GOVERNMENT OF ODISHA
DEPARTMENT OF WATER RESOURCES

OPERATION AND MAINTENANCE (O&M) MANUAL
BALIMELA DAM

PROJECT ID CODE: OR10MH0061

PREPARED BY:

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Government of Odisha
Department of Water Resources

Disclaimer

This *Operation and Maintenance Manual for Balimela Dam* in no way restricts the dam owner in digressing from her/his responsibilities. The Central Dam Safety Organization or the Central Water Commission cannot be held responsible for the efficacy of this Manual developed based on documents provided by the dam owner. The Dam Owner and her/his Operators must exercise appropriate discretion while implementing and using this Operation and Maintenance Manual for the O&M of Balimela dam and its appurtenant structures.

The Manual was developed for the purposes of organizing and managing the Operation, Inspection and Maintenance of Balimela dam which will help in reducing its risk and optimizing its performance.

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PREFACE

This Operation and Maintenance (O&M) Manual for Balimela Dam contains procedures for carrying out Reservoir and Gates operations, Inspections and Maintenance. It will assist in safe functioning of the dam and in properly operation and maintenance. Timely inspection and maintenance is necessary for the safe functioning of the dam and continued productive use of the dam and reservoir. The term “O&M” as employed in this Manual includes operation, inspection, maintenance and repair of dam components, replacement of equipment and appurtenant structures, as required.

This Manual is provided to assist the dam owner in management of their project in a safe and efficient manner.

This Manual was prepared following the Guidelines for preparing O & M Manuals for dams (Doc. No. CDSO_GUD_DS_03_v1.0) published by CWC in the year 2018 under DRIP.

Director,
State Project Management Unit,
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CHAPTER 1

1. GENERAL INFORMATION

This Operation and Maintenance (O&M) Manual contains procedures for carrying out Reservoir and Gates operations, Inspections and Maintenance for Balimela dam. It will assist in ensuring that the dam is functioning safely and to keep it in a good condition by periodic repairs/maintenance. Timely maintenance is important for the continued safe functioning of the dam and productive use of the dam and reservoir.

The term “O&M” as employed in this Manual includes operation, maintenance, general repairs of dam components including replacement, as necessary.

The Manual is prepared primarily for the dam operations staff and their supervisors who are assigned the responsibility for the physical operations and maintenance of the dam. It contains all information and instructions necessary for them to perform their allotted tasks. In addition to instructions for dam operations staff, the Manual defines responsibilities of various dam officials and provides the systematic procedures, guidance and standard forms to ensure safe operation, extend the life and achieve the intended purpose of the dam.

If any unusual and emergency condition arises, then the procedures laid down in the Emergency Action Plan (EAP) are to be followed.

1.1 Purpose, Location & Description of Balimela Dam

Balimela dam has been constructed across river Sileru near village Chitrakonda of Chitrakonda Tehsil in the district of Malkangiri, Odisha. Its latitude is 18^0-08’-25” N and longitude is 82^0-07’-22” E. The reservoir has a gross storage capacity of 3610 Mm^3 and live storage capacity of 2676 Mm^3.

Balimela is a joint project of the States of Odisha and Andhra Pradesh. Both the state’s share the live storage equally. The storage is utilized for generation of 135 MW of firm power at Balimela for Odisha State (510 MW installed capacity) and for supplying water to Andhra Pradesh at Guntawada in the reservoir of Upper Sileru dam through Andhra Pradesh tunnel /Spillway gates/ sluices in Masonry dam.

The released water from the power house of Balimela in Odisha is picked up by constructing a barrage at Surlikonda to irrigate about 60,000 ha of CCA. Even though the project was originally contemplated for power generation, it was later on changed to a multipurpose project due to the inclusion of irrigation component of Odisha.

The construction of the dam was started in the year 1962 and completed in the year 1977. The project consists of 1821 m long rolled filled type Earth dam across river Sileru with maximum height of 70m in the left side and three no. dykes in the right side. The total length of three nos. of earthen dykes is 2278 m. The Dyke No. 1 has maximum height of 36m and length 853.00m, Dyke No. 2 has maximum height of 37m and length 613m and Dyke No. 3 has maximum height of 46m and length 812m.

The spillway is located in the 4^{th} saddle in between the main earthen dam and three no. dykes. It is a straight gravity masonry spillway with an ogee crest. The spillway has 10 nos. radial gates of size 12.19 m x 12.19m each. The total length of the Masonry dam is 262.4 m which includes the spillway and non-over flow sections on both its side.

Two number sluices of size 2.44 x 3.66m each with sill level at RL 432.61m have been provided on the left flank of Masonry dam in Block No.5 which is a non-overflow block. These sluices help in silt evacuation besides releasing water for Upper Sileru power house in Andhra Pradesh when the Andhra Pradesh tunnel is closed. The maximum discharge capacity of the sluices is $227 m^3/s$.

The Andhra Pradesh power tunnel with a discharge capacity of $383 m^3/s$ is located in the right abutment of the main Earth dam.

It was earlier planned to have a power house which was to be fed by this tunnel with tail waters to be discharged downstream into Sileru river. However this power house was not constructed.

The Balimela power tunnel for the powerhouse of Odisha has the same discharging capacity and is located near Dyke No.1.

1.2. Assignment of Responsibility:

Sl. No.	Function	Officers having responsibility
1.	Project Administration-Officer-in-Charge	Chief Construction Engineer, Potteru Irrigation Project, Balimela
2.	Operations of equipment at the dam	Asst. Executive Engineer (Mechanical)
3.	Estimating Inflows in the reservoir and flood forecasting	Executive Engineer, Earth Dam Division, Chitrakonda
4.	Authorizing spillway releases	Chief Construction Engineer, Potteru Irrigation Project, Balimela
5.	Authorizing releases for hydro power of both Odisha & Andhra Pradesh	Chief Construction Engineer, Potteru Irrigation Project, Balimela
6.	Recording reservoir data	Junior Engineer
7.	Routine inspection	Executive Engineer, Earth Dam Division, Chitrakonda
8.	Maintenance	Executive Engineer, Earth Dam Division, Chitrakonda
9.	Dam safety surveillance including instrumentation.	Executive Engineer, Earth Dam Division, Chitrakonda

1.3 Collection & Reporting of Dam and Reservoir Data:

Routine data for the following is to be recorded.

- Reservoir water surface elevation.
- Reservoir inflow.
- Spillway outflow.
- Hydro Power releases for both Odisha & Andhra Pradesh
- Rain gauge station at Dam site
- Surveillance and monitoring
- Water quality

1.4 Public Utilities and Safety:

Inconformity to the public safety norms a signboard is provided at RD 262.50m of Spillway and at Main gate of Balimela Dam.

The distance to the nearest medical assistance and police station from the dam is 5km each.

The following are the safety equipment's at dam site:

1. Helmet
2. Life Jacket

1.5 Restricted Area

Public is not allowed to enter in the dam gallery & hoist bridge.

1.6 Communication & Warning system :

1.6.1. Communication system:

The Junior Engineer, Flood cell of the project has been entrusted with the effective transmission of hydro-metrological and stream flow data through different means which include Short Mail Service (SMS), telephone and wireless to the Flood Cell of the State.

The Chief Construction Engineer ensures appropriate mechanism to keep local administration informed about extreme inflows, sudden release of water and other exigency conditions.

Directory of contact numbers of key persons of Civil Administration, Police, Ambulance, Fire Station etc. is available in Division office. Regular revision / updating of the Directory is being carried out.

One display board is provided containing the contact numbers of the Chief Engineer, Superintending Engineer, Executive Engineer, Assistant Executive Engineer and others related to operation of the dam.

The available means of communication are landline, mobile phones.

The proper accessibility with jeep able roads has been ensured to all the vulnerable points for constant monitoring during emergent situations.

1.6.2 Warning System:

At the time of release of water from dam, the District Administration and Press are being intimated.

Public of downstream areas are informed through mike announcement before release of water in monsoon period.

Twelve hours prior to the opening of gates, the sirens are blown at every 1 hr. interval.

1.7 Distribution of Operation & Maintenance Manual

The list of units/offices to whom the O&M Manual is required to be distributed, are mentioned below:

a) Chief Engineer, Dam safety, Odisha
b) Chief Construction Engineer, Potteru Irrigation Project,Balimela
c) Executive Engineer, Earth Dam Division, Chitrakonda
d) Executive Engineer, APGENCO, Upper Sileru
e) Assistant Executive Engineer, Earth Dam Sub division-1
f) Assistant Executive Engineer, Earth Dam Sub division-4
g) Junior Engineer, Main Earth Dam Section
h) Junior Engineer, Flood Cell, Balimela Dam Project
i) Junior Engineer, Spillway Section

1.8 List of Supporting Documents & Reference Material

The list of supporting documents for the O&M Manual of Balimela dam are as under:

1. Operating criteria for the reservoir, spillway & outlets.
2. Emergency Action Plan.
3. Flood forecasting and operating criteria.
4. Basin operating plan.
5. Water releases for Hydro Power of both Odisha and Andhra Pradesh requirements Manual.
6. Dam site security plan
7. Reservoir or river pollution contingency plans.
8. Maintenance procedures
9. Maintenance schedules
10. Manufacturer's Manuals & drawings.
11. Reservoir management plan (land, recreation, fish and wildlife).
12. Regional communications directory for dams
13. Latest review of design flood and flood Routing Study carried out under DRIP.
14. Drawings of the dam (Civil, Mechanical and Electrical)

1.9 Schedule of duties for operating personnel

The duty schedules for operating personnel are given below. All activities should be recorded in dam log book /site registers.

Sl. No.	Component	Frequency	Personnel
1	Visual inspection of crest of the dam (dam top) and visible portions of dam (upstream and downstream faces), dykes, foundation, abutment contacts, Masonry dam, Gallery system, Spillway, Sluices and all appurtenant structures.	Weekly	Junior Engineer.
2	Record water surface elevation	Hourly during monsoon and daily during non-monsoon	Junior Engineer.
3	Record estimated reservoir inflow and spillway discharge	Hourly during monsoon and daily during non-monsoon	Junior Engineer.
4	Record releases from outlets /sluices.	Daily	Junior Engineer.
5	Record seepage from drainage systems in Earth dam -Toe drains etc.	Daily	Junior Engineer.
6	Record meteorological data.	Daily	Junior Engineer.
7	Check security and safety devices.	Daily	Junior Engineer.
8	Record seepage from gallery drains in spillway	Daily	Junior Engineer.
9	Standby generator (DG Sets)	Weekly	Junior Engineer
10	Drainage systems – Toe drains, Gallery drains etc.	Weekly	Asst. Executive Engineer
11	Inspection of crest of dam and dykes	Monthly	Asst. Executive Engineer.
12	Critical landslides area of Dam & Reservoir	Monthly during monsoon	Executive Engineer
13	Reservoir Periphery	Monthly during monsoon	Executive Engineer
14	Visual inspection of crest of the dam (dam top) and visible portions of dam (upstream and downstream faces), dykes, foundation, abutment contacts, Masonry dam , Gallery system, Spillway, Sluices and all appurtenant structures.	Monthly	Executive Engineer
15.	Measuring devices/Instruments	Monthly	Asst. Executive Engineer

16	Communication Devices	Monthly	Asst. Executive Engineer
17	Status of Vegetation growth	Monthly	Asst. Executive Engineer
18	Check Sign/Warning display boards near vulnerable locations	Monthly	Asst. Executive Engineer
19	Replace fuse light bulbs	Monthly	Junior Engineer(Electrical)
20	Visual inspection of u/s and d/s faces of dam and dykes, visible portions of foundation and abutments, Masonry dam, Gallery system, Spillway, Sluices and all appurtenant structures.	Monthly	Asst. Executive Engineer
22	Abutment contacts	Monthly	Asst. Executive Engineer
23	Rodent problems	Monthly	Asst. Executive Engineer
24	Availability of updated operating instruction of outlet works.	Quarterly	Chief Construction Engineer
25	Check gate air vents of outlet works	Quarterly	Asst. Executive Engineer(Mech.)
26	Operation of sluice gates	Before and after monsoon	Asst. Executive Engineer(Mech.)
27	Grease gate hanger / dogging of all gates.	Quarterly	Asst. Executive Engineer, Mechanical
28	Check condition of trash rack of intake structure	Quarterly	Asst. Executive Engineer, (Mech.)
29	Operation of radial gates of spillway	Before and after monsoon	Executive Engineer
30	Damage in sluices, spillway, energy dissipation arrangement, d/s area etc. of spillway	Quarterly	Executive Engineer
31	Clear spillway bridge drains of spillway	Quarterly	Asst. Executive Engineer
32	Cleaning of gallery etc. in spillway	Quarterly	Junior Engineer.
33	Checking condition of V-notch/other seepage measuring devices	Quarterly	Asst. Executive Engineer
34	Checking paint on gates of spillway and outlet works/sluices	Six monthly	Asst. Executive Engineer (Mech.)
35	Checking lubrication of wire ropes and application of cardium compound.	Six monthly	Asst. Executive Engineer (Mech.)
36	Checking mechanical hoist bearings and flexible coupling bearings	Six monthly	Asst. Executive Engineer (Mech.)
37	Checking gear systems	Six monthly	Asst. Executive Engineer (Mech.)
38	Exercise of spillway gates	Six monthly	Asst. Executive Engi-

			neer (Mech.)
39	Checking rubber seals and seal clamp bar	Six monthly	Asst. Executive Engineer (Mech.)
40	Lubricate gate rollers	Six monthly	Asst. Executive Engineer (Mech.)
41	Change oil in Generator	Six monthly	Asst. Executive Engineer (Elect.)
42	Check exposed Electrical wiring, Gate limit switches and adjust.	Six monthly	Asst. Executive Engineer (Elect.)
43	Check condition of painting of metalwork, Gate, Hoists and all exposed metal parts of spillway & outlet works/sluices	Six Monthly	Asst. Executive Engineer (Mech.)
44	Inspect intake structures, trash racks and stilling basin / energy dissipation arrangement by dewatering	Every 5 years	Asst. Executive Engineer
45	Review O&M Manual	Every 10 years	Executive Engineer
46	Checking of metal welds for damages/cracks (in gate structure, hoist bridge, tie flats, trunnion girder/supports etc.)	Six monthly	Asst. Executive Engineer (Mech.)
47	Check Electrical Conduits, Pull-out boxes and Switches in Gates/Hoists, Outlet works, Galleries etc.	Six monthly	Asst. Executive Engineer (Mech.)

CHAPTER 2

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 maintaining a safe structure.

