00 m
	Gross storage at FRL	-	0.67 Mm^3
	Live storage at FRL	-	0.607 Mm^3
	Water spread area at FRL	-	6.35 Ha
	Approximate volume of dam	-	14560 m^3
	No. of scour sluice	-	1 No
	Size of scour sluice	-	1.80 m x 2.70 m
	Size of sluice gate	-	1.80 m x 2.70 m
C	**Water conductor system**		
a)	**Intake at Moozhiyar Reservoir**		
	Location	-	8 m upstream of Moozhiyar dam with centre line parallel to dam axis
	Inlet sill level	-	173.79
	Length	-	23 m
	Size and shape	-	Rectangular to circular 4.15 m diameter
	Type of lining	-	Steel lining
b)	**Intake at Veluthode Reservoir (Vertical Shaft)**		
	Location	-	25 m upstream of Veluthode dam with vertical centre line
	Inlet sill level	-	186
	Length	-	18.85 m
	Diameter	-	4.15 m

	Type of lining	-	concrete lining
c)	**Inter connecting tunnel**		
	Size and shape	-	4.15 m finished diameter, Circular
	Length	-	3168.01 m
	Inlet sill level	-	173.79 m
	Exit sill level	-	163.00 m
	Type of lining	-	Steel lining 67 m, concrete lining 3101 m
	Lining thickness	-	250 mm
	Maximum discharge	-	47.19 Cumec
	Maximum Velocity	-	3.49 m/s
d)	**Power tunnel**		
	Size and shape	-	4.15 m diameter, Circular
	Length	-	7925.10 m
	Inlet sill level	-	163.00 m
	Exit sill level	-	129.325 m
	Type of lining	-	Steel lining 114 m, Concrete lining 7811.10 m
	Maximum flow	-	47.19 cumec
	Maximum Velocity	-	3.49 m/s
e)	**Surge Shaft**		
	Type	-	Restricted orifice
	Size and shape	-	16 m dia Circular
	Top level of surge shaft	-	+203.00 m
	Maximum upsurge level	-	+196.248 m
	Minimum down surge level	-	+154.453 m
	Bottom level of surge shaft	-	+129.325 m
f)	**Expansion Gallery**		
	Bottom level	-	+ 192 m
	Top level	-	+200 m

	Size	-	6 m x 8 m
	Length	-	50 m
	No and size of orifice	-	2 No, 2.13 m dia, circular shaped
	Control gate	-	Vertical lift gate(fixed wheel type)
	Lining	-	RCC, 30 cm thick up to El. 191.00m and 60 cm thick above El. 191.00 m
g)	**Pressure shaft**		
	Total length	-	687.57 m
	Finished section	-	4.15 m for 476.31 m length, 3.60 m (3.65 m) for 187 m length, 2.60 m (2.65 m) for 24.26 m bifurcated portion
	Type of lining	-	Steel lining 266.83 m, concrete lining 420.74 m
h)	**No of Adits**	-	7 nos
	Size and shape	-	3.00 m , D-shaped
i)	**Length of Adits**		
	Adit I	-	303.00 m, I C tunnel and power tunnel at Chorakakki
	Adit II	-	18.85 m Vertical Shaft
	Adit III	-	231.51 m at Veluthode
	Adit IV	-	607.72 m at Pannikunnu
	Adit V	-	225.216 m at Seethakuzhy
	Adit VI	-	190 m at Surge bottom
	Adit VII	-	51.75 m at Power House
	Plugging of Adits- I, III, V and VI Plugging with provision of access door & Adit IV and VII- solid plugging.		
j)	**Power House**		
	Installed Capacity	-	50 MW
	No. of Machines	-	2
	Type of Machine	-	Francis Turbine Vertical Shaft
	Capacity of machine	-	25 MW

	Overall size of Power House	-	44.50 m x 24.60 m
	Unit spacing	-	14 m c/c
	Service bay length	-	14.90 m
	Width of transformer deck	-	24.60 m
	Power House yard level	-	+ 68.00 m
	Generator floor	-	+ 66.00 m
	Centre line of runners	-	+ 57.00 m
	Bottom most level of excavation	-	+50.00 m
	Normal tail water level	-	+59.60 m
	Minimum tail water level	-	+59.00 m
	Maximum tail water level	-	+67.00 m
	Average gross head	-	132.60 m
	Capacity of main hook of EOT Crane	-	100 T
	Capacity of auxiliary hook	-	20 T
	Type of scroll case	-	Steel fabricated
	Type of draft tube	-	Single pier draft tube
k)	**Width of tail race channel**	-	7 m
	Length of channel	-	100 m
	Firm power draft	-	28.40 cumec
	Rated turbine output	-	25.86 MW
	Discharge for rated output	-	22.58 m^3/s
	Maximum turbine output	-	28.45 MW
	Transmission line	-	110 KV Double circuit from Seethathode to Pathanamthitta

Cost and benefits

The project was estimated to cost Rs. 150 crores with annual net revenue on firm power @ Rs.1.36/unit as Rs. 36.5 crores which corresponds to a net average return of the order of 24%. The annual energy generation on a firm basis will be 262 MU and secondary energy generation will be 7 MU making a total of 269 MU per year.

1.3 Background Details of the Project

The proposal to utilize the tail race water from Sabarigiri Power House at Moozhiyar for power generation originated along with the conception of Sabarigiri H E Scheme itself. After completing the investigations of the Sabarigiri Project, the initial investigations were done for utilization of the tail race water independently or combined with the waters of Pamba, Azhutha and Kakkad Rivers. Later it was finalized to utilize the tail race water alone. Different alternatives for the dam site were proposed and studies were made to select a suitable alignment for the dam. Trial bore holes were taken to ensure the rock availability and levels of hard rock.

During the Field season of 1970-71, Geologist conducted the geological investigations of Kakkad H E Project. The dam site chosen is the same as considered in the geological report having more favorable rock conditions. Foundation excavation was done manually using Jack hammers, wagon drills and explosives for rock blasting. Muck removal was arranged using earthmoving and haulage equipments.

The construction of the project was commenced during 1980. The project was delayed beyond expectation due to so many factors. The total number of working days/ actual working days, at various sites in this project varied from 5 to 9 years, out of the total construction period of 18 years. The two generating units were commissioned in 1999.

a. Date of Starting the construction : 1980
b. Date of Completion : 1999 March
c. Name of Design Agency : KSEB Ltd
d. Name of Dam Contractor : M/s HCC Ltd., Bombay
e. Major accidents/incidents if any : No major accidents reported during construction

Veluthode diversion dam is located towards south west of Moozhiyar Dam. The geographic coordinates are latitude $9^0$18'5" N and longitude $77^0$2'22"E respectively. This diversion structure is constructed across Veluthode stream, a tributary of the Kakkad River. The dam site is accessible from Angamoozhi – Moozhiyar road by taking a deviation towards right for a distance of about 3 km after Veluthode bridge.

1.4 Salient Features of Veluthode Dam

Component Structures

1. Dam& Reservoir	
Type	Concrete- gravity
Latitude	$9^0$18'05" N
Longitude	$77^0$03'22" E
Deepest River Bed Level	175.50 m
FRL	192.00m
MWL	195.00 m
Top of Dam	196.00 m
MDDL	186.00 m
Length of dam at top	107.00m
Width at top	4.00 m
Height above deepest foundation	22.00 m
Height above bed level	20.50 m
Gross storage at FRL	0.67 Mm^3
Live storage at FRL	0.607 Mm^3
Dead storage	0.063 Mm^3
Approximate volume of Dam	0.01456 Mm^3
Catchment area at Dam site	6.84 km^2
Reservoir spread area at FRL	0.063 km^2
Downstream slope	0.70 H : 1 V from El +192.50
Upstream slope	0.10 H : 1 V from El +181.00
No. & size of scour sluice	1 no, 1.80 m x 2.70 m sized scour sluice (Bl. No. 4)
Outlet sill level	184.00 m
Size of sluice gate	1.80 m x 2.70 m
Foundation gallery	1.80 m x 2.75 m

Drain holes	250 mm dia. @ 3 m c/c
No of blocks	7
2. Spillway	
Shape	Ogee
No. of bays	1
Type of gate	Ungated overflow structure
No. of gates	Nil
Maximum spillway discharge at MWL	216.65 m^3/s
Design Flood (original)	146 m^3/s
Design Flood (revised)	201.23 m^3/s
Spillway crest	192.00 m
Spillway length (single bay)	20 m
Energy dissipation	Flip bucket

Veluthode Dam:

Veluthode dam is a diversion dam which diverts the water to the Kakkad Power House through the water conductor system of Kakkad HEP. The tunnel from Moozhiyar Reservoir passes under the Veluthode stream. Just downstream of the intersection of tunnel with Veluthode, a diversion dam is constructed. Water from this reservoir is led to the tunnel of Kakkad HEP through a vertical shaft.

It is a concrete straight gravity ungated ogee spillway dam, 20.50 m high above the deepest river bed and 107 m long across Veluthode. The top width of dam is 4 m. The FRL and MWL of the dam are +192.00 m and +195.00 m respectively. The spillway structure has single bay of length 20 m and is ungated overflow type structure. There is one lower level sluice provided in the dam. The total spillway capacity is 216.65 cumec. The reservoir has a gross storage capacity of 0.67 Mm^3 at FRL and a live storage capacity of 0.607 Mm^3 at FRL.

Google view of Veluthode dam is shown in **Fig 1.4**. Photograph showing downstream elevation and upstream elevation of Veluthode dam are given in **Fig 1.5a** and **Fig 1.5b**. This **Fig 1.5b** shows the ungated spillway and the trash rack of the scour sluice.

Fig 1.4 Google map view of Veluthode dam

Fig 1.5a Downstream Elevation of Veluthode Dam

Fig 1.5b Upstream Elevation of Veluthode Dam with ungated Spillway and trash rack of scour sluice

Galleries: Drainage cum inspection gallery of 1.50 m width and 2.25 m height is provided in the dam. Access gallery is also provided to reach the inspection gallery.

1.5 Assignment of Responsibility

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

Project Administration Officer in Charge	-	Executive Engineer, Research & Dam Safety Division No. I, Kakkad.
Authorizing releases for irrigation and water supply from scour vent (Power intake from Veluthode dam is ungated)	-	Executive Engineer, Research & Dam Safety Division No. I, Kakkad.

Dam safety surveillance including instrumentation.	-	Executive Engineer, Research & Dam Safety Division No. I, Kakkad.
Routine inspection	-	Assistant Executive Engineer, Research & Dam Safety Sub Division, Seethathode.
Maintenance	-	Assistant Executive Engineer, Research & Dam Safety Sub Division, Seethathode.
Operations of Equipment at the dam	-	Assistant Engineer, Research & Dam Safety Sub Division, Seethathode.
Recording reservoir data	-	Assistant Engineer, Research & Dam Safety Sub Division, Seethathode.

1.6 Collection & Reporting of Dam and Reservoir Data

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

- Reservoir water surface elevation
- Reservoir inflow
- Spillway outflow
- Downstream Irrigation, water supply and hydropower releases
- Weather related data
- Instrumentation data

1.7 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 and Canteen are located nearly 5 km from the dam.

A private nursing home and a Government Health Centre are available at Angamoozhy, 13 km away from the dam.

Police station is located at Angamoozhy, 13 km away from the dam.

Safety equipment like first aid kit and fire extinguisher are available at the dam site.

1.8 Restricted Areas

Certain areas of the dam and reservoir are restricted for entry of the general public. The purpose of restrictions is for security of the dam, public safety and uninterrupted safe operation of the dam. Restricted areas include: confined spaces such as Control room, Gate operation area, Adits, galleries, spillway approach, chute, energy dissipation arrangements, intake, tunnel etc. Warning boards are installed in the prohibited areas near dam.

1.8.1 Dam safety surveillance including instrumentation

Security arrangements are already provided through private agency at the security check posts near dam. Also CCTV surveillance will be provided soon covering the dam and premises.

V notch is provided for seepage measurement. Some new digital instruments are also proposed under DRIP.

1.9 Staff position, Communication & Warning System

The number and description of operating unit personnel posted/placed at different locations of the dam are noted in supporting documents and referenced in this Manual. Communication means available include satellite phones and wireless sets etc. Communication Directory is maintained.

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 Organization, Pallom, Kottayam	Ph: 9446008005, 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. I, Kakkad	Ph: 9446008424 e-mail: ddrdskkds@gmail.com
Assistant Executive Engineer, Dam Safety Sub Division, Seethathode	Ph: 9496011955 e-mail: aeedssdmzhr@gmail.com
Assistant Engineer, Dam Safety Sub Division, Seethathode	Ph: 9496011953 e-mail: aeedssdmzhr@gmail.com

A hierarchy of organizational structure for the control and safety of Veluthode dam is outlined below in **Fig 1.6**.

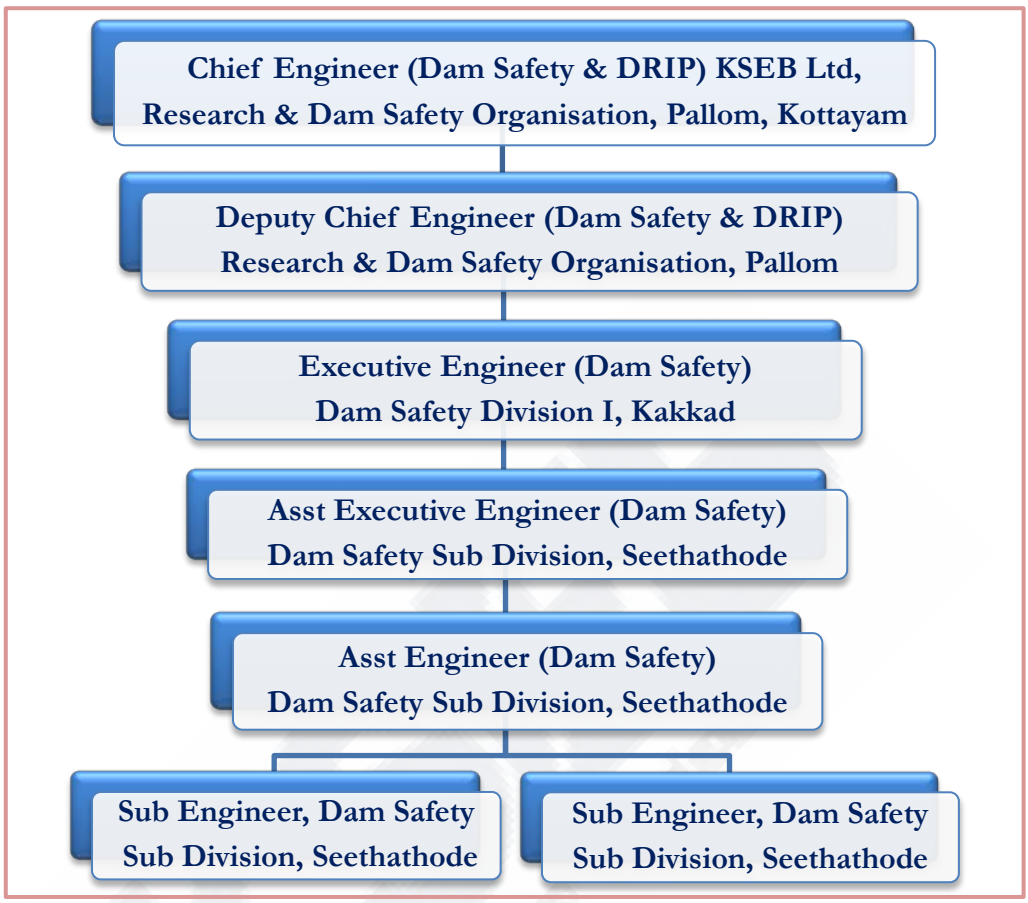

Fig 1.6 Dam Safety Organisation Structure for Veluthode Dam

Spillway flood releases

Kakkad and Sabarigiri Power stations are operated integrally such that the releases from Pamba Kakki Reservoirs regulated together with the waters of Moozhiyar catchment for utilising maximum generation of power in the system. But water level in the Moozhiyar Dam will rise up, if the Kakkad Power station is not in operational condition and during the flood season also, the expectation of flood is high. In such a case, warning for opening of Moozhiyar spillway gates is given as water level reaches 190.0 m level. Veluthode act as a Forebay for utilising the yield from Veluthode River also for power generation at Kakkad HEP through a vertical shaft connected to the IC tunnel from Moozhiyar reservoir. If there is no generation at Kakkad HEP or inflow of Veluthode reservoir is high, the excess water overflows through the ungated ogee overflow spillway. Since the Forebay capacity at Veluthode is only 0.607 Mm^3

and the overflow spillway is ungated, no spillway operation is required at Veluthode; no warning is given for flood control. The river sluice is operated as per requirement based on the Gate Operation Manual.