2.1 Basic data

2.1.1 Salient features

1. Location

a) State : Orissa

b) District : Malkangiri

c) Latitude : 18^0 08' 25"N

d) Longitude : 82^0 07' 22"E

2. Hydrology

a) Catchment area : 4910 km^2

b) Mean annual rainfall : 1977 mm

c) Maximum annual rainfall : 3827mm (year 2004)

d) Minimum annual rainfall : 1090 mm (year 2012)

e) Original Inflow design flood : 14300 m^3/s

3. Reservoir

a) Original MWL : 462.69m

b) FRL : 462.08m

c) MDDL : 438.91m

d) Gross Storage Capacity : 3610Mm^3

e) Live Storage Capacity : 2676.00 Mm^3

f) Dead Storage Capacity : 934 Mm^3

4. Main Dam

a) Type	:	Earth Fill
b) Top Elevation	:	466.34 m
c) Maximum Height	:	70.00m
d) Length of Top	:	1821m
e) Top Width of Dam	:	9.15m

5. Dyke-I

a) Type	::	Earth Fill
b) Maximum Height	:	37 m)
c) Length of Top	:	853 m

6. Dyke-II

a) Type	:	Earth Fill
b) Maximum Height	:	36.57 m
c) Length of Top	:	613 m

7. Dyke-III

a) Type	:	Earth Fill
b) Maximum Height	:	46 m
c) Length of Top	:	812 m

8. Spillway

a) Location	:	Located at 4th Saddle.
b) Type	:	Straight Gravity Masonry (Ogee crest)
c) Original Spillway Capacity	:	386000cusec (10930m^3/s)
d) Length of Spillway	:	262.40m including NOF section

152.40m (Overflow section)
110.00m (NOF section)

e) Number of bays : 10 nos.

f) Pier width : 2 m.

g) Spillway Crest Level : 449.88 m.

9. Spillway Gates

a) Number : 10 nos.

b) Type : Radial Gate

c) Size : 12.19 m (W) x12.19 m (H)

d) Operating arrangement : Local control panel (one for each gate)

e) Gate position : Mechanical Dial Indicator

10. Spillway Hoists

a) Type : Rope Drum type

b) Number : 10 nos.

11. Spillway Stop-log Gates

No stop log gates.

12. Sluice Outlets

a) Location : Left flank of Spillway in NOF Block no. 5

b) Number : 2 nos.
(Both the states share the live storage equally)

c) Size : 2.44 x 3.66 m (each)

d) Sill level : 432.61m

e) Hoist Type : Rope drum hoist (electrically operated)

13. Sluice Emergency Gate:

Emergency Gate

a) Size : 4.90 m x 5.40 m (Two numbers)

b)	Level	:	432.61 m
c)	Operation arrangement	:	Electrically Operated.(Rope drum hoist)

14. Andra Pradesh Tunnel

Service gate:

Size	:	Circular 7.62m. dia.
Sill	:	424.13m.
No. & size of gates	:	2 nos., 3.05 x 7.62m.
Operation arrangement	:	Electrically operated.
Discharge Capacity	:	383 m^3/s

Stop-log gate:

No. & size of gates	:	2 nos., 3.05 x 12.73 m.
Sill	:	424.13m.
Top Level of stop-log	:	436.85m.
Operation arrangement	:	Manually
Size of each piece	:	3.05 x 1.55 m.

15. Odisha Tunnel

Size of tunnel	:	7.62m.
Sill	:	424.13m.
Invert Level at inlet	:	402.79m.
Invert Level at the exit	:	399.14m.
Discharge Capacity	:	383 m^3/s

2.1.2 AREA CAPACITY TABLE:

A drawing showing area-capacity curves of Balimela dam is at Appendix-IV. In tabular form it is given as under

Reservoir Level (m)	Capacity (Mm^3)	Area (Mm^2)
420.62	162.82	20.25
422.15	198.22	23.04
423.67	233.61	26.38

425.20	276.09	30.01
426.72	318.56	33.07
428.24	375.20	36.60
429.77	442.45	40.41
431.29	513.24	44.59
432.82	587.57	48.68
434.34	668.98	52.58
435.86	750.40	57.60
437.39	838.89	61.78
438.91	934.45	66.89
440.44	1040.64	71.16
441.96	1153.91	76.55
443.48	1270.72	82.22
445.01	1398.14	87.79
446.53	1532.65	93.83
448.06	1677.77	99.87
449.58	1833.51	106.37
451.10	2003.41	112.41
452.63	2187.47	119.38
454.15	2389.23	126.81
455.68	2583.91	134.24
457.20	2789.20	141.68
458.72	3001.58	150.97
460.25	3256.43	157.94
461.77	3551.38	167.23
462.08	3610.39	169.08
462.38	3652.87	172.15
462.69	3695.34	175.12

2.1.3 Data of historical floods

Statement showing the Maximum discharge released from the spillway since inception is given below. It is seen that the reservoir level never exceeded the MWL (EI.1518.00ft)

DATE	Reservoir Level (m)	Spillway outflow Discharge (m^3/s)
29.10.1990	462.37	125.349
22.10.1994	462.23	590.2265
20.9.2006	462.26	7689.2965

29.10.2013	462.38	470.3718
2.10.2018	461.93	964.4999

2.1.4 Latest Design Inflow Flood and Flood Routing Studies :

Originally at the time of construction of the dam the design flood was calculated considering a two days storm depth of 503mm. Unit hydrograph was developed basing on the observed flood of 1962. The peak inflow design flood arrived at was 14300m^3/sec. The spillway capacity at the original MWL of 462.63 m is 10930 m^3/s.

After the dam was included for rehabilitation under DRIP the design flood was reviewed by CWC. This dam has a gross storage capacity of 3610Mm^3 and height of 70m. The dam is classified as large dam and to be designed for PMF. There is no observed short interval rain fall and concurrent stream flow data for the stream, so it is not possible to develop any Unit Hydrograph based on real data. Hence synthetic UG parameters developed by CWC for Mahanadi Sub-Zone 3f (Revised 1995) has been used to derive the Unit Hydrograph. 1 day PMP of 539mm, 2 day PMP of 671mm has been considered. After convolution and addition of base flow, the inflow design flood hydrograph has been computed with a peak of 26603 m^3/sec.

Flood routing studies were carried out by the State DSO. The maximum routed outflow comes out to be 13981.13 m^3/s and the MWL reach up to 464.76 m .The TBL of the dam is 466.34 m.

2.2 Operation Plan

The operation of the dam includes maintaining reservoir levels as per the general rule levels, operation of the spillway radial gates, sluice gates, Odisha Power intake gates and Andhra Pradesh tunnel gates safe disposal of the surplus flood waters during monsoon consistent with dam safety, keeping records and ensuring public safety.

This Manual covers the normal operation procedures to be followed during both monsoon and non-monsoon. The draw down rates are normally limited to 0.3m per day except during emergency situations.

Special operational procedures are to be followed during emergency situations (outlined in Para 4.2.1 under Immediate maintenance) and the Emergency Action Plan is to be invoked.

Mock drill in respect of operation of gates and all hydro mechanical equipment's is organized prior to the onset of monsoon and the observations are transmitted to State DSO. Exercising of all the radial gates of the spillway and service gates of other structures is carried out at least twice in a year.

Before operation all the gates and hoists are inspected and their parts lubricated and repaired as necessary.

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.

2.3 Normal Operation:

2.3.1 Rule curve & reservoir operation:

Rule curve for the dam has not been prepared so far.

However in general the following reservoir levels are to be maintained during the monsoon period:

End of August : 461.78 m

End of September : 461.93 m

End of October : 462.08 m

2.3.2 Operation instructions

2.3.2.1 Spillway Radial gates and Rope drum hoists

The operation of the spillway radial gates shall be done as per the reservoir operating criteria & prevailing practices. There are no spillway stop log gates. There are 2 emergency gates for 2 sluice gates.

The DOL starter is provided with three buttons namely 'Forward',' Reverse', 'Stop'. When the forward push button is pressed the gate is raised similarly when the reverse push button is pressed the gate is lowered. With the stop push button, the gate movement is stopped.

In case of power failure the gate operation is done by using a stand by DG set. When DG set is not available the gates are lowered or raised manually by operating the hand drive unit.

Only trained authorized persons are allowed to operate the gates.

The maintenance instructions are strictly followed to ensure smooth trouble free operation of the gates.

Before operation, the gates, hoists and allied structures are inspected before monsoon, as specified below.

Spillway Radial Gates:

a. Rubber seals: The seals are checked for damages and are replaced if found damaged.
b. Guide rollers: The rollers are tested for free rotation. The guide roller bushes and pin are lubricated properly.
c. Trunnion: The trunnion bush are greased. The trunnion seal cover shall be checked for damage and replaced if found damaged.
d. Nuts & Bolts/Anchorages: All connecting bolts and nuts and fixing nuts of anchorages of the gate are checked for slackness and are tightened by suitable method.

Visual Inspection of Gate Leaf with Accessories: The gates are inspected for cracks in weld joints, particularly in critical components such as trunnion bracket, trunnion and end arm connection, end arm to bracings, tie beam joints, horizontal girders, rope brackets/pulley brackets, skin plate to vertical stiffeners and all other major components and are rectified if any defect is noticed.

a. The gates are checked for restoration of any components and are rectified suitably.
b. Filling between trunnion brackets and trunnion girder are checked.
c. The skin plates are observed for pitting, scaling and corrosion and if noticed on the skin plate beyond the limit of 1.5 mm in depth the same should be checked and filled up by metal deposit and then ground smooth.
d. Rope connection on gate leaf are checked for shearing and wear and are rectified if any defect is found.

Hoist (For Spillway gate and all other gates) (All are Rope drum hoists)

a. Checking of wire ropes: The wire ropes are checked for damaged rope strands and if found, the rope shall be replaced. Cadmium compound shall be applied to the full length

of the rope after cleaning the rope with the wire brush. The rope shall be checked for equal tension on both sides. If not then equal tension shall be achieved through adjustment of turn buckles.

b. Turn buckles and rope socket: Turn buckles and rope socket should be examined for any sign of failure and shall be rectified if defects are noticed. The thread of turn buckles should be lubricated with proper lubricants specified in Annexure A (Enclosed at the end of the chapter on Maintenance)

c. Pulleys: The pulleys shall be checked for free movement. Pulley bushes and pins shall be lubricated. The pulley bushes and pins shall be checked for any wear and should be replaced if found defective.

d. Line shafts: The line shafts should be checked for straightness and shall be rectified if found bent.

e. Gear and pinions: Gear and pinions of end reduction unit and position indicator should be checked for wear and cracks and the defects found should be rectified. These components shall be lubricated with proper lubricants specified in Annexure-A.

f. Electromagnetic brake: The brakes are checked for any damage to brake linings and proper functioning and the springs are adjusted if the linings are found partially worn out. The linkage and springs are lubricated.

g. Plummer block and Bearings: Plumber blocks and bearings should be checked for any damage and proper lubrication and shall be lubricated with proper lubricants as specified in Annexure -A.

h. Worm gear reducer: Oil levels in worm gear reducer should be checked and topped up if necessary. Adjustment of flexible coupling shall be checked for slackness. The coupling bushes should be checked for wear and tear and shall be replaced if damaged.

i. Electric motor: Current taken by the electric motor should be measured. Insulation of the winding shall be checked.

j. Wiring, switches and electrical relays: Voltage drop in the main wiring system should be checked and rectified.

k. Bushes: Wire rope drum bushes and position indicator bushes shall be checked for wear and tear and shall be lubricated with proper lubricants as specified in Annexure-A

Testing.

a. The gates should be tested for its travel up and down to see that it moves smooth without excessive sway throughout the travel.

b. There should be no unusual sound during operation and the operation should be trouble free.

c. There should be no un-due vibration in the gate and structure during operation of the gate on load. In case of vibration is noticed the position of gate opening and the water level should be recorded and reason there of should be investigated.
d. Based on inspection and testing, suitable remedial measures shall be taken.

2.3.2.2 Other Gates and Hoists

The gates of the Sluices in Masonry dam/ Andhra Pradesh Tunnel /Radial gates are operated to release water for Andhra Pradesh requirements/ silt removal purposes. Similarly the gates of the Odisha power intake are operated to provide water for the hydro-power/irrigation requirements of Odisha.

The gates are operated electrically. Skilled and authorized personnel need only be allowed to operate the gates.

The maintenance instructions shall be strictly followed to ensure smooth and trouble free operation of gates.

Before operation the gates, hoists and allied structures are being inspected as specified below. Hoists are rope drum hoists and before operation inspected properly.

Embedded parts

All debris and blockages over the embedded parts (sill beam, side seal seats, top seal seat, guide and wheel track) should be cleared. The surfaces of embedded parts should be checked for pitting and should be suitably rectified if pitting is noticed. The welding of stainless steel plates on side seal seat, sill beam, top seal seat and wheel track should be checked for weld cracks and shall be repaired if crack is noticed in weld joint. Due to wear and tear, surface may become uneven and may have indentations such as roller mark over the track path. The entire gate track should be thoroughly checked so that there is no obstruction for travel of gate.

Gate leaf with accessories.

All debris and scaling should be removed from the gate leaf. The skin plate and other components should be tapped lightly by hammer to examine the soundness.

The weld joint between skin plate to horizontal stiffeners and end vertical girders, end vertical girders to horizontal stiffeners and hoist bracket to top horizontal stiffeners should be checked thoroughly and suitably rectified if defects are noticed. The hoisting connection on the gate should be checked for shearing and wear and tear and should be rectified if any

defect is noticed.

Alignment of seals should be checked by means of feeler gauge. The rubber seals should be checked for twist, over tapping, bulb flatness, deformation etc. All un-desirable materials on the rubber seal and between the rubber seal and skin plate should be cleaned thoroughly and should be free from oil and grease etc. All nuts and bolts fixing the rubber seal to the skin plate should be checked for slackness and rusting and should be tightened/replaced as considered necessary. Rubber seals when damaged or found leaking profusely should be adjusted, repaired or replaced as considered necessary.

The wheel pins and bushes should be lubricated properly.

Each wheel should be checked for improper adjustment of wheel pin and retainer plate and shall be rectified by adjusting the retainer plate which is provided with eccentricity adjustment. Whenever necessary the wheel assembly should be opened for rectification of defects. The brass spacer rings should be checked for wear and shall be replaced if found worn out. No defective part shall, however, be refitted. The guide shoes shall be inspected for any damage or bending and shall be repaired if damaged or bent. The welding between the end vertical girder and guide shoe should be checked and defects if found should be suitably rectified.

The hoist pin should be lubricated. All nuts, bolts and screws etc. should be checked for slackness and should be tightened if necessary. The wheel assemblies should be adjusted by the eccentric arrangement provided in retainer plates to ensure that all wheels bear uniformly on wheel tracks, particularly in closed position of gates.

Testing.

1) The gate should be tested for smooth travel throughout the groove without appreciable swing. All wheels shall always be in contact with the wheel track face during the entire travel.
2) The gate should neither be subjected to under pressure nor any extra effort be needed to operate the gate in no load condition.
3) There should not be undue vibration in the gate and structure during its travel while on load. If undue vibrations are noticed the reasons should be investigated and the RL at which this occurs should be recorded. The gate shall not be kept in the position where vibration is noticed until remedial measures are taken.
4) In closed position, the gate should be watched against any leakage under maximum head condition during the year.