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

Water from the reservoir is mainly used for power generation at a 2 x 25 MW power house of KSEB Ltd. The water requirement downstream of Veluthode weir is met by opening the river sluice provided in the Forebay dam.

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 guidelines are carried out by the respective officers and reports are submitted to higher office and updated in DHARMA web site.

Maintenance

Routine maintenance is carried out for sluice gate, trash rack and control shaft before the onset of monsoon.

1.10 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 has been entrusted with the specific responsibility for carrying out O & M activities for Veluthode dam.

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

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

1. Dam Safety Division No. I, Kakkad
2. Dam Safety Sub Division, Seethathode
3. Assistant Engineer in charge of Veluthode Dam

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.

1.11 Supporting Documents & Reference Material

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

- Detailed drawings of the Project
- Emergency Action Plan (EAP)
- Latest Hydrology Review and DSRP Reports
- Flood forecasting and operating criteria
- Agreements with user agencies
- Power station operation plan
- Administrative procedures
- Gate Manufacturer's manual and drawings
- Regional communication directory
- Instrumentation reports / results

1.12 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 1.2**.

Sl. No.	Component/ Duty	Frequency	Personnel
1	Visual inspection of dam including Dam top, upstream and downstream faces visible portions of foundation and abutments, Galleries, Spillway and its energy dissipation arrangements.	Daily	Sub Engineer/Dam operators on contract
2	Record water surface elevation.	Daily (Hourly basis during monsoon)	Sub Engineer/Dam operators on contract

3	Record depth of flow over spillway during monsoon.	Daily	Sub Engineer/Dam operators on contract
4	Outflow over spillway during monsoon (To be estimated from depth of flow over the spillway).	Daily	Sub Engineer/Dam operators on contract
5	Record meteorological data, Record releases from outlet/sluices.	Daily	Sub Engineer/Dam operators on contract
6	Check security and safety devices, Complete logbook / site registers which include the above information.	Daily	Assistant Engineer
7	Record seepage from drainage systems, Gallery drains etc.	Weekly	Sub Engineer/Dam operators on contract
8	Visual inspection of dam including Dam top, Upstream and downstream faces, visible portions of foundation and abutments, Galleries, Spillway and its energy dissipation arrangements etc.	Weekly	Assistant Engineer
9	Check Drainage systems, Gallery drains, Toe drains etc.	Weekly	Assistant Engineer
10	Visual inspection of dam top, upstream and downstream faces, visible portions of foundation and abutments, Galleries, Spillway and its energy dissipation arrangements, Intake shaft etc.	Fort nightly	Assistant Executive Engineer
11	Check drainage systems, Toe drains, Gallery drains etc.	Fort nightly	Assistant Executive Engineer
12	Check Sign/Warning display boards near vulnerable locations	Fort nightly	Assistant Executive Engineer

13	Visual inspection of dam including Crest of dam (Dam top), Upstream and downstream faces, visible portions of foundation and abutments, Galleries, Intake shaft etc.	Monthly	Executive Engineer
14	Check measuring devices/Instruments, Security and safety devices, Communication devices, Status of vegetation growth, - rectification, if needed.	Monthly	Executive Engineer
15	Check Sign/Warning display boards near vulnerable locations	Monthly	Executive Engineer
17	Check outlet works, updating operating instruction, check gate air vents, clean gate control switchboxes, check operation of gates& valves, grease gate hanger/dogging	Quarterly	Executive Engineer
18	Check condition of spillway, debris in inlet channel, trash rack of intake structure, Check condition of Outlet works & its Energy Dissipation Arrangement.	Quarterly	Executive Engineer
19	Check for damages in spillway glacis, energy dissipation arrangement, d/s area etc.	Quarterly	Executive Engineer
20	Check condition of V-notch/other seepage measuring devices, Check hydro mechanical components.	Quarterly	Executive Engineer

Table 1.2 Schedule of duties/inspections

1.13 Hydro-Mechanical Inspections / Checks

Frequent inspections/checks for hydro-mechanical components are to be conducted and necessary action to be taken up during maintenance. Routine maintenance is carried out for outlets 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

The operation plan for Veluthode dam consists of instructions for operating the dam and reservoir during routine (normal) and emergency conditions. The operating procedures for normal operations are discussed in this chapter including operating criteria for the reservoir & outlets.

2.1.1 Dam

The Veluthode dam is 107.00 m long at top and the top width is 4.00 m. The deepest river bed level is 175.50 m and the top of the dam is 196.00 m. The FRL and MWL of the dam are 192.00 m and 195.00 m respectively. The live storage above the dead storage level of 186.00 m is 0.607 Mm^3. The dam is divided into 7 blocks. The dam has a catchment area of 6.84 sq km and has a concrete content of 0.01456 Mm^3.

The downstream elevation showing important levels is given in **Drg 2.1** of **Annexure 1**. A typical cross-section of the dam is given in **Fig 2.1.**

2.1.2 Spillway

The spillway of Veluthode dam is an ungated overflow type structure, which has a single bay of length 20 m. The elevation of the crest of the spillway is 192.00 m. A photograph of spillway at Veluthode dam is given in **Fig 2.2**. A section of the dam through the overflow portion of spillway is given in **Fig 2.3**. The details of spillway crest are given in **Drg 2.2** of **Annexure 1**.