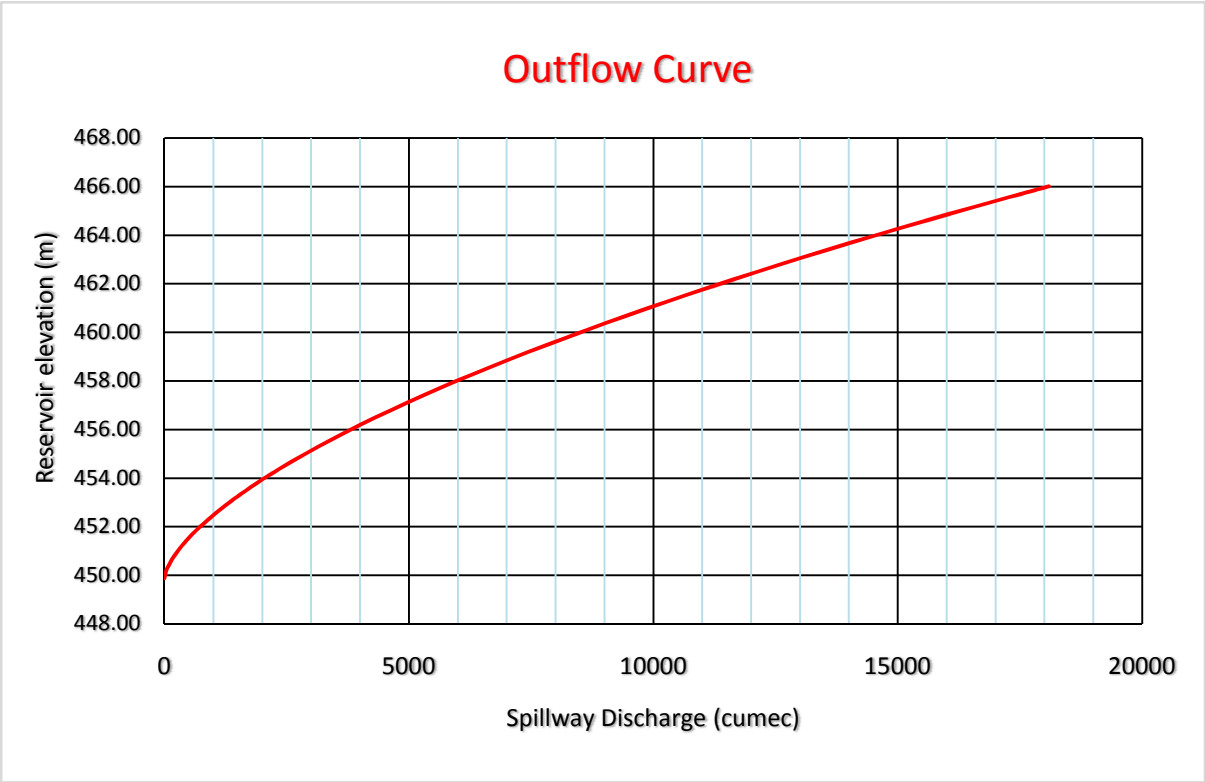
2.3.3 Discharge through spillway for different reservoir levels with different gate openings

Spillway discharge (free flow) for Balimela dam through its 10 Nos. spillway gates for different reservoir levels under full gate open condition has been calculated as per IS 6934 and is given in tabular and graphical format below.

Sl. No.	Reservoir Elevation (m)	Spillway Discharge (m^3/s)
1	449.88	0
2	450.18	37
3	450.48	106
4	450.78	196
5	451.08	304
6	451.38	429
7	451.68	568
8	451.98	721
9	452.28	888
10	452.58	1065
11	452.88	1253
12	453.18	1453
13	453.48	1663
14	453.78	1884
15	454.08	2116
16	454.38	2357

17	454.68	2609
18	454.98	2869
19	455.28	3138
20	455.58	3416
21	455.88	3703
22	456.18	3999
23	456.48	4304
24	456.78	4618
25	457.08	4941
26	457.38	5273
27	457.68	5613
28	457.98	5961
29	458.28	6319
30	458.58	6684
31	458.88	7058
32	459.18	7441
33	459.48	7831
34	459.78	8228
35	460.08	8629
36	460.38	9039
37	460.68	9456
38	460.98	9880
39	461.28	10313
40	461.58	10752

41	461.88	11200
42	462.18	11655
43	462.48	12117
44	462.78	12587
45	463.08	13064
46	463.38	13549
47	463.68	14041
48	463.98	14540
49	464.28	15047
50	464.58	15561
51	464.88	16082
52	465.18	16611
53	465.48	17147
54	465.78	17690
55	466.00	18092



Further the spillway discharge from a single spillway bay for different reservoir levels with partial gate openings has also been calculated as per IS 6934 and is given in tabular and graphical format below. This is also required to be verified at site as per actual measure-ments and modified, if required

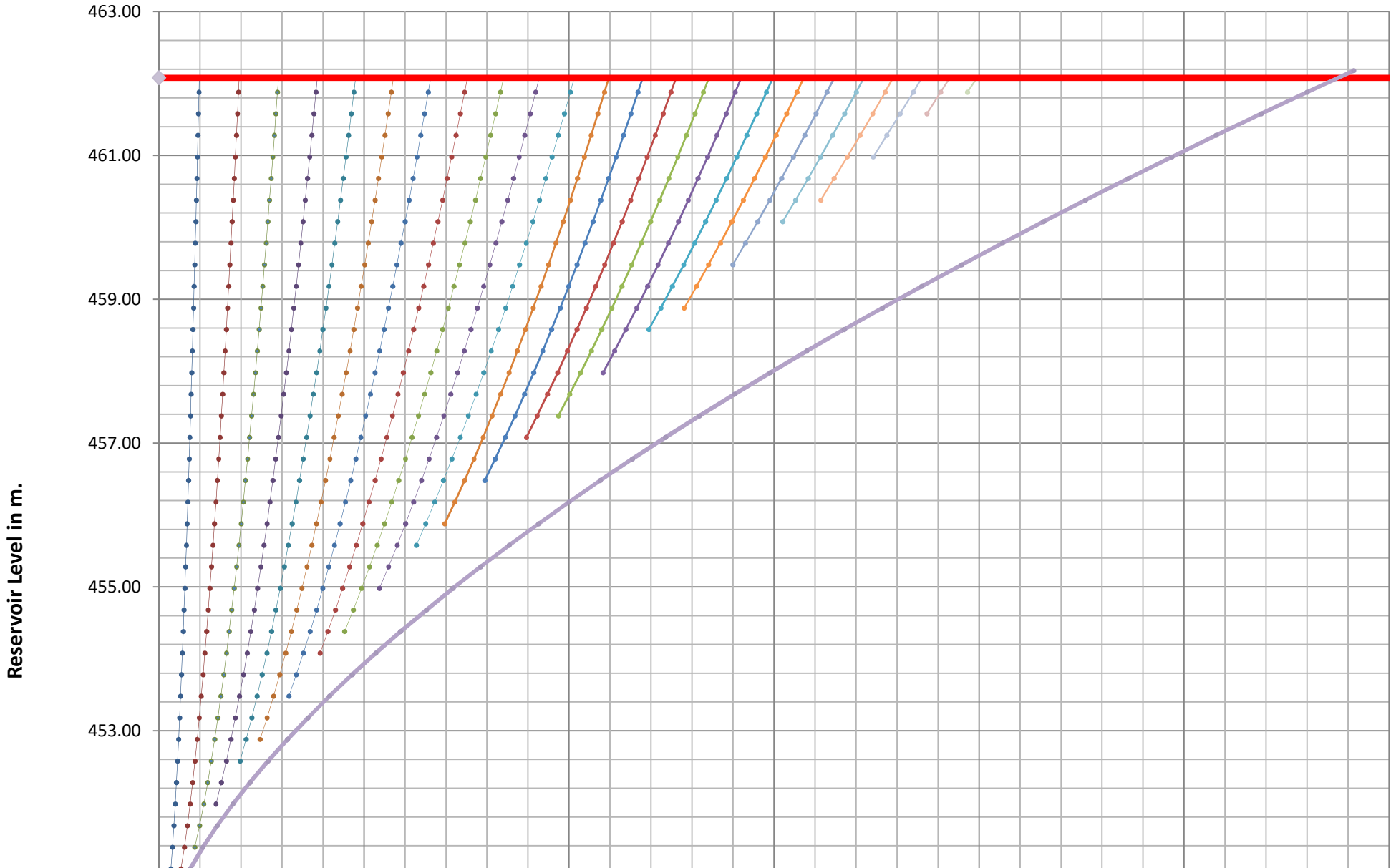
Balimela Project,Odisha

Spillway Discharge computations through one bay with different gate openings

FRL= 462.08m.		Crest level= 449.88
L= 12.19	C_g = 0.7	**$Q=C_g*G_0*L*(2gH_c)^{0.5}$**

Sl No.	Reservoir Elevation	Discharge through one bay with gate opening as under																								
		0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6	6.3	6.6	6.9	7.2	7.5
1	450.18	-																								
2	450.48	8																								
3	450.78	10																								
4	451.08	12	22																							
5	451.38	13	25	35																						
6	451.68	15	28	40																						
7	451.98	16	30	44	56																					
8	452.28	17	33	48	61																					
9	452.58	18	35	51	66	79																				
10	452.88	19	37	54	70	85	99																			
11	453.18	20	39	57	75	91	105																			
12	453.48	21	41	60	79	96	112	127																		
13	453.78	22	43	63	82	101	118	134																		
14	454.08	23	45	66	86	105	124	141	157																	
15	454.38	24	46	68	90	110	129	147	165	181																
16	454.68	24	48	71	93	114	134	154	172	190																
17	454.98	25	50	73	96	118	139	160	179	198	215															
18	455.28	26	51	76	99	122	144	166	186	205	224															
19	455.58	27	53	78	102	126	149	171	192	213	232	251														
20	455.88	27	54	80	105	130	154	177	199	220	241	260	279													
21	456.18	28	56	82	108	134	158	182	205	227	248	269	289													
22	456.48	29	57	84	111	137	162	187	211	234	256	278	298	318												
23	456.78	29	58	86	114	141	167	192	217	240	263	286	307	328												
24	457.08	30	60	88	117	144	171	197	222	247	271	294	316	338	358											
25	457.38	31	61	90	119	147	175	202	228	253	278	302	325	347	369	390										
26	457.68	31	62	92	122	151	179	206	233	259	285	309	333	357	379	401										
27	457.98	32	63	94	124	154	183	211	238	265	291	317	342	366	389	411	433									
28	458.28	33	65	96	127	157	186	215	243	271	298	324	350	374	398	422	444									
29	458.58	33	66	98	129	160	190	220	248	277	304	331	357	383	408	432	455	478								
30	458.88	34	67	99	131	163	194	224	253	282	311	338	365	391	417	442	466	490	512							
31	459.18	34	68	101	134	166	197	228	258	288	317	345	373	400	426	452	477	501	524							
32	459.48	35	69	103	136	169	201	232	263	293	323	352	380	408	435	461	487	512	536	560						
33	459.78	35	70	105	138	171	204	236	268	298	329	358	387	416	443	470	497	523	548	572						
34	460.08	36	71	106	141	174	207	240	272	304	334	365	394	423	452	480	507	533	559	584	609					
35	460.38	36	72	108	143	177	211	244	277	309	340	371	401	431	460	489	516	544	570	596	621	646				
36	460.68	37	73	109	145	180	214	248	281	314	346	377	408	439	468	497	526	554	581	607	633	659				
37	460.98	38	75	111	147	182	217	252	285	319	351	383	415	446	476	506	535	564	592	619	645	671	697			
38	461.28	38	76	113	149	185	220	255	290	324	357	389	422	453	484	514	544	573	602	630	657	684	710			
39	461.58	39	77	114	151	188	224	259	294	328	362	395	428	460	492	523	553	583	612	641	669	696	723	749		
40	461.88	39	78	116	153	190	227	263	298	333	367	401	435	467	499	531	562	593	622	652	680	708	736	763	789	
41	462.08	39	78	117	154	192	229	265	301	336	371	405	439	472	505	537	568	599	629	659	688	716	744	771	798	824

Rating Curve of Single Spillway Gate for partial gate opening



2.3.4 Sequence of Spillway Gates operation

Total length of spillway is 262.40m. Number of spillway radial gates is Ten - each of size 12.90 m (W) x 12.90 m (H).

The regulation of the gates is based on past experience. First of all the central gate no.5 & 6 shall be opened. .Thereafter the gates 4& 7 shall be opened by the same amount. In this manner the spillway gates shall be opened in asymmetrical manner starting from the centre towards the end through gradual increase in openings to avoid cross/return flows due to d/s topography. Also care is to be taken to maintain such a gate opening at which there are no vibrations.

While closing the gates, the gate that is opened last should be closed first. The procedure to be followed for closing the gates shall be reverse of the procedure followed for opening of the gates.

Sequence of gate operation shall be as under:

Gate no.	1	2	3	4	5	6	7	8	9	10
Opening sequence						5		6		
						4		7		
						3		8		
						2		9		
						1		10		
Closing Sequence						1		10		
						2		9		
						8		3		
						7		4		
						5		6		

Complete closure of the gates shall be accomplished by gradual lowering of the gates by the sequence mentioned above. Gate operation should also be aimed at avoiding flooding of inhabitants on downstream.

2.3.5 Methodology to workout gate opening for passing required discharge through irrigation outlet:

No Irrigation outlet is present in Balimela Dam. Water is released to both Odisha & Andhra Pradesh for Power generation Purpose. Water is released to Odisha Hydro Power Corporation through OHPC tunnel (Odisha power intake).Water is released to Andhra Pradesh through A.P tunnel/Sluices/Radial gates of Spillway.

2.3.6 Safety Aspects:

The safety and security of dam against the structural damages by vandals, public and authorized operation of A.P tunnel, OHPC tunnel ,Sluices in masonry dam and Radial gates is of paramount importance. A committee consisting of Chief Construction Engineer, Potteru Irrigation Project, Balimela**,** S.E, APGENCO, Upper Sileru**,** SGM, OHPC and other officials is formed. Every month a water body meeting is done and various aspects related to water allocation, release and various aspects of dam is discussed.

2.4 Emergency operation:

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

2.5 Reservoir Capacities:

The reservoir capacity may reduce with time because of reservoir sedimentation. Bathymetric survey on a periodic basis is to be considered after every 10 years.

2.6 Record Keeping

Following records shall be kept for reservoir operations:

1. Reservoir levels –on daily basis during non-monsoon and on hourly basis during monsoon.
2. Rainfall data – on daily basis.
3. Releases through the odisha power intake/sluices in masonry dam/Andhra Pradesh tunnel on daily basis.
4. Outflow through spillway during monsoon on hourly basis.
5. Water audit register to be maintained for estimating the inflows on hourly basis during monsoon and on daily basis during monsoon by accounting all the releases/outflows and the incremental change in storage in the reservoir.
6. Records of drawdown with reservoir levels, quantity of water released, drawdown rate, reason for drawdown.
7. Security protocols along with operating protocols.
8. All reservoir and gates operating procedures

CHAPTER 3

3. PROJECT INSPECTION

An effective inspection Programme is essential for identifying problems and ensuring a safe performance of the dam.

3.1. Objective of dam inspection

The principal purpose of dam safety inspections is to determine whether the structural and operational aspects of the dam and its component parts are functioning safely in accordance with the design and established standard/ acceptable practices. It helps to identify deficiencies or concerns that potentially affect the safety of the dam and to take corrective actions to remedy those deficiencies before serious consequences develop.

Detailed description on project inspections is available in the Guideline for Safety Inspection of dams:(Doc.No: CDSO_GUD_DS_07_v1.0), CWC 2018)https://damsafety.in/ecm-includes/PDFs/Guidelines_for_Safety_Inspection_of_Dams.pdf.

However an overview of the various types of inspections to be carried out are given below. Note that for uploading Inspection Data into DHARMA, the Inspection Instructions &Forms given in the aforementioned Guideline for Safety Inspection of Dams should be used (see Appendix-I & II).

3.2. Types of dam safety inspections:

The type of inspection to be conducted will depend on the purpose of the inspection. Dam safety inspections are conducted to determine the health status of the dam and its permanent structures.

Four types of dam safety inspections are to be carried out. They are:

1) Informal inspections
2) Scheduled inspections
3) Special (unscheduled) inspections
4) Comprehensive Evaluation inspections.

3.2.1 Informal Inspections

The informal inspections are performed by the Engineer-in-charge of the dam and his staff while carrying out their regular duties (See duty schedules in Chapter 1). Informal inspections assist in a continuous surveillance of the dam which is critical to proper operation and maintenance of the dam. They consist of frequent inspections for observing the general issues/problems and functioning of the dam and appurtenant structures. The informal inspections are important and performed at every available opportunity. The informal inspections are not as detailed as comprehensive, scheduled, and special inspections. They require that a formal report be submitted to the dam authorities only if a condition is detected that might endanger the dam.

3.2.2 Scheduled Inspections:

Scheduled inspections are performed to gather information on the current condition of the dam and its appurtenant works. The scheduled inspections consist of pre-monsoon and post monsoon inspections and other scheduled inspections. The Pre-monsoon& Post-monsoon inspections are conducted by field engineers every year as per the inspection schedule below. The deficiencies, thus noticed, and shall be endorsed to State Dam Safety Organization for scrutiny and suggestion for possible remedial measures.

Inspection Schedules

Type of Inspection	Last date for	
	Completion of inspection	Sending inspection reports to SDSO
1. Pre- monsoon	15th May	30th June
2. Post-monsoon	30th November	31st December

NOTE: These inspections are to be carried out by Chief Construction Engineer, Potteru Irrigation Project, Balimela and Executive Engineer, Earth Dam Division, Chitrakonda,

Other scheduled inspections are conducted at least once in every 5 years by the engineers of State DSO along with Geologist and representative of Mechanical Wing.

All scheduled inspections are to be carried out as per the Guideline for Safety Inspection of dams (Doc. No. CDSO-GUD-DS-07 v 1.0,CWC 2018.https://damsafety.in/ecm-includes/PDFs/Guidelines_for_Safety_Inspection_of_Dams.pdf)

These inspections will include the following components as a minimum:

1. Review of the past inspection reports, Monitoring data and photographs, Maintenance records and other pertinent data.
2. Inspection of the dam and its appurtenant works.
3. Preparation of a report with relevant documentation and photographs.

3.2.3 Special (Unscheduled) Inspections :

Special inspections are performed to resolve specific problems of the dam. This is performed by an independent Expert Panel or Dam Authorities. 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.

Japan Water Agency (JWA) has developed an excellent system of carrying out inspections after an earthquake event. For details refer “Inspection Manual for Dam Field Engineers after Seismic Events, Ichari Dam, and Uttarakhand. (CDSO_GUD_DS_0_v1.0, September 2017). The Manual is available at the following link: https://damsafety.in/ecmincludes/PDFs/Inspection_Manual_for_Dam_Field_Engineers_After_Seismic_Events.pdf.

3.2.4 Comprehensive Evaluation Inspections:

For comprehensive dam safety evaluation an independent panel of experts known as Dam Safety Review Panel (DSRP), is to be set up by the OWRD which shall consist of experts from the fields of Geology, Hydrology, Designs, and Construction for determining the condition of dam and appurtenant works. The main objective of the DSRP is to carry out an independent expert review of the overall health status of the dam and to propose remedial measures. The panel would undertake the evaluation of the dam once in 10years or after occurrence of any extreme events, if required. The State Dam Safety Organization arranges the meetings and site visits of DSRP.

Terms of Reference (TOR) of comprehensive dam safety evaluation shall include but will not to be limited to:

1. General assessment of hydrologic and hydraulic conditions, review of design flood, flood routing for revised design flood and mitigation measures.

2. Review and analysis of available data of dam design, construction, operation maintenance and performance of dam structure and appurtenant works.
3. A visual inspection or field examination of the dam, its appurtenant works, and the surrounding areas.
4. Review of the instrumentation records and structural behavior reports, if any.
5. Evaluation of procedures for operation, maintenance and inspection of dam and to suggest improvements / modifications.
6. Evaluation of any possible hazardous threat to the dam structure such as dam abutment slope stability failure or slope failures along the reservoir periphery.

3.2.4.1 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:-

a) **General Information**

1. Scope of project
2. Basic data and salient features
3. Issues related to safety of dam including any earlier dam safety related incidents
4. Emergency preparedness – Communications, Auxiliary power, Downstream Warning system and security at site.

b) ***Hydrology***

1. Description of drainage basin
2. Original inflow design flood, MWL and routed outflow
3. Revised design flood and flood routing study carried out by the project authorities and approved by CWC.
4. Area – Capacity curves.

c) ***Geology***

1. Dam site Geology including Geological reports.
2. Any Special problems and their treatment.
3. Reservoir competency as per geological report.
4. Slope stability issues along reservoir rim.

d) ***Drawings of the dam and HM works***

1. Layout plan
2. Upstream & Downstream Elevation.

3. Cross – Sections of the Dam and Spillway
4. Foundation treatment details
5. Junction between Earthen embankment & Concrete abutment of spillway.
6. Power intake of Odisha and Andhra Pradesh Layout details of all gates and hoists
7. Instrumentation details

e) <u>Dam and Spillway</u>

1. Geological reports
2. Special problems encountered, if any.
3. Foundation treatment including treatment of faults / shear zones / weak zones, curtain / consolidation grouting, drainage provisions, any other special treatment, cut-off trench, etc.
4. Design criteria and result of stability analysis
5. Adequacy of design – from dam safety considerations
6. Hydraulic design of Spillway
7. Pre-construction material testing reports including adequacy of field and laboratory investigations, appropriateness of materials selected etc.
8. Post-construction testing reports, if any,

3.2.4.2 Field Inspection – Observation & Recommendations regarding Remedial Measures:

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

Various project components to be inspected include:

a) <u>Dam</u>

1. Upstream face
2. Downstream face
3. Top of dam
4. Structural behaviour as observed visually and as per evaluation of instrumentation data (any visible cracking, deflections etc.)
5. Seepage assessment
6. Condition of natural / excavated slopes in the abutments, both on u/s and d/s of the dam.

7. Any specific problems / deficiencies.

b) Spillway

1. Civil structure
2. Spill channel, drop structures etc.
3. Downstream safe carrying capacity of river / channel

c) River / Canal Outlets

1. Civil structures
2. Conduits / outlets through Embankment dam.

d) Flood Hydrology

1. Extent & Sufficiency of data available
2. Method used for estimating the design flood.
3. Design flood review study.
4. Flood routing studies with the revised flood.
5. Adequacy of free board available.

e) Miscellaneous services / facilities

1. Access Roads
2. Communication facilities (Telephone, Mobile etc.)

3.2.4.3 Components Involved

A comprehensive evaluation inspection of a dam typically consists of five components:

1. Project records review (i.e., study of all design / construction records / drawings, history of the dam's performance, past inspection notes / reports, notes on distress observed etc.).
2. Inspection of the dam and its appurtenant works.
3. Preparation of a detailed report of the inspection.
4. Education and training of the dam engineers on the issues observed during dam inspection, identification of potential dam failure modes & to carryout additional field investigations & laboratory testing as required. Dam engineers should be made part of the inspection process so that they take ownership and are committed to implementing the recommended remedial measures.
5. Design studies e.g. review of design flood, checking of the adequacy of spillway capacity, freeboard requirements, dam stability, any special study as required & submission of the report.

CHAPTER 4

4. PROJECT MAINTENANCE

A good Maintenance program will protect a dam against deterioration, prolong its life, and greatly reduce the chance of failure. The dam authorities and operating and maintenance personnel must be knowledgeable of the potential problems which can lead to failure of a dam. Nearly all the components of a dam and its materials are susceptible to damage and deterioration if not well maintained.

This Manual is to be referred to mainly for routine maintenance works.

For most of the rehabilitation works in respect of Condition based and immediate maintenance works, the designs, drawings and technical specifications will need to be provided by the State DSO/Designs offices.

Guidance of experienced engineers/panel of experts will need to be taken.

4.1 Maintenance Plan

Timely maintenance assures that a dam and reservoir would remain in a good working condition and prevents more harmful conditions from developing.

4.2 Maintenance Priorities

Maintenance activities need to be prioritized.

4.2.1 *Immediate Maintenance*

The following conditions are critical and require immediate action by Dam authorities.

- Evidence of excessive seepage through the Earth dam, exiting on its downstream face or anywhere on the downstream of the dam and increasing in volume.
- Earth Dam showing signs of piping or internal erosion indicated by increasingly cloudy seepage or other symptoms.
- An increase in the reservoir level to near the top of the dam.
- Water overtopping the earthen dam.
- An Earth dam about to be breached by erosion, slope failure etc.
- A spillway being blocked or with some inoperable gates.

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

4.2.2.1 Condition based maintenance

The following maintenance should be completed as soon as possible after the defective condition is noted.

- Removal of all vegetation and bushes from the dam and restoring any eroded areas and to establish good grass cover.
- Fill animal burrows.
- Repair livestock trails and fences to keep livestock off dam.
- Restore and reseed eroded areas and gullies on embankment dams.
- Repairs of any cracks in earth dam.
- Repair of defective gates, valves, and other hydro-mechanical equipment.
- Repair any concrete or metal components that have deteriorated.
- Cleaning/Reaming of choked drainage holes in the dam body/ foundations in concrete / masonry dams / spillways.
- 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 Masonry/Concrete dam.
- Repairs of any cracks/cavities/joints in masonry/concrete dam/spillway.

4.2.2.2 Routine Maintenance

- Routine mowing, restore and reseed eroded areas and gullies on downstream face of the embankment section and general maintenance including repairs/cleaning of surface drains on downstream face & in the downstream areas.
- Observation of any springs or seepage areas, comparing quantity and quality (clarity) with prior observations in the embankment section.
- Monitoring of development in the upstream watershed which would materially increase runoff and sediment from storms.
- Monitoring of downstream development which could have an impact on the dam and its hazard category.
- Maintenance of Electrical & Hydro-Mechanical equipment and systems, e.g. servicing of spillway gates, hoisting arrangements, other gates and hoists, and standby generator.

- Proper lighting at dam top and in the operation/ drainage galleries, etc.
- Monitoring of seepage in the operation/ drainage galleries.
- Monitoring/cleaning & removal of leached deposits in porous concrete/ formed drains in dam body & foundation drainage holes.
- Maintenance of all dam roads & access roads.
- Operation of electrical and mechanical equipment and systems including 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 undertaking Routine Maintenance works

4.3.1 Earth work in earthen dam

The surfaces of an earthen dam may deteriorate due to several reasons. For example, wave action may cut into the upstream slope, vehicles may cause ruts in the crest or slopes, trails left by livestock can result in erosion, or runoff waters may leave erosion gullies on the downstream slope. Other special problems, such as shrinkage cracks or rodent damage, may also occur. Damage of this nature must be repaired constantly.

Conditions such as embankment slides, structural cracking, and sinkholes threaten the safety of a dam and require immediate repair under the directions of experienced engineers/experts.

The material selected for repairing embankments should be free from vegetation, organic materials, trash, and large boulders/rocks.
If flow-resistant portions (core) of an embankment are being repaired, materials that are high in clay or silt content should be used. If the area is to be free draining or highly permeable (such as pervious shell of an embankment dam) the material should have a higher percentage of sand and gravel. It is usually satisfactory to replace or repair damaged areas with soils like those originally in place.

An important soil property affecting compaction is moisture content. Soils that are too dry or too wet do not compact well. One may test repair material by squeezing it into a tight ball. If

the sample keeps its shape without cracking and falling apart (which means it is too dry), and without depositing excess water onto the hand (which means it is too wet), the moisture content is near the proper level.

Before placement of earth, the repair area needs to be prepared by removing all inappropriate material. All vegetation, such as bushes, roots, and tree stumps, along with any large boulders/rocks or trash need to be removed. Also, unsuitable earth, such as organic or loose soils, should be removed, so that the work surface consists of exposed, firm, clean embankment material.
Following cleanup, shape and dress the affected area so that the new fill can be compacted to the level specified in the technical specifications. Also it should properly key with the existing fill. Further trim the slopes and roughen the surfaces by scarifying to improve the bond between the new and existing fill and to provide a good base to compact against.

Place soils in loose layers up to 20 cm thick and compact manually or mechanically to form a dense mass free from large boulders/rock or organic material. Keep soil moisture in the proper range. The fill should be watered and mixed to the proper wetness and allowed to dry if too wet.

Erosion is one of the most common maintenance problems at embankment structures. Erosion is a natural process and its continuous forces will eventually wear down almost any surface or structure. Periodic and prompt maintenance is essential to prevent continuous deterioration and possible failure.
Turfing, free from weeds and bushes, is an effective means of preventing erosion.
Rills and gullies should be filled with suitable soil, compacted, and then seeded for growing the turfing. Erosion in large gullies can be slowed by stacking bales of hay or straw across the gully until permanent repairs can be made.

Paths due to pedestrian, livestock, or vehicular traffic (two and four-wheeled) are a problem on many embankments. If a path has become established, vegetation will not provide adequate protection and more durable cover will be required unless traffic is eliminated. Stones may be used effectively to cover such footpaths.

In addition, steps can be provided/ constructed at regular intervals along the length of the dam for going from downstream toe to the dam top. All vehicular traffic, except for maintenance, should be restricted from the dam.

Erosion is also common at the point where an embankment and the concrete walls of a spillway or other structure meet. Poor compaction adjacent to such walls during construction and later settlement can result in an area along the wall that is lower than the grade of the embankment.

Runoff, therefore, often concentrates along these structures, resulting in erosion. People also often walk along these walls, wearing down the vegetative cover.

Workable solutions include re-grading the area so that it slopes away from the wall, adding more resistant surface protection, or constructing steps.

4.3.2 Upstream Riprap

The upstream face of a dam is required to be protected against wave erosion. Rip-rap is normally provided for the purpose with filter layers below. Nonetheless, erosion can still occur in existing riprap. Water running down the slope under the riprap can erode the embankment. Sections of riprap that have slumped down-ward are often signs of this kind of erosion.

Effective slope protection must prevent soil from being removed from the embankment.

When erosion occurs on the upstream slope of a dam, repairs should be made as soon as possible. (Refer IS: 8237- Code of practice for protection of Slopes for Reservoir Embankments for specifications of stones to be used as rip-rap). The sunk rip rap may be brought back to its original levels by backfilling with suitable material duly compacted and with inverted filter as originally provided under the rip-rap. Further the riprap must be tightly packed.