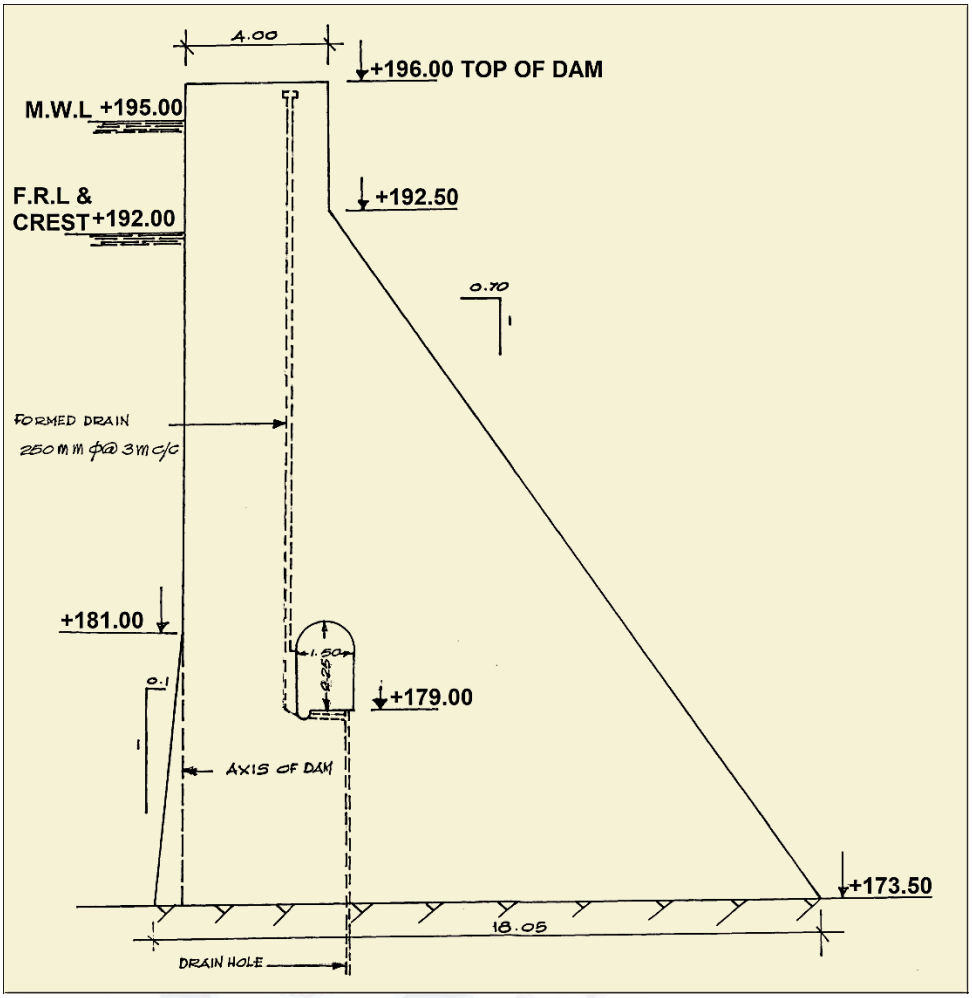

Fig 2.1 Cross-section of Veluthode dam

Fig 2.2 Spillway of Veluthode dam

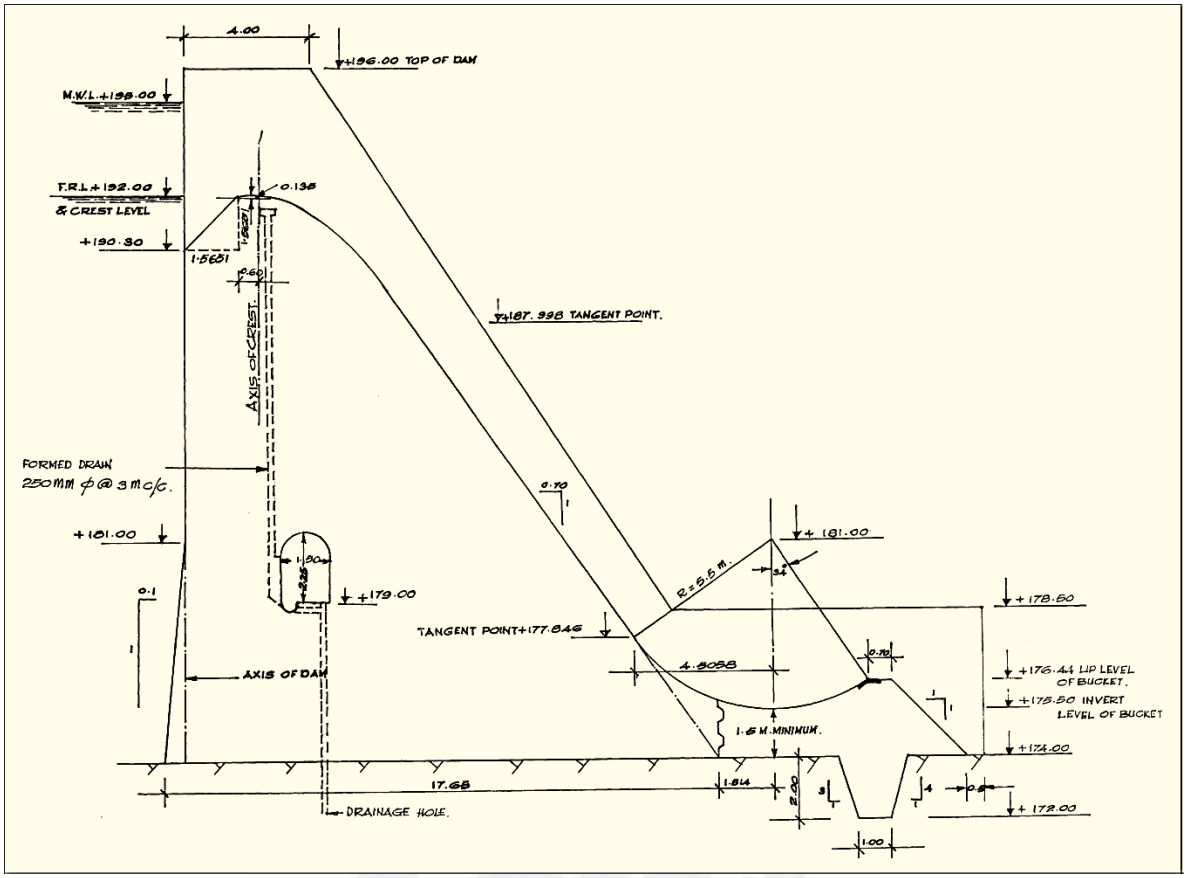

Fig 2.3 Cross-section through the overflow portion of Spillway

2.1.3 Outlet arrangements

There is one lower level scour sluice in Block no.4 of Veluthode dam controlled with a gate arrangement. For letting out water from the reservoir, an emergency gate and service gate of size 1.80 m x 2.70 m are provided. The discharge capacity of the sluice is 33.3 m^3/s.

The cross-section and sectional plan of scour sluice are shown in **Drg 2.3** and **Drg 2.4** of **Annexure 1**. The sectional plan, section and elevation of trash rack structure are shown in **Drg 2.5, Drg 2.6** and **Drg 2.7** of **Annexure 1**. Photographs of upstream elevation, downstream elevation and sluice gate of Veluthode dam is given in **Fig 2.4**, **Fig 2.5** and **Fig 2.6**.

The emergency & service gates and its hoisting system are supplied by M/s Kerala Electrical & Allied Engineering Company Ltd., a government undertaking.

Fig 2.4 Upstream view of Veluthode dam with scour sluice

Fig 2.5 Downstream view of Veluthode dam

Fig 2.6 Sluice gate at Veluthode dam

2.1.4 Elevation Capacity Curve

Veluthode dam is only a Forebay dam for Kakkad HEP which generates power from the tailrace discharge of SGHEP. The capacity of the reservoir is only 0.607 Mm^3 and is provided with an ungated overflow spillway with a maximum head of 3 m. The yield from Veluthode River is also drawn through an intake shaft into the tunnel which takes off from Moozhiyar reservoir and downstream water requirement of the river is met with the overflow as well as river sluice operation. Area Capacity for this Forebay is not prepared and available. A contour layout of the dam with spillway, intake shaft, Veluthode stream, leading channel, I C tunnel and power tunnel is given in **Fig 2.7** below.

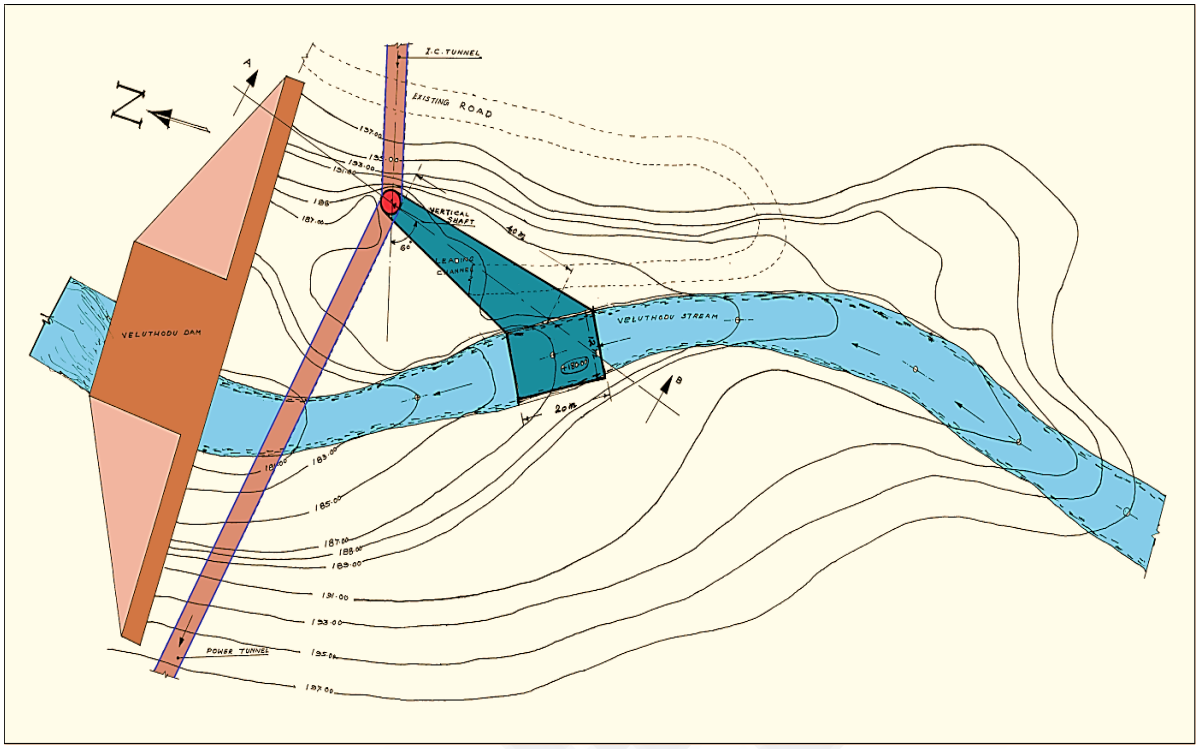

Fig 2.7 Layout of Veluthode dam with Intake shaft and spillway

2.2 Operation Plan

An effective operation plan and schedule is required for the safe project operation. The Kakkad and Sabarigiri Power stations will be operated integrally such that the releases from Pamba - Kakki Reservoirs (after generation from Sabarigiri HE Project) together with the waters of Moozhiyar catchment are used for maximum generation of power in the system.

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 occurred during August 14 to 17 in 2018 which resulted in record inflow in to the reservoir. The SW monsoon of the year 2018 in the State was similar to that of 1924 Devikulam storm, Kerala experienced an abnormally high rainfall from 1 June 2018 to 19 August 2018 which resulted in severe flooding in 13 out of 14 districts in the State. It is seen that the 2-day and 3-day rainfall depths of 15-17, August 2018 rainfall in Pamba,

Periyar and Bharathapuzha sub-basins are almost comparable to the Devikulam storm of 16-18, July 1924. For the entire Kerala, out of 758.6 mm rainfall from 1 August 2018 to 19 August 2018, about 414 mm rainfall occurred in just three days viz. 15-17, August 2018, which created severe flooding in the State, while the same during 16-18, July 1924 was 443 mm.

The Kakkad HE Project was designed in such a way that both Kakkad and Sabarigiri Power Houses are operated integrally so that the releases from Sabarigiri Power House together with the waters of Moozhiyar catchment are utilized for maximum generation of power in the system. Further releases through the Moozhiyar spillway may be required to be passed whenever unprecedented flash floods from small tributaries like Saipinthodu, Thottakuzhy etc. (upstream of the Moozhiyar Dam site) occur. In such occasions, the spillway shutters/gates are opened while attempting to keep the reservoir at FRL. The recent heavy flash flood of 14.08.2018 at 10.40 pm was managed by opening the spillway gates of Moozhiyar dam.

As said earlier, Veluthodu is an ungated overflow spillway which spills out as and when the reservoir level rises above its spillway crest level. The Forebay yield which can be utilized for Kakkad power station will be drawn through the vertical control shaft to the power tunnel and the rest rising beyond the spillway crest will overflow.

2.2.2 Design Flood and Features Related to Safety

Original Hydrology

The design flood was estimated earlier for from a small catchment area of (6.84 sq km) using Ryve's formula with value of C=2700 as 146 m^3/sec.

Hydrology review carried out in DRIP

The catchment area of Veluthode dam is 6.84 km^2. The length of stream up to dam location is 4.56 km. The equivalent slope of the stream is 142.776 m/km and the storage is only 0.67 hm^3. For catchment areas is less than 25 km^2, the flood is estimated using RBF-16. As the catchment area **6.84 km^2** of this Dam is very small, the revised design flood was estimated using **Improved Rational Formula** based on the document **RBF-16** published for estimating flood of smaller catchments collected from Central Water Commission. The revised flood of Veluthode dam is estimated as 201.23 m^3/s. Veluthode dam is provided with an ungated spillway of capacity 216.65 m^3/s.

2.3 Normal Operation of the Reservoir

The operating procedures developed for normal or day to day operation of a dam have been discussed in the sub-sections below.

2.3.1 Operation of Control Mechanisms

The emergency and service gate hoist motor is having 5 HP capacities each. The Operation manual of control mechanism is attached as **Annexure 2**.

River Outlets

The scour sluice is operated with a gate arrangement. The salient features of the gates and its hoist are given below.

Service and Emergency gates		
Type of gate	:	Fixed wheel type
Weight of gate	:	3.5 T each (approx.)
Type of seal	:	Teflon cladded rubber seal
Type of wheel bearing	:	Spherical roller bearing
Capacity and type of Hoist	:	15 T., Rope drum type
Lowering or raising speed	:	0.9 m /min (approx.)
Brake	:	Electro-magnetic (solenoid operation) brake with B.D coupling
Motor		
a. Speed	:	950 rpm
b. HP	:	5 HP
c. Supply	:	440 Volts, 3 phase 50 Hz

The river sluice/ emergency gate hoist structure is shown in **Fig 2.8a** and mechanism with motor and control panel in **Fig 2.8b.**

2.3.2 Operation of the Reservoir

Veluthode dam has an ungated overflow spillway. The reservoir water will overflow on reaching the Full reservoir Level i.e. El. 192.00 m which is also the spillway crest level. Discharge through spillway for different reservoir levels above FRL is tabulated in **Table 2.1** and plotted in **Fig 2.9**.

Fig 2.8a River sluice/ emergency gate hoist structure

Fig 2.8b Emergency gates hoisting mechanism

Reservoir water level in m	Head above crest in m	Discharge in m^3/s
192.00	0.00	0.0
192.25	0.25	4.3
192.50	0.50	12.5
192.75	0.75	23.1
193.00	1.00	35.6
193.25	1.25	52.8
193.50	1.50	70.7
193.75	1.75	90.6
194.00	2.00	112.2
194.25	2.25	135.6
194.50	2.50	160.8
194.75	2.75	187.8
195.00	3.00	216.6

Table 2.1 Free Spillway Discharge

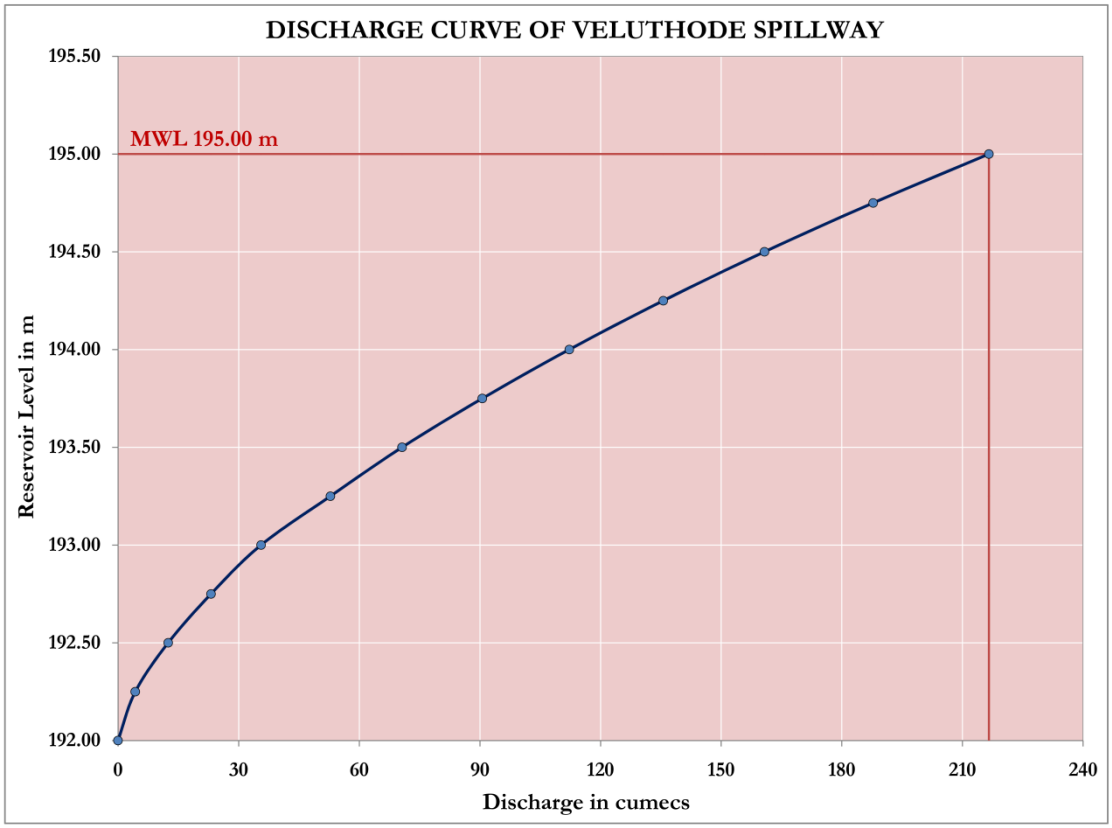

Fig 2.9 Discharge Curve for Veluthode spillway

2.3.3 Rule Curve

As per the Kerala flood study report of August 2018, CWC has recommended for reviewing the rule curves of all the reservoirs in Kerala. The rule curves need to be formulated for both conservation as well as operations during the flood, especially for storage 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 particularly in the early period of monsoon. Accordingly, rule curves for major reservoirs under KSEB Ltd have been reviewed considering the historic inflows and the power demand during respective months.

However, the gross storage capacity of Veluthode Forebay dam is only 0.607 Mm^3 and Kakkad HEP is designed as a tail race scheme of Sabarigiri HEP. Veluthode dam has an ungated overflow spillway. As such it has no rule curve.