4.3.3 Controlling Vegetation

Keep the entire dam clear of unwanted vegetation such as bushes or trees. All bushes/trees should be as far as possible removed by roots. The resulting holes should be filled with well compacted earth. It would be desirable to remove the plants/vegetation at their early stage to prevent their growing into big trees/bushes. In cases where trees and bushes cannot be removed, the root systems should be treated with herbicide (properly selected and applied) to retard further growth. Concerned Government Agencies should be consulted for selection of appropriate herbicides & their use for control of vegetation on dam structures.

Further, it is desirable that there are no trees or bushes within 500 m of the toe drain on the downstream side of the dam.

Mowing of turfing needs to be carried out at least twice in a year depending on its growth.

4.3.4 Controlling Animal Damage

Livestock should not be allowed to graze on an embankment surface. When soil is wet, livestock can damage vegetation and disrupt the uniformity of the surface. Moreover, livestock tend to walk in established paths and thus can promote erosion. Such paths should be re-graded and seeded, and the livestock permanently fenced out of the area.

The burrows and tunnels of burrowing animals (beaver, muskrat, groundhogs and others) weaken earthen embankments and serve as pathways for seepage from the reservoir. Large burrows on an embankment should be filled by mud packing. This involves placing vent pipe over the entrance of the den. Making sure that the pipe connection to the den does not leak, the mud-pack mixture is poured into the pipe until the burrow and pipe are filled with the soil-water mixture. The pipe is removed and more dry earth is tamped into the entrance. The mud pack is generally made by adding water to 90% earth & 10% cement mixture until a slurry or thin cement consistency is attained. For bigger holes, bentonite coated stones can also be used. All entrances should be plugged with well-compacted earth & vegetation re-established. Dens should be eliminated without delay.

4.3.5 Controlling Ants and Termites (White Ants)

Ants and termites have become one of the most serious pests for Embankment dams. They both need water to survive and have been found on most of the embankment dams in India. These insects can create problems in the dam itself and with any of its electrical components.

In some habitats, ants and termites can move as much or more soil as earthworms, thereby reducing soil compaction. Nest galleries can penetrate in a V-shaped pattern below the nest, penetrating as much as more than one meter deep in the soil. These galleries can create pathways for surface water to penetrate in the dam, resulting in internal erosion and collapse of the surface.

Ants and termites left undisturbed can build mounds that can become quite large. These can create problems for mowing. However, frequent mowing can induce the colonies to migrate to neighboring, undisturbed areas.

There are many options for managing ants and termites. Use only pesticides labeled as suitable for the location you want to treat. Make every effort to avoid contaminating water with pesticides. Concerned agencies dealing with anti- termite treatment can be contacted.

4.3.6 Controlling Damage from Vehicular Traffic

As mentioned earlier, vehicles driving across an embankment dam can create ruts in the crest if it is not surfaced with roadway material. The ruts can then collect water and cause saturation and softening of the dam. Other ruts may be formed by vehicles driving up and down a dam face; these can collect runoff and cause severe erosion.

Entry of vehicles should be restricted on the dam top and kept out by fences or barricades. Any ruts should be repaired as soon as possible.

4.3.7 Masonry and Concrete dams/Spillways and appurtenant works

Various issues that may need routine maintenance in concrete and masonry dams/spillways and appurtenant works may include but are not limited to:

• Removal of vegetation growth on the surfaces of the dam, spillways, energy dissipaters and spill channel.

• Monitoring of seepage in galleries.

• Removal of leached deposits from galleries and general cleaning.

• To ensure proper access & lighting in galleries.

• Minor repairs of routine nature.

For complicated problems advice of experienced engineers/ experts will need to be obtained.

4.3.8 Gates and Hoisting Equipments

A satisfactory operation of a dam envisages proper operation of its Gates & their Hoisting Equipment.

If routine inspection of the Hydro-Mechanical Equipment shows the need for maintenance, the work should be completed as soon as possible.

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.

4.3.8.1 Radial Gates

Radial gates are provided in the spillway of the BALIMELA dam. The aspects to be inspected and maintained periodically for ensuring proper operation of these gates are as under:

i) Rubber Seals

- Seals shall be inspected for leakages. Locations of excessive leakages shall be recorded for taking remedial measures. Weeping or slight flow in localized area will not require immediate remedial measures. However, measures like tightening of bolts are carried out. Further adjustment is carried out during annual maintenance.
- If leakage is excessive & immediate repair is considered necessary, the seals should be repaired as soon as the reservoir water level is below the spillway crest level.

ii) Trunnion block assembly and its anchorages

- All the nuts and bolts of Trunnion block assembly and its anchorages shall be checked for tightness.
- Check all the welds for soundness and rectify defects.
- Check whether the Yoke girder and thrust block is covered or not. If not, cover it with mild steel plates.
- Cover the trunnion pin with anti- corrosive jelly.
- Remove all dirt, grit etc. from trunnion assembly and lubricate trunnion bearings of the gate with suitable water resisting grease as recommended by bearing manufacturers (Annexure – A).

iii) Gate structure

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

iv) Embedded Parts

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

v) General Maintenance

- Defective welding should be chipped out and it should be re-welded duly following the relevant Codal provision (IS: 10096, Part-3).
- Damaged nuts, bolts, rivets, screws etc. should be replaced.
- Any pitting should be filled up by welding and finished by grinding if necessary.
- The gate leaf, exposed embedded metal parts, hoists and hoist supporting structure etc., should be thoroughly cleaned and repainted when required keeping in view the original painting system adopted and as per the guidelines contained in IS: 14177.
- Trunnion bearing should be greased as and when required(Annexure –A). Keeping trunnion bearings in perfect working condition is very important. All other bolted connections should also be checked up for proper tightness.
- Bolts and Trunnion bearing housing should be tightened wherever required.
- The seals of the gate should be checked for wear and tear and deterioration. These should be adjusted/replaced as and when necessary.
- The wall plates, sill beams shall be checked and repaired if necessary.
- Wire ropes should be properly lubricated (Annexure – A).
- Oil level in the worm reduction unit should be maintained by suitable replenishment. Oil seals should also be replaced if required. Lubrication of other parts of hoists such as chains, position indicators and limit switches should also be done (Annexure – A).
- The stroke of the brake should be reset to compensate for lining wear. Worn out brake linings should be replaced in time.
- Flexible couplings should be adjusted if required.
- Repairs and replacements of all electrical relays and controls should be attended to.

- Maintenance of alternative sources of Power such as Diesel Generating sets and alternative drives wherever provided should be carried out.
- The list of essential spare parts to be kept available should be reviewed and up-dated periodically. The condition of spares should be checked periodically and protective coating given for use.

4.3.8.2 Electrically operated fixed hoists

a) General Instructions

- Operation of fixed hoist without lifting the gate is not possible and need not therefore be attempted. It will be possible to operate the unit and observe operation of load carrying hoist component when gate is being lifted or lowered.
- 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 in-cluding motor brake and other electrical equipment.

b) Inspection and Maintenance

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

- Entrance to all hoist platforms shall be kept locked. All keys shall remain with the shift supervisor.
- A cursory daily inspection shall be made of hoist and gate to ensure that there is no unusual happening.
- Clean all hoisting equipment and hoist platform.
- Check oil level in gearboxes and replenish as and when required with oil of proper grade.
- Apply grease of suitable grade by grease gun (Annexure –A).
- Lubricate all bearings, bushings, pins, linkages etc. (Annexure –A).
- Check all the fuses on the power lines.
- All bolts and nuts on gear boxes, hoist drum and shaft couplings should be checked for tightness.

- Check the supply voltage.
- 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.
- All the geared couplings shall be greased (Annexure –A).
- Raise and lower the gate by hoist motor and check for smooth, and trouble free operation of gate without excessive vibration.
- 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.
- Check the condition of painting of various components and remove rust wherever noticed and repaint the portion after proper cleaning as per painting schedule.
- All trash, sediments and any other foreign material shall be cleared off the lifting rope and lifting attachment.
- All ropes shall be checked for wear and tear and if broken wires are noticed, the rope shall be replaced.
- All the wire ropes shall be checked and all visible oxidation shall be removed.
- All wire ropes shall be greased with cadmium compound (Annexure –A).
- Check the overload relays for proper functioning.
- 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.
- Check the pulleys, sheaves and turn-buckles.
- Raise and lower the gate for its full lift several time (at least three to four) and observe the following:
  - Check the limit switches and adjust for design limits.
  - 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.
  - When the gate is operated, there should not be any noise or chatter in the gears.
- 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 (Annexure –A).
- Repaint the hoist components, hoisting platform and its supporting structures as per requirement.
- The periodic maintenance of commercial equipment like motors, brakes, thrusts etc. shall be carried out as per manufacturers operation and maintenance manual.

4.3.8.3 Maintenance of Electrical components of Fixed Rope Drum Hoists

The Electrical components to be inspected and maintained periodically are as under;

- Starters should be cleaned free of moisture and dust.
- Each individual contactor should be tried by hand to make sure that it operates freely.
- All wearing parts should be examined in order to take note of any wear which may have occurred during operation.
- If the contactor hums, the contact faces should be cleaned.
- Examine all connections to see that no wires are broken and no connections are loose.
- Clean the surface of the moving armature and magnet core which comes together when the contactor closes, free of dust or grease of any kind.
- Examine the mechanical interlocks between the reversing contactor and see when the contact tips of one of the contactor units are touching, it is impossible to get the contact tips of the other unit to touch.
- The contact tips should be kept free from burns or pits by smoothening with fine sand paper or emery paper.
- Replace the contact tips which have worn away half-way.
- Do not lubricate the contacts.
- 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.
- Examine earth connections and motor leads.
- Examine motor windings for overheating
- Examine control equipment's
- Examine starting equipment for burnt contacts
- Check and tighten all nuts and bolts
- Clean and tighten all terminals and screw connections all contact surfaces shall be made clean and smooth.
- Lubricate the bearings

- Overhaul the controllers
- Inspect and clean circuit breakers.
- Wipe brush holders and check bedding of brushes.
- Blow out windings thoroughly by clean and dry air. The pressure shall not be so high that insulation may get damaged.
- 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.

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

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

Solenoids Operated Brakes

- All fixing bolts shall be checked and tightened at least once in three months.
- The magnet stroke should be reset to compensate for wear.
- Re-adjust the brake when the magnet stroke reaches the value given on the instruction plate.
- Brake lining should be checked and replaced when required.
- Examine all electrical leads and connections.
- Rubber bushes or couplings should be checked and replaced if defective.
- The pins should be tightened.
- Brake drum shall be cleaned to remove any dust or grease.
-

4.3.8.4 Painting of radial gates and hoists

Painting of gates is essential to prevent rusting and corrosion since the gates are exposed to sun, rain and air. The gates shall be painted in alternate years and the painting should be completed preferably by end of May every year.

Brass plates, stainless steel flats and rubber seals shall be cleaned only and shall not be painted.

Before painting, the surface must be perfectly cleaned by wire brushing and shall be free from moisture, dust, oil, grease, rust etc. If the surface shows cracks, it is advisable to scrap or burn the old film.

Painting schedule should be planned in such a way that 50% gates and hoists with allied components in a project are painted every year. The following paints are recommended for painting of gates and hoists.

Sl. No.	Item	Paints Recommended	Frequency of Painting
1	Gate leaf upstream side	Anti - corrosive black paint HD(Coal tar based epoxy paint).	Two coats in alternate years.
2	Gate leaf (downstream side) and other parts of gates and hoists.	Anti - corrosive black paint LC(Coal tar based epoxy paint)	Single coat in alternate years.
3	Hoist covers and railing pipes	a) Primary coat: Red oxide b) Final coat: Aluminium oxide or Enamel paint.	Single coat in alternate years.

Painting shall be carried out in accordance with latest Indian standards.

Each coat of primer and paint shall be compatible with previous and subsequent coats and shall be free from runs, drops, pinholes, waves, laps, sags and unnecessary brush marks and shall be allowed to dry or to harden before succeeding coat is applied.

During painting the air temperature shall be well above the dew point and not less than 7°C and the relative humidity not greater than 80% .The time of painting shall be such that moisture does not condense on gate before or during painting or until the paint is dry.

Painting shall be discontinued during rain and dust storm and shall not commence until the surfaces are perfectly dry and clean. Wherever practicable, surfaces shall be painted when in shade or when the temperature is falling.

Coats of coal tar epoxy paint shall be provided at an interval of 24 hours and each coat shall give a dry film of 100 microns.

4.3.8.5 Maintenance of Sluice Gates /Odisha intake gates/Andhra Pradesh tunnel gates:

The maintenance of Sluice gates and hoists/Odisha intake gates/Andhra Pradesh tunnel gates and ancillary components should be done regularly. Proper records of inspection, testing and maintenance should be kept by the officers in charge of the work.

The following maintenance work should be attended to:

1) The worn out bolts, screws etc. should be replaced. Any pitting to embedded portion should be filled up by welding and finished by grinding. Weld joints of major components should be checked thoroughly and defects if any should be rectified by welding and grinding.

2) The gates, hoists and allied structures should be painted once in three years. The original specification of painting done at the time of commissioning of gate and hoists should be kept in view while painting in subsequent years.

3) The wheel pins and bushes should be lubricated. All bolts and nuts of wheel assembly should be checked for slackness and should be tightened if found loose. The screws fixing the retainer plates to the end vertical girders should be checked for slackness and should be tightened if found loose. The spacer rings should be checked for wear and tear.

4) The rubber seals of the gate should be checked for wear and tear and damage and should be repaired/ replaced as considered necessary.

5) The bolts and nuts fixing the rubber seals to the skin plate should be checked for slackness and should be tightened if found loose. Damaged bolts and nuts should be replaced.

6) Drain holes provided in horizontal stiffeners of the gates should be cleaned to avoid stagnation of water on the horizontal stiffeners.

7) The lifting pin and lifting bracket bush if provided should be lubricated properly as specified in Annexure - B.

8) The sill beam, side seal seat, top seal seat, guide and wheel track should be checked

for pitting and should be rectified suitably. The welding of stainless steel flats on wheel tracks, bottom sill beam, side seal seats and top seal seats should be checked for weld cracks and should be re-welded and ground smooth if weld cracks are noticed.

9) Gap between guide and guide shoe should be checked and suitably rectified if excessive way on gate is noticed.

10) Distance between face to face of guide, centre to centre of track and side seal seats and distance between the bottom sill beam and centre of top seal seat should be checked and remedial measures may be taken if felt necessary.

11) The stems of restraining arrangement and the split bushes should be lubricated properly as specified in Annexure - B. The bolts and nuts of restraining brackets and stem flanges should be checked for slackness and should be tightened if found loose.

12) The steam should be checked for straightness and suitable remedial measures may be taken if the stems are found bent.

13) The welding of eye piece to the bottom stem and other weld joints shall be checked and suitably rectified if defects are noticed.

14) The worm, worm wheel, worm shaft, bronze bushes, thrust bearings and screw rod should be lubricated properly as specified in Annexure-B.

15) All bolts and nuts of hoist and hoist bridge should be checked for slackness and tightened if found loose.

16) All major weld joints of hoist and hoist bridges/walk-way bridge shall be checked for cracks etc. and shall be rectified suitably.

17) The screw rod, worm and worm wheel should be checked for damage to teeth or hair cracks etc. and should be rectified/replaced as considered necessary.

18) The thrust bearings should be opened and checked for damage to the inner/ outer cones & rollers etc. & shall be rectified/replaced as considered necessary.

19) The chequred plates/wooden planks should be checked for rusting/damage and shall be repaired/replaced as considered necessary.

20) The wheel track, guide, side seal seat and top seal seat should be lubricated properly.

21) The emergency gates shall be maintained in the similar method.

22) In addition to the above other defects noticed during pre-monsoon inspection shall also be attended to before onset of monsoon, if the defects need immediate attention. All other defects can be rectified during the working season i.e. between 1st November to 15th June of every water year.

Maintenance Schedule:

a. Quarterly Maintenance :

1. **Wheel Assembly**.
   The wheel pins and bushes should be lubricated.
2. **Stems and Split bushes**.
   The stems and split bushes should be lubricated.
3. **Lifting bracket bush and pin**.
   The lifting bracket bush and pin should be lubricated.
4. **Gear Box Assembly**.
   a. The screw rod should be lubricated.
   b. The worm, worm wheel, worm shaft & thrust bearing should be lubricated.

b. Yearly maintenance:

1. Grease shall be applied to guide, wheel track side seal seat and top seal seat.
2. All bolts and nuts should be checked for slackness and shall be tightened if found loose.
3. The rubber seals should be checked for deformation and damage etc. and shall be Repaired/ replaced.

4.3.8.6 Painting of Sluice Gates and Hoists

Painting of gates is essential to prevent rusting, scaling and corrosion since the gates are exposed to sun, rain and air. The gates shall be painted once in three years in and the painting should be completed preferably by end of May every year.

Brass plates, stainless steel flats and rubber seals shall be cleaned only and shall not be painted.

Before painting, the surface must be perfectly cleaned by wire brushing and shall be free from moisture, dust, oil, grease, rust etc. If the surface shows cracks, it is advisable to scrap or burn the old film.

Painting schedule should be planned in such a way that 33 % gates and hoists with allied components in a project are painted every year. The following paints are recommended for painting of gates and hoists.

Sl. No.	**Item**	**Paints Recommended**	**Frequency of Painting**
1	Gate leaf upstream side	Anti - corrosive black paint HD or equivalent (Coal tar epoxy based).	Two coats once in every 3 years.
2	Gate leaf (downstream side) and restraining structure	Anti - corrosive black paint LC or equivalent (Coal tar epoxy based)	Single coat once in every 3 years.
3	Gear box, Gear box support frame, hoist bridge/walkway bridge.	a) Primary coat: Red oxide b) Final coat: Aluminium oxide or Enamel paint.	Single coat once in every 3 years.

Painting shall be carried out in accordance with latest Indian standards.

Each coat of primer and paint shall be compatible with previous and subsequent coats and shall be free from runs, drops, pinholes, waves, laps, sags and unnecessary brush marks and shall be allowed to dry or to harden before succeeding coat is applied.

During painting the air temperature shall be well above the dew point and not less than 7°C and the relative humidity not greater than 80% .The time of painting shall be such that moisture does not condense on gate before or during painting or until the paint is dry.

Painting shall be discontinued during rain and dust storm and shall not commence until the surfaces are perfectly dry and clean. Wherever practicable, surfaces shall be painted when in shade or when the temperature is falling.

Coats of coal tar epoxy paint- shall be provided at an interval of 24 hours and each coat shall give a dry film of 100 microns.

4.3.9 Electrical System

Electricity at BALIMELA dam is used for lighting and operation of 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 *Metal Component Maintenance*

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

4.3.11 *Access Roads*

For a dam to be operated and maintained there must be a safe means of access to it at all times. Access road surfaces must be maintained to allow safe passage of automobiles and any required equipment for servicing the dam in any weather conditions. Routine observations of any cut and fill slopes along the sides of the road should be made. If unstable conditions develop assistance of experienced Engineers/Expert Panels should be obtained and remedial measures initiated.

Drains are required to be provided and maintained along roads to remove surface and subsurface drainage. This will prolong the life of the road and help reduce deterioration from rutting.

Road surfacing should be repaired or replaced as necessary to maintain the required traffic loadings. In most cases, specialized contractors will be required to perform this maintenance.

4.3.12 *General Cleaning*

For proper operation of spillways, sluiceways, approach channels, inlet and outlet structures, stilling basin/ energy dissipation arrangements, discharge conduit, dam slopes, trash racks, debris control devices etc., regular and thorough cleaning and removal of debris is necessary. Cleaning is especially important after large floods, which bring a lot of debris.

4.4 Materials requirements for maintenance during monsoon period

Materials required during monsoon period for both immediate maintenance and preventive maintenance should be stocked in adequate quantity. A 24x7 hour patrolling is to be carried out during the monsoon period.

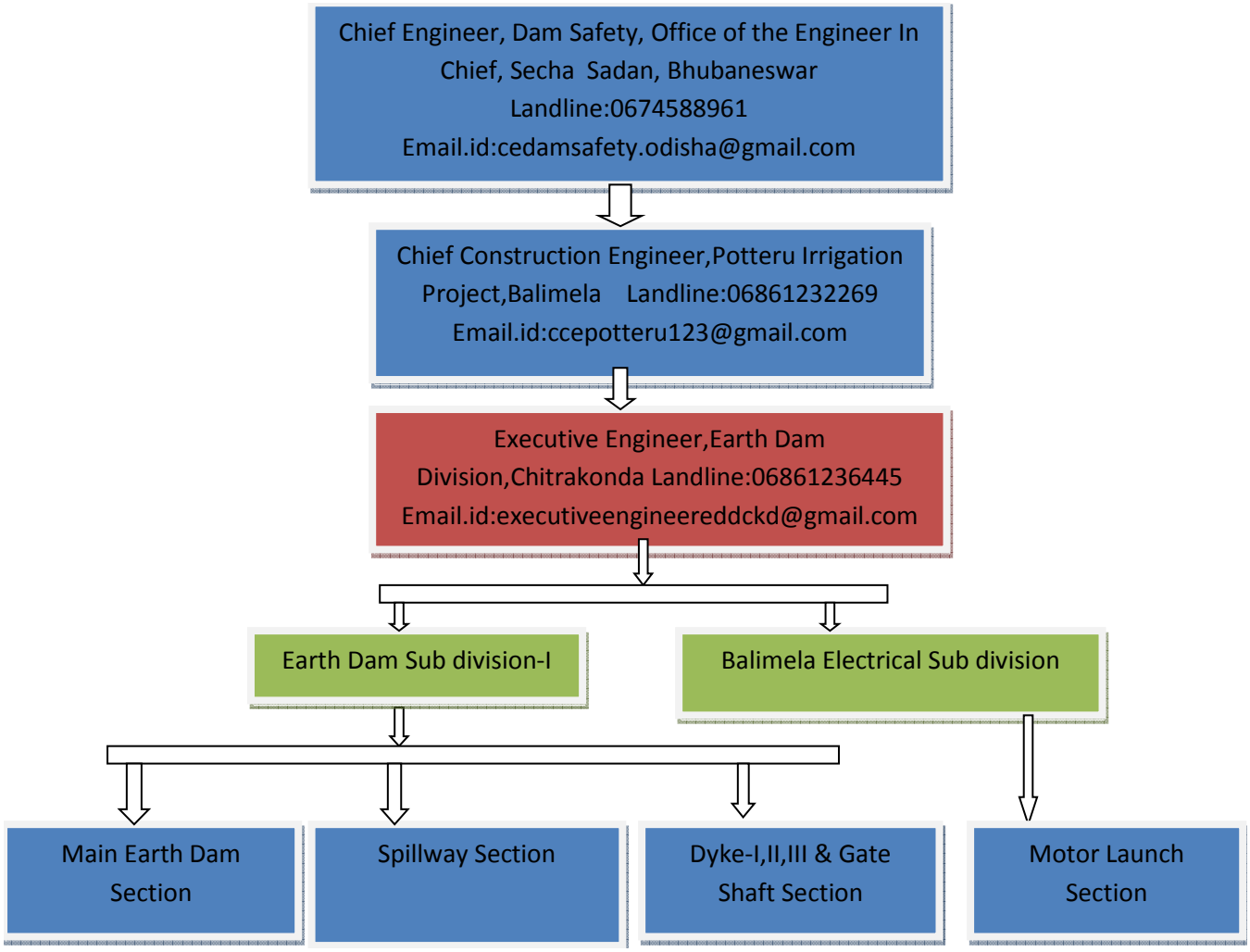
The dam owner should have a list of laborer's and contractors who can be engaged immediately at the time of emergency.

The materials normally required to be stocked in sufficient quantity are:-

- Gunny Bags
- Sand, Boulders/Wire crates
- Bamboos / Bali's
- Baskets, ropes
- Petromax Lamps with Spares
- Torches with spare cells
- Diesel for DG set
- Kerosene Oil
- Match Boxes
- Rain Coats
- Gum Boots
- Life Jackets
- Warning sign indicator
- Danger zone lights

4.5 Establishment Requirements

The following figure show the Organizational Structure for the Operation and Maintenance of BALIMELA dam. The Hydro-Mechanical works are looked after by the Mechanical wing of OWRD.



Engineering O&M Organization Structure for BALIMELA dam

In addition to the personnel shown above, there will be other supporting staff (skilled/unskilled), regular/ work charged staff/ Labour and clerical staff depending upon the requirements in monsoon & non-monsoon period.

4.6 Preparation of O&M budget

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

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

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

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

Office Expenses –Rent for office, Telephone/Mobile/any other Telecommunication bills, Electricity bills, water bills, Office stationery, Day to day office requirements.

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

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

T&P - T&P requirements for offices, colony, works etc. as applicable.

Works - Painting, oiling, greasing, overhauling of HM equipment's, Repair/replacement of gates seals & wire ropes, POL for pumps & generator sets, Electricity charges and maintenance of Electric systems of dam site, specific requirements for all Civil, H.M & Electrical maintenance works, vegetation removal and mowing of turfing on earth dams, maintenance/cleaning of drains in dam, maintenance of lift/elevators in dam (as applicable), maintenance of access roads & basic facilities, provision for flood contingency works during monsoon, unforeseen events/items (about 10% of the cost of works) etc.

A summary table for the O&M budget is given in Appendix – III.

4.7 Maintenance Records

Maintenance records are of utmost importance. A record should be kept of all maintenance activities, both immediate and preventive maintenance works. Information that should be recorded includes the following as a minimum:

- 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.

ANNEXURE- A

(For Radial Gates and Hoists)

Sl. No.	Parts to be Lubricated	Method of Lubrication	When to Lubricate	Lubricants Recommended
I	II	III	IV	V
1.	Trunnion Assembly (Brushes and Pins)	Volume grease gun	Quarterly	Mobil Grease No. 2
2.	Guide roller Assembly (bushes and pins)	Hand grease gun	Quarterly	Mobil Grease No. 2
3.	Gerars and Pinions of end reduction gear boxes	By brush/hand	Quarterly	Dorcia 150
4.	Hinges, pins and spring of Electromagnetic brake	Hand grease gun	Quarterly	Mobil Grease No. 2
5.	Gears and pinions of position Indicators	By brush/hand	Quarterly	Dorcia 150
6.	Bushes of position Indicators	By oil can	Quarterly	DTE oil Medium
7.	Electric Motor Bearings	Hand grease gun	Yearly	Mobil Grease No. 2
8.	Wire ropes	By brush/Hand	Half Yearly	Cadmium compound
9.	Worm gear reducer	Fill upto mark on dip stick	Change oil in alternate year	Servo C-60 or Servo Mark 59 SAE-140
10.	Anti-friction bearings	Hand grease gun	Hand Grease gun	Mobil Grease No. 2
11.	Pins of Wire rope attachment turn buckles and equaliser plate turn-buckle thread	By grease gun	By grease gun	Mobil Grease No. 2
12.	Drum shaft bushing	Volume grease gun	Volume grease gun	Mobil Grease No. 2
13.	Limit Switches	By oil can	By oil can	Mobil Oil

Note: Lubricants of other makes equivalent to the lubricants specified in column V above can also be used.

ANNEXURE- B

(Sluice Gates and Hoists)

Sl. No.	Parts to be Lubricated	Method of Lubrication	When to Lubricate	Lubricants Recommended
1.	Wheel Assembly (Pin & Bushes)	Volume Grease Gun	Quarterly	Mobil Grease No. 2
2.	Worm Wheel, Worm, Worm shaft and screw rod	Smear	Quarterly	Mobil Grease
3.	Bushes of Gear Box	By Oilcan	Quarterly	DTE Oil
4.	Restraining stems & split bushes	Smear	Quarterly	Mobil Grease
5.	Lifting Bracket Bush and Pin	Smear	Quarterly	Mobil Grease
6.	Thrust Bearing	Smear	Quarterly	Mobil Grease No. 2
7.	Guide, Wheel Track side Seal Seat & Top Seal Seat	Smear	Yearly	Dorcia 150

Note: Lubricants of other make equivalent to the lubricants specified above can also be used.

CHAPTER 5

5. INSTRUMENTATION AND MONITORING

Instrumentation in a Dam, helps in checking that whether it is functioning as designed or not.

5.1 Types of instruments at BALIMELA dam

The table below gives the details of instruments installed at BALIMELA dam along with their location and frequency of measurements.

Sl. No.	Instrument	Location and Number	Parameter measured	Frequency of measurement	Condition of instrument
1	Automatic Water Level Recorder	U/S of spill way gate (one no.)	Recording water level		Not functioning
2	Manual Water level gauge	U/S of spillway gate(one no.)	Recording water level	Daily during non-monsoon and hourly in monsoon	In working order
3	Rain Gauge	Near Security room at main gate of MED(one no.), Another at Division office	Recording Rain fall	Daily	In working order
4	Pore Pressure Cell	No instrument			
5	V-Notch	RD Spillway drainage gallery(2 numbers) & Cut throat flume at Dyke-I,III	Recording seepage	Daily	In working order

5.2 Weirs

Weirs are usually metal or plastic plates with a notch in the top edge. The quantity of water flowing through the notch is calculated by measuring the depth of water from the invert of the notch to the upstream water surface. The notch can be triangular, rectangular, or trapezoidal.Triangular notches or V-notch are widely used. The advantage of the V-Notch weir is its ability to measure small flows accurately. The discharge through aStandard90°V-Notch weir may be computed by the following formula as per IS 14750**:**

$Q = O.O138\ H^{5/2}$

where,

Q = Discharge in litre/ sec;

H = Head in cm.

Rectangular or trapezoidal weirs are appropriate for larger flows.