2.3.4 Safety Aspects

The safety and security of dam against the structural damages by vandals, public and unauthorized operation of outlet gates is e taken care of by deployment of security personnel.

Reservoir Capacities

The Gross storage and the Live Storage of the reservoir at FRL are 0.67 Mm^3 and 0.607 Mm^3 respectively and the ungated spill details are given in **Table 2.1.** The reservoir capacity may reduce with time because of reservoir sedimentation. Bathymetric survey/Desilting of the reservoir may need to be considered every 10 years.

2.3.5 Climate

The area experiences moist tropical climate with moderate temperature and heavy rainfall. The South-West monsoon which occurs from middle of May to September accounts for the bulk of the rainfall. The period January to April is comparatively dry during which the balance 10% of the rainfall in the year occurs.

2.3.6 Emergency Operation

The Emergency operation will be carried out following the Emergency Action Pan (EAP). The Emergency conditions are outlined in **Chapter 4** under **Cl.4.2.1** on Immediate Maintenance. The EAP together with this Manual will be available at site at all times. Summary of alert conditions during Emergency are given in **Annexure 7**.

2.4 Power Generation

The Kakkad and Sabarigiri Power stations will be operated integrally such that the releases from Pamba - Kakki Reservoirs (after generation from Sabarigiri HE Project) together with the waters of Moozhiyar catchment are used for maximum generation of power in the system. The surface Power House is located on the left bank of Kakkad River at Seethathode. There are two generating units of 25.00 MW each. The turbines are of vertical Francis type manufactured by BHEL. A firm power draft of 28.40 cumec will be available for utilization at the Kakkad Power House, generating 262 MU of energy annually.

The installed capacity of the Kakkad project is 50 MW (2 x 25 MW) with firm power 30 MW. The water released from the Kakkad Power station is used for power generation at Ullumkal Power station (IPP) & Karikkayam Power station. The tail water flows into the Maniyar reservoir for power generation in the Maniyar power station, operated by M/s Carborandum Universal Ltd.

2.4.1 Power Outlets

Intake Shaft

This vertical intake (See **Fig 2.7**) is located 25 m upstream of Veluthode dam. Its diameter is a 4.15 m and length is 18.85 m (See **Drg 2.9** of **Annexure 1**). The inlet sill level is El.186.00 m. The vertical intake shaft is ungated.

The water conductor system starts from Moozhiyar dam as a lined interconnecting tunnel 3.168 km long of 4.15 m finished diameter up to its intersection with the vertical intake from Veluthode reservoir. A lined Power tunnel 7.925 km long of 4.15 m finished diameter starts from this intersection point at Veluthode and it connects with a restricted orifice surge shaft of 16 m finished diameter. A lined pressure shaft starts from the surge shaft with a length of 687.57 m (266.83 m steel lined and 420.74 m concrete lined) with bifurcation at Power House end. Photographs of circular shaft at Veluthode Forebay are given below in **Fig 2.10**. The details are given in **Drg 2.10, Drg 2.11** and **Drg 2.12** of **Annexure 1**.

Trash-rack structure

Trash rack arrangements are provided, at the vertical shaft in a semicircular pattern around the vertical inlet face of the shaft which joins with the IC tunnel and power tunnel below, supported by R.C.C. columns and ribs as in **Drg 2.8** & **Drg 2.9** of **Annexure 1**. There are six

bays and four panels each in a bay i.e., total 24 panels. The elevation and section of a typical panel of trash rack is given in **Drg 2.13** of **Annexure 1**.

Fig 2.10 Vertical Intake Shaft

2.4.1 Power Tunnel

The entire length of the tunnel is lined with the cement concrete with an average thickness of 25 cm. Slope of the tunnel is 1 in 200 (approx). Normal and maximum velocity of flow is 1.58 m/s and 3.5 m/s. On completion of the work of power tunnel, trial run was done for both the machines of power house during 1999, after filling the power tunnel.

2.4.2 Surge Shaft

The surge shaft is a restricted orifice of 16.00 m diameter with two number circular shaped orifices of 2.13 m diameter. The bottom level at the center of the surge shaft is +129.325 m. Top level of the surge shaft is+200.00 m. Maximum and minimum upsurge level are +196.248 m and +154.453 m respectively. Photograph showing the surge shaft gallery is given in **Fig 2.11**. A vertical lift gate **(Fig 2.12)** of size 3.5 m x 4.15 m is provided as control gate. The salient features of this gate are given below.

Surge shaft gate		
Type of gate	:	Fixed wheel type
Weight of gate	:	24 T (approx.)
Type of seal	:	Teflon cladded rubber seal
Type of wheel bearing	:	Spherical roller bearing
Capacity and type of Hoist	:	85 T., Rope drum type
Lowering or raising speed	:	1 m /min (approx.)
Brake	:	Electro-magnetic (solenoid operation) brake with B.D coupling
Motor		
a. Speed	:	1000 rpm
30 HP	:	
440 Volts, 3 phase 50 Hz	:	

Expansion gallery of size 6.00 m x 8.00 m for 50.00 m length is provided to outflow the surplus water. The bottom and top level is at +192.00 m and +200.00 m. Section through surge shaft with details is given in **Fig 2.13**. The plan and sectional plan of surge shaft are given in **Drg 2.13** and **Drg 2.14** of **Annexure 1**.

2.4.3 Pressure Shaft

From the surge tank one pressure tunnel takes off having 4.15 m diameter for 476.31 m length, 3.60 m diameter for 187 m length and 2.60 m diameter for 24.26 m bifurcating at the power house end to feed two machines.

2.4.4 Initial Filling of Reservoir

The Reservoir was initially filled during 1999. First power tunnel filling was started from 07.05.1999 onwards and the trial run of the machines was done successfully. The commissioning of the machines of the Power House was done in 1999 and they were put into commercial operation in the same year.

Fig 2.11 Surge shaft gallery

Fig 2.12 Vertical lift gate of the surge shaft

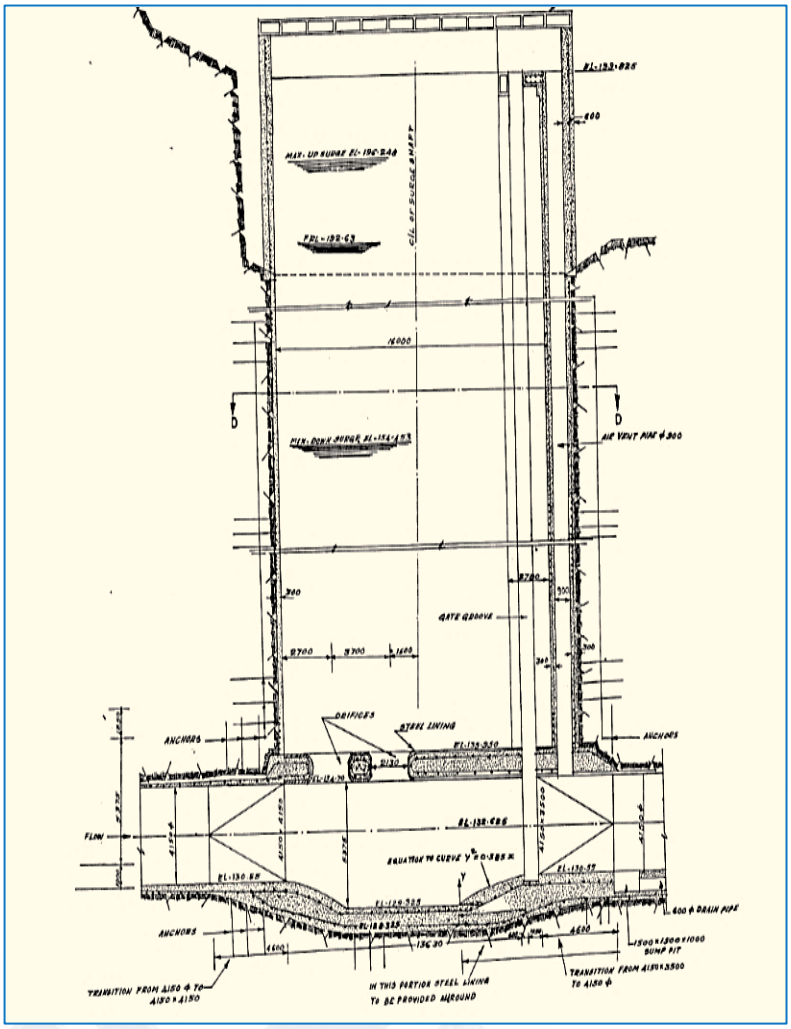

Fig 2.13 Section through Surge shaft

2.5 Record Keeping

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

Following records of reservoir operations are being maintained:

1. Reservoir levels on daily basis during non-monsoon and hourly basis in monsoon.
2. Depth of outflow /Outflow discharge over the spillway on hourly basis during monsoon.
3. Discharge data through scour sluice (river outlet) and power outlet.
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 Veluthode dam includes the Executive Engineer in presence of Assistant Executive Engineer at site to carryout pre-monsoon and post-monsoon inspections as per CWC guidelines in the format issued by CWC. 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 incorporated in DHARMA. Detailed description on project inspections is available in the Guideline for Safety Inspection of dams. However an overview of the various types of inspections to be carried out at Veluthode dam is given below.

3.1 Types of inspections

Four different types of dam safety inspections are being carried out at Veluthode Dam. These include, but are 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 dam safety 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.
- A visual inspection or field examination of the dam, its appurtenant works, and the surrounding areas.
- Review of the instrumentation records and structural behavior reports, if any.
- 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.

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 - (both Original and design flood review study)
- Basic data and Issues related to safety of dam
- Problems if any during construction
- Drawings of dam, spillway, gates and appurtenant structures
- Status of the instrumentation

- Construction History
- Geological Report including Special problems at site and their treatment
- Field Inspection- Observation & recommendation regarding Remedial Measures

Dam Incidents and Reservoir filling

First power tunnel filling was started from 07.05.1999 onwards and the trial run of the machines was done successfully. The commissioning of the machines of the Power House was done in 1999 and they were put into commercial operation in the same year.

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.

Scheduled inspections include the following components as a minimum:

- Review of past inspection reports, monitoring data, photographs, maintenance records, or other pertinent data as may be required
- Visual inspection of the dam and its appurtenant works
- Preparation of a report or inspection brief, with relevant documentation and photographs. The report should be filed in the dam owner's project files

3.3.1 Pre- and Post-Monsoon Checklist and Example of 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	:	Deputy Chief Engineer along with SPMU Executive Engineer, Field Executive Engineer, 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 available relevant files or data,
2) Visual inspection of all components of the project and surroundings, and
3) Report preparation covering status of project and recommendations.

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

3.5 Informal Inspections

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

Operators, maintenance crews, or other staffs who are posted at Veluthode dam site are supposed to conduct informal inspections on routine basis (See duty roasters in Chapter 1). 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 while walking across the dam for inspection / surveillance, checking the operating equipment, and noting changes in conditions may prevent serious mishaps or even dam failures.

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

Chapter 4

Project Maintenance

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

4.1 Maintenance Plan

A basic maintenance schedule for the various monitoring components prepared for Veluthode dam based on manual of operating parts, frequent inspections, priority, and interval for Veluthode dam is arrived showing the tasks to be performed and how frequently that is to be inspected/observed and repaired **Annexure 5**.

4.2 Maintenance Priorities

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

4.2.1 Immediate Maintenance

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

- The dam is about to be overtopped or being overtopped during high flood.
- The dam showing signs of piping or internal erosion along faults, weak zone etc. indicated by increasingly cloudy seepage or other symptoms.
- Evidence of excessive seepage as seen in the gallery/on downstream face of the dam.

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

4.2.2 Preventive Maintenance

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

4.2.2.1 Condition Based Maintenance

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

- Remove all vegetation and bushes from the dam and restoring any eroded areas in the vicinity of the dam.
- Repair of defective gates and other hydro-mechanical equipment.
- Repair any concrete or metal components that have deteriorated.
- Cleaning of the choked drainage holes in the dam body/ foundations in concrete / masonry dams.
- Repair any damages on spillway glacis, piers, energy dissipaters, training/divide walls, downstream areas etc.
- Controlling any heavy seepage in the foundation/ inspection galleries in Concrete dams from drainage holes.
- Repairs of any cracks/cavities/joints in concrete dam.
- 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 in shear zones, faults etc., 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 e.g. servicing of gates/hoist of outlet works/sluices.
- Maintaining proper lighting at dam top, galleries, etc.

- Monitoring of seepage in galleries.
- Monitoring/ cleaning & removal of leached deposits in porous concrete / formed drains in dam body and foundation drainage holes.
- Removal of trash from trash racks.
- Maintenance of all dam roads & access roads.
- Operation of electrical and mechanical equipment and systems including exercising gates
- 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. Vehicles are permitted after security checking at check posts.

4.3.2 Controlling Vegetation

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

4.3.3 Masonry / Concrete dams & spillways

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

- Cracking in concrete (potential causes are alkali – aggregate reaction, thermal stresses because of heat of hydration or temperature variations, foundation problems).
- Damages on spillway glacis, training/divide walls, energy dissipaters, downstream areas (probable causes are cavitation, abrasion, un-symmetrical flows, unfavorable down-stream conditions)
- Vegetation growth in spillways, spill channel, approach channel etc.

- Seepage in Galleries and on d/s face of the dam.
- Cleaning and removal of leached deposits from choked drainage holes in the dam body/foundations.
- Status of rectification works undertaken from time to time need to be assessed during periodic maintenance.
- To ensure proper access & lighting in galleries.
- To ensure that the dam is behaving as designed based on instrumentation programs.

Some routine maintenance works of concrete surfaces to repair deteriorated areas can be undertaken following the standard specifications for repair of concrete surfaces. For remedial measures of problems of special nature advice of experienced engineers/ Panel of Experts needs to be obtained.

4.3.4 Outlet Works

The Civil and HM components of intake shaft and river outlet provided in Veluthode Dam are detailed in **Cl.2.4.1** and **Cl.2.3.1**. The operation and maintenance of service and emergency gates of river sluice are detailed out in the manufacturer's manual attached as **Annexure 2**. The outlet conduits should be inspected thoroughly once a year.

Painting of metallic components of gates and valves shall be done as per BIS codes and subsequent paras. Provision for timely maintenance shall be made every year for all activities necessary for HM works including application of cardium compound to wire ropes. If routine inspection of the Hydro-Mechanical Equipment shows the need for maintenance, the work should be completed as soon as possible. Painting of sluice valve was done in the DRIP works.

4.3.5 Trash Racks

Trash racks of river outlet and power intake shaft may become clogged with debris or trash which can reduce their discharging capacity. The head losses through clogged trash racks also increase. Maintenance of trash racks includes periodic inspections for rusted and broken sections and repairs to be made as needed. Trash racks should be checked during and after floods to ensure that they are functioning properly and to remove accumulated debris periodically as per site requirements. The trash rack cleaning for this dam is possible only after depleting the reservoir through the river outlet.

4.3.6 Gates & Hoisting Equipment

The safe and satisfactory operation of a dam depends on proper operation of its Gates & Hoisting Equipment. 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 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.

4.3.6.1 Vertical lift fixed wheel and Slide Gates

These gates are provided in spillways, outlet works, sluices etc. for controlling/regulating the flow. Service and Emergency gates provided for river outlet of Veluthode dam are of this type. The main components of these gates are as under;

i). Embedded parts:

- Sill beam assembly
- Top and side seal seats
- Roller track
- Side guide
- Dogging arrangement

ii). Gate Parts:

- Skin plate Assembly
- End Verticals
- Horizontal girders
- Vertical Stiffeners
- Roller assembly
- Seal Assembly
- Side guide assembly
- Lifting Arrangement

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

i. The gate slot and bottom platform/sill beam should be cleaned periodically. Scales formed over the embedded parts should be removed. Second-stage concrete should be checked for any development of cracks / leakages and repairs should be attended to immediately.

ii. Rubber seals should be smoothed, if required, for proper alignment. All nuts and bolts fixing the seal to the gate should be tightened uniformly to required torques. Seals, if found damaged or found leaking excessively should be adjusted, repaired or replaced as considered necessary.

iii. The wheel shall be rotated to check their free movement. Gate roller bearings and guide roller bushes should be properly lubricated. Whenever necessary these should be opened for rectifications of defects, cleaning and lubrication and should thereafter be refitted. These may be replaced if repairs are not possible.

iv. Hoisting connection of the gate leaf should be lubricated where necessary and defects if any should be rectified.

v. All nuts, bolts, check nuts and cotter pins of the lifting devices should be checked periodically.

vi. All components should be greased and lubricated. Recommended and approved oils and grease only should be used.

vii. Roller assembly should be adjusted by the eccentricity arrangement to ensure all rollers rest uniformly on the track plates particularly in the closed position of the gate.

viii. All welds shall be checked for cracks/ damages. Any weld that might have become defective should be chipped out and redone following the relevant codal provisions. Damaged nuts, bolts, rivets, screws etc. should be replaced without delay.

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

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

xi. All nuts and bolts shall be tightened.

4.3.7 Maintenance of Electrically operated fixed hoists

General Instructions:

a. 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.

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

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

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

   iii. Clean all hoisting equipment and hoist platform.

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

   v. Apply grease of suitable grade by grease gun.

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

   vii. Check all the fuses on the power lines.

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

   ix. Check the supply voltage.

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

   xi. All the geared couplings shall be greased.

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

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

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

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

xvi. All ropes shall be checked for wear and tear and if broken wires are noticed, the rope shall be replaced.

xvii. All the wire ropes shall be checked and all visible oxidation shall be removed.

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

xix. Check the overload relays for proper functioning.

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

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

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

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

b) The effectiveness and slip of the 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.

xxiii. 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.

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

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

4.3.8 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 connector 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 connector 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 connector 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 connector 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.

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

4.3.9 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.

4.3.10 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 H M 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:

- <u>Primer Coat:</u>

  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.

- <u>Finished paint:</u>

  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 off 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 de scaled 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.

4.3.11 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 cut and fill slopes along the sides of the road should be made. In case of unstable conditions/slopes developing 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.

4.3.12 General Cleaning

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

4.4 Materials and Establishment Requirements during Monsoon

Materials required during monsoon period for both immediate maintenance and preventive maintenance must be stocked in adequate quantities for emergency situations that may arise. At Veluthode Dam, round the clock patrol is to be carried out during monsoon period. Details of manpower are given in below in table.

Present Manpower		
Designation	**Veluthode 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.1.8.1**	

Following materials are the minimum 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 Veluthode 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**- T&P requirements for offices, colony, works etc. as applicable.

viii) **Works**-Painting, oiling, greasing, overhauling of HM equipment's, Repair/replacement of gates seals & wire ropes, 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 & basic facilities, provision for flood contingency works during monsoon, unforeseen events/items (about 10% of the cost of works) etc.

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 & colony complex			
	Sub-total - a			
b.	**Works**			
1	**Civil works**			
1.1	Concrete / masonry dam			
1.2	Sluices in concrete / masonry dams			
1.3	Approach / inspection roads within dam area			
2	**Hydro-Mechanical works**			
2.1	Sluices in concrete/masonry dams – service & emergency gates & hoists, trash racks in river sluice, power shaft etc.			
3	**Electrical works**			
3.1	Electrical fittings, motors, controls for all gate hoists			
3.2	Power supply lines			
3.3	Electrical fittings on dam top, dam galleries, etc.			
4	**Instrumentation**			
5	**Miscellaneous works**			
6	**Salary of work charged staff including all benefits**			

7	**Materials to be stored before monsoon**			
	Sub-total - b			
c.				
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 by drawing information from a wide spectrum of instruments and procedures, ranging from simple to complex. The program must be based on prevailing geotechnical conditions at the dam, and must include consideration of the hydrologic and hydraulic factors present before and after the project is in operation.

5.1 Instrument Types and Usage

Instruments are not installed for Veluthode dam except V notch. It is proposed to install Tilt meters, Joint meters and Uplift gauges in the dam under DRIP. Only seepage through the foundation drain holes is observed. The status of instrumentation in Veluthode dam is given in the **Table 5.1.**

Sl. No.	Name of the instruments	Parameters monitored	Total no installed	Functioning	Frequency of observation
1	V Notch	Seepage	1	1	Monthly (weekly during monsoon)

Table 5.1 Instrumentation Present Status

Certain instruments are proposed under DRIP as below.

INSTRUMENTS PROPOSED UNDER DRIP			
Sl. No.	**Name of the Instruments**	**Existing**	**Proposed under DRIP**
1	V Notches	1	2
2	Survey Markers (Target Points)/settlement plates	0	5
3	Uplift Gauges / Pore Water Pressure Gauges	0	5
4	Joint Meter	0	5
5	Tilt Meter	0	2

In Veluthode dam, there are 11no's vertical drain holes and 6no's foundation drain holes (**Drg 5.1** of **Annexure 1**). The seepage measured during the recent past is tabulated below in **Table 5.2**. A monthly observation, mainly through the foundation drain holes are being carried out and are reported to the higher ups.

Seepage details of Veluthode dam from 2014 to 2019

Date	Water Level in m	Seepage in lit/min
22.04.2014	187.00	4.80
20.05.2014	187.00	4.80
29.07.2014		0.60
25.08.2014	186.25	1.20
11.09.2014	186.35	2.40
20.10.2014	186.25	2.40
29.11.2014	187.50	4.80
22.12.2014	187.00	4.80
28.01.2015	186.20	8.40
20.02.2015	186.20	8.40
23.03.2015	186.00	2.40
23.04.2015	186.50	4.80
22.05.2015	186.00	2.40
22.06.2015	186.20	8.40
23.07.2015	187.00	4.80
24.08.2015	186.50	4.80
29.09.2015	186.20	8.40
21.10.2015	186.20	8.40
26.11.2015	186.25	2.40
22.12.2015	186.70	4.80
22.01.2016	187.10	8.40
22.02.2016	188.55	8.40
17.03.2016	186.00	2.40
22.04.2016	186.30	8.40
20.09.2016	186.30	9.00
25.10.2016	186.00	9.00
17.11.2016	186.00	V notch damaged
25.01.2017	192.00	V notch damaged
09.03.2017	187.20	V notch damaged
25.03.2017	187.20	V notch damaged
28.04.2017	191.90	V notch damaged

31.10.2017	186.90	V notch damaged
17.11.2017		V notch damaged
22.12.2017	187.45	V notch damaged
23.01.2018	185.50	V notch damaged
21.02.2018	185.35	V notch damaged
27.03.2018	187.10	V notch damaged
16.04.2018	184.90	V notch damaged
23.05.2018	188.00	V notch damaged
12.06.2018	186.50	V notch damaged
18.07.2018	189.60	V notch damaged
31.08.2018	187.75	V notch damaged
26.09.2018	185.00	V notch damaged
30.10.2018	189.55	V notch damaged
29.11.2018	185.80	0.487
18.12.2018	186.90	0.237
31.01.2019	185.75	0.237
28.02.2019	188.05	0.237
30.03.2019	184.70	0.237
29.04.2019	186.40	0.237
29.06.2019	183.20	0.237
29.07.2019	185.20	0.804
29.08.2019	184.50	0.276
25.09.2019	185.95	0.276
30.10.2019	185.10	0.688

Table 5.2 Seepage details of Veluthode dam from 2014 to 2019

5.2 Data Processing, Evaluation, Interpretation and Performance Evaluation reports

The instrumentation monitoring is done periodically as above and monthly reports are prepared for evaluation. Data interpretation is being done yearly.

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 DSRP under DRIP; recommendations were given for works/remedial measures to be attempted for improving the safety and performance of the Dam. Accordingly the following works were carried out under DRIP.

- Painting of Veluthode dam
- Pressure washing the downstream face and painting parapet and allied structures of Veluthode dam
- Removal of debris/ loose stones from downstream of spillway channel of Veluthode dam
- Improvements to road to Veluthode dam gallery
- Painting of emergency gate & hoist mechanism of Veluthode dam
- Improvements to road from Veluthode bridge to Veluthode dam and short access road.

The photographs showing the DRIP works are given below:

Before - Painting works of Veluthode dam

After - Painting works of Veluthode dam

Before - Pressure washing the downstream face and allied structures of Veluthode dam

After - Pressure washing the downstream face and allied structures of Veluthode dam

Before - Removal of debris/ loose stones from downstream of spillway channel of Veluthode dam

After - Removal of debris/ loose stones from downstream of spillway channel of Veluthode dam

During - Improvements to road to Veluthode dam gallery

After - Improvements to road to Veluthode dam

Before - Painting of gate at Veluthode dam

After - Painting of gate at Veluthode dam

Chapter 7

Updating the Manual

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

Aspects to be considered when updating the Manual must include:

1. Increase/decrease in the frequency of an inspection or the maintenance routine based on additional data/experience acquired
2. Changes in the operation and/or maintenance procedures based on additional data/experience acquired
3. Alterations to the project data because of changes/modifications in the dam by way of additional spillway etc.

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