The discharge through the standard contracted rectangular weirs notch may be computed by the Francis formula, as per IS 14750:

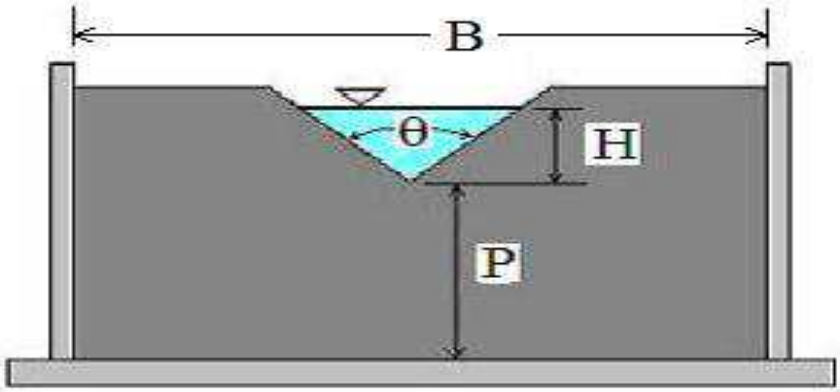
$$Q = 0.0184(L - 0.2H)^{3/2}$$

Where,

Q = Discharge in litres/ sec,

L =Length of crest in cm

H= Head over the weir in cm



V Notch Weir

CHAPTER 6

6. PREVIOUS REHABILITATION EFFORTS

Before DRIP, maintenance activities were limited to routine greasing, oiling, and patch painting of hydro-mechanical devices; routine repair of electrical systems; gallery drainage; routine mowing, vegetation removal, repair of eroded section, etc. Apart from these routine maintenance activities, no major rehabilitation was carried out before the involvement of DRIP.

Under DRIP, major Rehabilitation Works have been carried out at a total cost of about INR 1662.62 Lakhs(with some activities still ongoing during the preparation of this O&M manual).

The major rehabilitation works carried out under DRIP include:

- Stabilization of left bank of Spillway & river sluice block of NOF portion.
- Improvement to approach road and top road of Dam and Dykes.
- Installation of V-notch at Drainage gallery of Spillway.
- Restoration of spillway, stilling basin, spill channel and revetment.
- Renovation of damaged transverse and longitudinal drains on the d/s face of Earth dam and Dykes.
- Installation of Digital water level recorder, Manual gauge plates, Salient feature boards, Chain age boards.
- Removal of outcropped rocks from spill channel.
- Installed 62.5KVA(KOEL) 3phase silent Diesel Generator for A.P tunnel.
- Lighting arrangement in Drainage Gallery and Himax light fixing at Dam and Spillway.

Other important works carried out under DRIP include Review of design flood; Preparation of Inundation maps and Emergency Action Plan (EAP); Preparation of O&M Manual; Data entry into DHARMA; etc.

CHAPTER 7

7. UPDATING THE MANUAL

The O & M Manual should be reviewed and updated periodically based on additional data. Updating of O&M Manual should be done whenever major changes like revision of design flood, any change in project features, construction of any additional spillway, construction of a dam on the upstream etc. take place.

Aspects to be considered when updating include:

- Increase/decrease in the frequency of inspections or routine maintenance.
- Changes in the operation and/or maintenance procedures.
- Alterations to the project data because of changes/modifications in the dam.

All up-dates/revisions of the O&M Manual need to be sent to all the locations/addresses to whom the copies of the original O&M Manual had been sent earlier. The O&M Manual is to be reviewed/ updated after every 10 years by the E.E., Earth Dam Division, Chitrakonda.
Updates in the O & M Manual will be approved by the Chief Construction Engineer of the project after getting the needful checking done through the DSO of OWRD.

7.1 Training and Exercises

Training: The training of the personnel, involved in implementation of the O & M Manual will be conducted by the Chief Construction Engineer once in a year so as to make the implementing staff familiar with the elements of the O&M plan, their responsibilities and duties, the available equipment, detection of problems and remedial measures.
A sufficient number of people will be trained to ensure adequate coverage at all the time.

Exercises (Testing): The CCE shall organize following exercises.

1. Orientation
2. Mock drills

Orientation: The CCE will regularly carry out orientation meetings with personnel involved in implementation of the O&M Manual

Mock drills: The SE in collaboration with the State DSO shall annually organize mock drill to rehearse the operation of gates and hydro-mechanical equipment prior to onset of monsoon.

Appendix I: Scheduled Dam Safety Inspection Form

Part 1a - Inspection Details:

Dam Name:		Project ID Code (PIC):	
Dam Type:		Dam Purpose:	
Dam Owner:		Hazard Classification:	
Dam Operator:		Type of Inspection:	
Commissioning Date:		Inspection by:	
City/State/PIN:		Date of Inspection:	
District:		Reservoir water level in metre on the date of inspection:	
Latitude:		Storage Capacity (MCM):	(i) Gross ……..(ii) Live……
Longitude:		Weather Conditions:	
Important Controlling Level	a) TBL RL ……. b) MWL RL ……. c) FRL RL …….. d) Spillway Crest RL ……. e) MDDL RL ……. f) Lowest River bed RL …….. g) Deepest foundation level RL ……..		

Part 1b - Inspection Remarks:

Please provide any additional information or comments not covered by Part 1a form above.

Part 2a - Inspection Checklist:

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
A-Reservoir						
A-1.1	**General Condition**					
1.1.1	Is the reservoir water level unusually high or low?					
1.1.2	Are there signs of decline in water quality?					
1.1.3	Are there signs of recent sediment deposition?					
1.1.4	Is floating debris present?					
1.1.5	Any indications of major active or inactive landslide area in the reservoir rim If so, indicate their locations and extent.					
1.1.6	Are there people or livestock in and around reservoir?					
1.1.7	Any other issues?					
B-Dam and Dam Reach (Embankment)						
B-1.1	**General Condition**					
1.1.1	Any major alterations or changes to the dam since the last inspection?					
1.1.2	Is there any new nearby development in the downstream flood-					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
	plain?					
1.1.3	Any misalignment of poles, fencing or walls due to dam movement?					
B-1.2	**Upstream Slope**					
1.2.1	Any signs of bulging or concavity (depressions)? If so, indicate their locations and extent. (Check up the cross-sections with tape and level at random locations, at least two)					
1.2.2	Does the section of the dam and upstream slope appear structurally sound and stable?					
1.2.3	Presence of longitudinal or transverse cracks?					
1.2.4	Whether any signs of distress to stability of slopes noticed at any time in any part of the dam? If so, give brief details of the incidents and location, the method of treatment adopted and its effectiveness. Indicate the general condition of upstream pitching.					
1.2.5	Any degradation to slope protection (rip-rap)?					
1.2.6	Is there any profuse growth of bushes or weeds over any portion of the dam? If so, indicate the locations.					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.2.7	Does the upstream slope shows existence of crab holes or holes made by rodents or burrowing animals or ant hills? If so, indicate the locations.					
1.2.8	Any other issues?					
B-1.3	**Crest of Dam**					
1.3.1	Is the crest profile at proper elevation? (To be test checked at random locations by taking level)					
1.3.2	Does it show any signs of excessive and/or uneven settlement? If so, indicate such locations and extent of settlement. (Surface settlement points must be installed for observing this aspect)					
1.3.3	Is the surface of the crest free from undulations and local depressions or heaving?					
1.3.4	Does it provide an all-weather road surface?					
1.3.5	Any degradation to access road (sealed/unsealed)?					
1.3.6	Does it develop any visible cracks in transverse or longitudinal directions? If so, attach a map showing their locations and extent. Depth of cracks must be ascertained by taking open trenches extending below the bottom of cracks.					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.3.7	What is the condition of the edges of crest? Have got eroded and cut up resulting in reduced effective width?					
1.3.8	Is the crest free from local slips throughout its length on either sides?					
1.3.9	Do the headers, guard stones and parapet wall provided at the edges of the crest appear in proper profile and plumb?					
1.3.10	Any degradation to upstream parapet or downstream curb wall?					
1.3.11	Evidence of livestock on dam crest?					
1.3.12	Trees or profuse growth of weeds/bushes at any location?					
1.3.13	Proper lighting arrangement at dam top?					
1.3.14	Any other issues?					
B-1.4	**Downstream Slope**					
1.4.1	Any signs of bulging or concavity (depressions)?					
1.4.2	Are there any wet or slushy patches or any concentrated leaks, springs or trickles observed on the downstream slopes or the toe? If so, indicate their locations and extent. Please look out for patches of extensive vegetation growth and examine them carefully and record the findings.					
1.4.3	Presence of longitudinal or transverse cracks?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.4.4	Any signs of distress to the stability of slopes?					
1.4.5	Are rain cuts/erosion channels present at any location?					
1.4.6	Are all the rain cuts and erosion channels properly treated and made good? Please indicate location of recurring damages, if any.					
1.4.7	Is there any profuse growth of bushes or weeds over any portion of the dam? If so, indicate the locations.					
1.4.8	Does the downstream slope shows existence of crab holes or holes made by rodents or burrowing animals or ant hills? If so, indicate the locations.					
1.4.9	Any other degradation to slope protection (turfing)? Indicate the general condition of downstream pitching/ turfing and rock toe.					
1.4.10	Is the downstream area clear of debris and free draining?					
1.4.11	Any other issues?					
B-1.5	**Downstream Drainage**					
1.5.1	Are there any signs of water logging, slushy conditions or growth of aquatic weeds on the downstream of the dam? To be checked up to 300 m downstream of toe					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.5.2	Are there any standing pools of water in the downstream of dam? If so, give their locations and extent. To be checked upto 300 m downstream of toe					
1.5.3	Are there any boils observed in the vicinity of the downstream toe of the dam? If so, give locations.					
1.5.4	Is the downstream area sufficiently clear and free draining?					
1.5.5	What is the depth of ground water table on the downstream as evident from the existing wells in the vicinity of the dam To be checked up to 300 m downstream of toe. Does the water table show any marked variation in accordance with the variations in reservoir water level?				a) Max. ground water level…… b) Location …… c) Date…… **d)** Corresponding Reservoir level……	
1.5.6	Are all the exposed drains working satisfactorily?					
1.5.7	Toe drains and cross drains. i. Are the portions of longitudinal toe drain and exposed cross drains beyond the downstream toe of the dam in regular section and freely draining? ii. Is the pitching to these drains intact? iii. Is there any weed growth in these drains? iv. Indicate other defects noticed in the drains, if any.					
1.5.8	Outfall Drain:					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
	(a) Is the outfall drain in proper shape and grade and freely draining? **(b)** Is the outfall drain properly cleaned and maintained? Does the outfall drain show any stagnant pools of water or weed growth?					
B-1.6	**Surface Drainage of Downstream Slope**					
1.6.1	Is the condition of the downstream slope drainage arrangements, if provided, satisfactory?					
1.6.2	Is the paving to these drains intact?					
1.6.3	Are all the drains properly maintained and free of vegetation growth and debris?					
1.6.4	Does the slope have a tendency to develop severe rain cuts at any location?					
1.6.5	Enumerate any other defects noticed in the surface drainage of downstream slope.					
B-1.7	**Seepage Measurement**					
1.7.1	Is the quantity of seepage being daily or periodically measured and recorded? Please check the registers and record observations.					
1.7.2	Does it show any abnormal rise or fall? If so, does it have any relation to a certain reservoir level elevation?					
1.7.3	Does the seepage show a turbid colour at any stage? Was such a phenomenon observed at any stage at any location in the past?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.7.4	What is the measured rate of seepage flow with date and reservoir level; i. On the day of present inspection ii. Maximum since last June iii. Minimum since last June				a) Date b) Rate of seepage flow (lpm) c) Reservoir level (m)	
1.7.5	Is the portion upstream and downstream of measuring points of seepage easily accessible with proper steps and paths and free of vegetation growth?					
1.7.6	Are the measuring points properly located, constructed and maintained so as to give accurate and reliable measurements of seepage in accordance with the relevant IS Codes?					
1.7.7	Is the method of taking seepage measurements satisfactory?					
B-1.8	**<u>Breaching Section (if provided)</u>**					
1.8.1	Is the breaching section easily accessible?					
1.8.2	Is the condition of the breaching section satisfactory?					
1.8.3	Is the note of instructions as to when and how to operate the breaching section available on record?					
1.8.4	For reconstruction after the breach are the following items decided in advance? a) Quarry for embankment material b) Suitable routes of access Is the maintenance staff fully aware of the instructions related to					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
	operation of the beaching section and for reconstruction after the breach					
1.8.5	Ascertain and indicate the latest event of operation of breaching section and its performance.					
1.8.6	Evidence of recent degradation?					
1.8.7	Any other issues?					
B-1.9	**Junction of Earth work with Masonry/Concrete dam sections and outlets**					
1.9.1	Is there any existence of leaks, springs or wet spots in the earth work in the vicinity of the junctions between earth work and masonry works? If so, what is the approximate rate and colour of the leakage? Does it turn turbid at any time? Please ascertain from enquiries and record the findings.					
1.9.2	Is there any tendency for separations, cracking, settlement or upheaval of the earth work in the vicinity of masonry or concrete? If so, indicate the locations and the exact nature of deficiency.					
1.9.3	Is there any tendency for surface erosion or slope instability at the junction?					
1.9.4	If the outlet conduit is located in the earth dam section, is the entire length of the conduit in perfect order and profile and free from offsets, open joints, cracks and leakage? Examine the conduit carefully from the downstream or from inside, if possible, and indicate the deficiencies observed, if any.					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.9.5	Any other issues?					
B-1.10	**Relief Wells**					
1.10.1	Are the relief wells in good working condition and functioning well?					
1.10.2	Are the relief properly surged and cleaned periodically?					
1.10.3	Please indicate the dates of last surging and cleaning and the next surging due.					
1.10.4	Are the necessary plant and equipment for cleaning the relief wells, available with the office?					
1.10.5	Is the record of periodical measurements of discharge from each relief well maintained? If so, indicate total discharge and maximum discharge observed from a single well on the date of inspection.					
B-1.11	**Abutment Contacts**					
1.11.1	Any presence of leaks, springs or wet spots near the abutment?					
1.11.2	Any presence of cracking, settlement or upheaval of earthwork?					
1.11.3	Any evidence of erosion or slope instability?					
1.11.4	Trees or profuse growth of weeds/bushes?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.11.5	Any degradation to up/downstream slope protection (rip-rap, turfing)?					
1.11.6	Any other issues?					
C-1	**Dam and Dam Block/Reach (Concrete/Masonry)**					
C-1.1	**General Condition**					
1.1.1	Any major alterations or changes to the dam since the last inspection?					
1.1.2	Is there any new nearby development in the downstream floodplain?					
1.1.3	Any misalignment of poles, fencing or walls due to dam movement?					
C-1.2	**Upstream Face**					
1.2.1	Evidence of surface defects (honeycombing, staining, stratification)?					
1.2.2	Concrete/masonry deterioration (spalling, leaching, disintegration)?					
1.2.3	Is cracking present (structural, thermal, along joints)?					
1.2.4	Evidence of differential settlement (displaced/offset/open joints)?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.2.5	Presence of vegetation (growth in joints between blocks)?					
1.2.6	Evidence of any other damage to joints and/or water stops?					
1.2.7	Any other issues?					
C-1.3	**Crest of Dam**					
1.3.1	Evidence of differential settlement (displaced/offset/open joints)?					
1.3.2	Presence of cracking (structural, thermal, along joints)?					
1.3.3	Profuse growth of weeds/grass/plants at any location?					
1.3.4	Any degradation to access road?					
1.3.5	Any degradation to upstream parapet or downstream curb wall?					
1.3.6	Any other issues?					
C-1.4	**Downstream Face**					
1.4.1	Evidence of surface defects (honey-combing, staining, stratification)?					
1.4.2	Concrete/masonry deterioration (spalling, leaching, disintegration)?					
1.4.3	Presence of cracking (structural, thermal, along joints)?					
1.4.4	Evidence of differential settlement (displaced/offset/open joints)?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.4.5	Presence of vegetation (growth in joints between blocks)?					
1.4.6	Evidence of any other damage to joints and/or water stops?					
1.4.7	Excessive seepage/sweating at any location on downstream face?					
1.4.8	Significant leakage at any location on downstream face?					
1.4.9	Any other issues?					
C-1.5	**Abutment Contacts**					
1.5.1	Any presence of leaks, springs or wet spots in vicinity of abutment?					
1.5.2	Any presence of cracking or settlement?					
1.5.3	Profuse growth of weeds/grass/plants at any location?					
1.5.4	Any other issues?					
D	**Gallery/Shaft and Drainage (Concrete/Masonry)**					
D-1.1	**General Condition**					
1.1.1	Slushy condition or water logging immediately downstream of dam?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.2	Any evidence of boiling in vicinity of dam toe?					
D-1.2	**Gallery/Shaft Condition**					
1.2.1	Any problems accessing or inspecting gallery/shaft (obstruction)?					
1.2.2	Any safety issues (inadequate handrails, lighting or ventilation)?					
1.2.3	Problems of inadequate drainage (slippery stairs, water logging of gallery, clogged porous or foundation drains)?					
1.2.4	Evidence of differential settlement (displaced/offset/open joints)?					
1.2.5	Excessive seepage/sweating at any location along gallery/shaft?					
1.2.6	Significant or excessive leakage at any location along gallery/shaft / porous drain? If yes, provide location(s).					
1.2.7	Are proper arrangements made for the measurement of seepage into the gallery? Is the seepage measured separately from- 1. Porous pipes? 2. Foundation drains? And 3. Monolith Joints? Are the above arrangements satisfactory?					
1.2.8	Has there been substantial progressive reduction in the seepage through the foundations? Is it due to choking of the drain holes? If so, indicate number of holes choked.					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.2.9	Are all the foundation and porous holes periodically cleaned with reaming tool and air water jetting? Indicate the last date of such cleaning and extent of variation observed in the seepage discharge before and after the cleaning.					
1.2.10	Is the seepage water and the deposit, if any, from the seepage being regularly examined for chemical composition? If so, indicate the result and the probable source of dissolved salts, if any.					
1.2.11	Are any seepage water springs observed in the downstream area anywhere? If so, indicate the locations and state the physical nature of this seepage. Look out for such seepage spots particularly near the dykes, fault zone etc. Ascertain if chemical testing are made of water samples from such springs for dissolved salts.					
1.2.12	Is there any leachate deposition? If yes provide location					
1.2.13	Any other issues?					
D-1.3	**Drain Condition**					
1.3.1	Is the flow in the drain unusually high or low?					
1.3.2	Presence of calcium or other deposits in drain?					
1.3.3	Is dewatering pumping station fully operational?					
1.3.4	Any problem inspecting pump?					
1.3.5	Any obstruction preventing or impairing smooth operation?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.3.6	Any deterioration of pump and associated equipment?					
1.3.7	Is sump well clean and maintained?					
1.3.8	Is V-notch before sump well clean and maintained?					
1.3.9	Any other evidence of the drain being blocked/having reduced section?					
1.3.10	Is the flow in the drain noticeably sporadic/irregular?					
1.3.11	Does the drainage water have unusual color (leachate)?					
1.3.12	Any other issues?					
D-1.4	**Body Wall (Masonry/Concrete) of 'NOF' Dam and Spillway**					
1.4.1	What is the total seepage into gallery from the porous pipes in the dam at lake full condition? How does it compare with the seepage when the reservoir was first filled? (For the corresponding water level)					
1.4.2	If there has been substantial reduction in this seepage? Ascertain and indicate the probable reasons therefore.					
1.4.3	Has there been a tendency for gradual reduction of drainage through pipes and progressive appearance of sweating on the downstream face of the dam?					
1.4.4	Has there been considerable leaching from the seepage water and deposition of lime near the seepage exit spots?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.4.5	Are the samples of the seepage water and reservoir water being regularly tested for reactive and corrosive properties?					
1.4.6	Is there excessive seepage, sweating at any locations on the downstream face of the dam? (Examine the monolith or construction joints for such seepage and leaching and indicate the findings)					
1.4.7	Is there any swelling or cracking observed on the downstream face especially near the points of concentration of stresses like the toe or locations of abrupt change in geometry of the face of the opening? If so, indicate the details of observations.					
1.4.8	Is the pointing on upstream face of the dam in good condition? If not, indicate the nature and extent of deficiency.					
1.4.9	Are the registers and graphs showing the periodical measurements of seepage discharge from the porous drains in the gallery and from the downstream face at various lake levels maintained at site?					
D 1.5	**Waste Weir Bar and Tail Channel**					
1.5.1	Is the Concrete/masonry spillway bar in good condition? Is there any leakage through the masonry or from the foundation? If so, what remedial measures are proposed / taken for minimizing the leakage? Is the record of leakage measurement maintained? What is the quantity of Seepage/Leakage on the date of inspection?					
1.5.2	Is the coping over the spillway bar in good condition?					
1.5.3	Does the upstream and downstream face of waste weir bar need					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
	pointing?					
1.5.4	Is there any scouring on downstream side of the bar and/or EDA? If so what remedial measures are proposed/ taken?					
1.5.5	Are there any damages or undermining to guide walls, divide wall and other appurtenants? If so, what remedial measures are proposed /taken?					
D 1.6	**Structural performance of the 'NOF' and 'OF' Portions of Dam Foundations**					
1.6.1	Are there any signs of structural distress noticed in the dam spillway and foundations in the form of- i. Excessive deflection with respect to permissible deflection at the time of design ii. Tendency of gradual sliding iii. Cracking and upheaval or settlement in any part of the body wall or foundations, iv. Excessive uplift, v. Excessive seepage and leaching through the body of the dam and the foundation.					
1.6.2	Conspicuous weathering of materials or components in any portion of the body wall or the foundations.					
E	**Spillway and Energy Dissipation Structure**					
E 1.1	**Spillway**					
1.1.1	Any problems inspecting spillway (obstructed access, damaged catwalk)?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.2	Any obstructions in or immediately downstream of the spillway?					
1.1.3	Evidence of abrasion, cavitation or scour on glacis (e.g. exposed reinforcement)?					
1.1.4	Presence of displaced, offset or open joints?					
1.1.5	Presence of cracking (structural, thermal, along joints)?					
1.1.6	Evidence of surface defects (honeycombing, staining, stratification)?					
1.1.7	Concrete/masonry deterioration (spalling, leaching, disintegration)?					
1.1.8	Presence of vegetation (growth in joints between blocks)?					
1.1.9	Evidence of any other damage to joints and/or water-stops?					
1.1.10	Excessive seepage/sweating at any location on spillway glacis?					
1.1.11	Significant leakage at any location on spillway glacis?					
1.1.12	Any other issues?					
E-1.2	**Energy Dissipation Structure**					
1.2.1	Any problems inspecting energy dissipation structure?					
1.2.2	Any obstructions in or immediately downstream of dissipation structure?					
1.2.3	Evidence of abrasion, cavitation or scour on dissipation structure?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.2.4	Presence of displaced, offset or open joints?					
1.2.5	Presence of cracking (structural, thermal, along joints)?					
1.2.6	Evidence of surface defects (honeycombing, staining, stratification)?					
1.2.7	Concrete/masonry deterioration (spalling, leaching, disintegration)?					
1.2.8	Presence of vegetation (growth in joints between blocks)?					
1.2.9	Evidence of any other damage to joints?					
1.2.10	Any problems with under-drainage (blockage of open drain holes)?					
1.2.11	Can the tail pond be drained easily for inspection of the stilling basin or bucket? If not, what are the alternatives available for dewatering? Please ascertain and indicate the last event of inspection of stilling basin (or bucket).					
1.2.12	From the examination of the levels and contour plans and reference marks in tail channel; ascertain if there is progressive erosion and retrogression in the tail channel. If so, indicate the extent and location of such erosion with reference to the various components of dam, spillway, outlet, power house etc.					
1.2.13	Is the concrete surface of the stilling basin and apron (or bucket) in good condition? Are there any indications of pitting, cracking, spalling or wearing of the surface of bedding concrete? If so, please give details of the nature and extent of the damage.					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.2.13	Is there any indication of abrasion and cavitation damage (pitting of concrete) especially at friction blocks, chute blocks and slotted roller teeth, the surface near the lower tangent point and the end sill? If so, please give the details of nature and extent of damage.					
1.2.14	Is the under drainage of the stilling basin (or bucket) satisfactory? Are all the open drain holes clear and functioning well?					
1.2.15	Any other issues?					
F	**Intake/Outlet and Water Conveyance Structure**					
F-1.1	**Intake/Outlet Structure**					
1.1.1	Any problems inspecting intake/outlet structure (obstructed/unsafe access)?					
1.1.2	Any obstructions in, upstream or downstream of intake/outlet structure?					
1.1.3	Evidence of abrasion, cavitation or scour on intake/outlet structure?					
1.1.4	Any evidence of structural distress (displaced/offset/open joints, cracking)?					
1.1.5	Any evidence of surface defects and/or concrete/masonry deteri-					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
	oration?					
1.1.6	Any other issues?					
F-1.2	**Water Conveyance Structure**					
1.2.1	Any problems inspecting intake/outlet structure (obstructed/unsafe access)?					
1.2.2	Any obstructions in, upstream or downstream of water conveyance structure?					
1.2.3	Evidence of abrasion, cavitation or scour on structure?					
1.2.4	Any evidence of structural distress (displaced/offset/open joints, cracking)?					
1.2.5	Any evidence of surface defects and/or material deterioration?					
1.2.6	Any evidence of seepage or leakage from water conveyance structure?					
1.2.7	Any other issues?					
G-1	**Hydro-Mechanical Component and Pump**					
G-1.1	**Spillway Gates (Radial gates, Vertical lift gates, Automatic gates)**					
1.1.1	Any problems inspecting gate/Stop-logs (obstructed/unsafe access)?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.2	Is the condition of the steel surface and the surface paint deteriorated?					
1.1.3	Are any connection bolts of rubber seals loosened or damaged? If so, indicate the details of defects.					
1.1.4	What is the general condition of rubber seals? Do any of the rubber seals show signs of weathering, hardening, cracking or tearing and damage?					
1.1.5	Are the rubber seals of side and bottom touching uniformly all along the sealing surface?					
1.1.6	Do the rollers (wherever applicable) touch the track plates uniformly? Are the rollers well lubricated?					
1.1.7	Are the embedded parts of spillway gates, emergency gates and stop-logs in sound condition and free from corrosion, uneven wear, cracking, chipping and dents? If not, state the nature of defects or deficiencies and observation, if any, regarding such defects.					
1.1.8	Check the following for structural soundness of all members and welded, bolted and riveted connections, uneven wear, uneven bearing, cracking, chipping and dents and indicate the findings: (1) Gate leaf and stiffeners (2) End arms (3) Trunnion girders / Yoke girder (4) Stop logs (5) Lifting beams (6) Gantry cranes					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
	(7) Tracks (8) Trunnion bracket (9) Chains/ wire ropes (10) Bridge structure					
1.1.9	Are the trunnion bearings of radial gates properly lubricated?					
1.1.10	Is there any damage or wear caused to the seal plates? If so, indicate the nature of damage noticed.					
1.1.11	Are any of the mechanical or structural components and fasteners or seals subjected to excessive wear? If so, please give details. Is there any tendency for recurring damage to any particular component? If so, please give details.					
1.1.12	Is sufficient stock of spares which need frequent replacement maintained at the site?					
1.1.13	Any issues with storage of equipment (emergency stop logs, lifting beam and gate leaves)?					
1.1.14	Any deterioration, corrosion? scaling? pitting? or cracking? of equipment (connecting bolts, welds?)					
1.1.15	Any obstructions preventing or impairing smooth operation?					
1.1.16	Any problems with the rollers (not touching tracks, inadequate lubrication)?					
1.1.17	Any debris, etc., in the gate grooves?					
1.1.18	Any damages to Radial Gate trunnion pins? gate arms? lubrica-					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
	tion? etc.?					
1.1.19	Any damage to embedded parts above waterline? access structure?					
1.1.20	Any damage to concrete grooves?					
1.1.21	Is the staff posted at the site for maintenance and operation of gates, hoists, equipments and electrical installations, well experienced, fully trained and conversant with the job requirements and responsibilities?					
1.1.22	Are the following documents maintained at the respective location of all the units? (1) Maintenance schedules specifying each operation, its frequency and 'due' and' done' dates. (2) Operating instructions with 'dos' and 'don't' for all operational units.					
1.1.23	Are the trunnion hub and the brackets well maintained?					
1.1.24	Are the trunnions likely to get submerged during actual working of the spillway? if so, ascertain the causes for the same and specify. Please enquire for occurrence of such events, if any.					
1.1.25	Are all the nuts of connecting bolts and anchorages properly tightened?					
1.1.26	Any other issues?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
G-1.2	**Hoists, Cranes and Operating Mechanisms**					
1.2.1	Are the hoists working satisfactorily?					
1.2.2	Any problems inspecting hoist/crane/operating mechanism?					
1.2.3	Is sufficient stock of spares which need frequent replacement maintained at the site?					
1.2.4	Is the full length of the chains or wire rope of the hoist in sound condition and free from broken strands?					
1.2.5	Is the electrical wiring in sound condition?					
1.2.6	Is the alternative power system for gate operation working properly?					
1.2.7	Is the alternate hand operation system of hoist working					
1.2.8	Any deterioration of equipment (connecting bolts, welds, surface, paint work?)					
1.2.9	Any wear or damage to wire cables and other moving parts?					
1.2.10	Any obstructions preventing or impairing smooth operation?					
1.2.11	Any health and safety concerns (e.g. lack of "danger" sign during maintenance)?					
1.2.12	Any other issues?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
G 1.3.	**Spillway Bridge, Hoist Bridge, Trunnion Level Bridge Catwalks**					
1.3.1	Are the decking, girders and structural supports of spillway bridge, hoist bridge, trunnion level bridge and catwalks structurally sound?					
1.3.2	Is the chequered platform of the bridge structurally sound and safe?					
1.3.3	Is there satisfactory arrangement to prevent unauthorized entry into the control structures and bridges?					
1.3.4	Are the structural members and joints sound and free from corrosion?					
1.3.5	When were the steel components painted last?					
1.3.6	Is the surface of steel work and paints satisfactory?					
1.3.7	Is the parapet or railing over the bridges sound, safe and painted?					
1.3.8	Is the walkway properly anchored to the piers?					
1.3.9	Are the track rails for gantry cranes structurally sound and intact?					
G-1.4	**Valves**					
1.4.1	Any problems inspecting valve?					
1.4.2	Any obstructions preventing or impairing smooth operation?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.4.3	Any deterioration of valve and associated equipment?					
1.4.4	Any other issues?					
G-1.5	**Walls: Guide walls/Divide walls/Junction walls/Return walls/Spray walls etc. (Strike out whichever is not applicable)**					
1.5.1	Are all the locations of such wall accessible for inspection, maintenance and repairs?					
1.5.2	Is the drainage of back sides of the walls (wherever applicable) from the weep holes satisfactory? If not, indicate the nature of deficiencies.					
1.5.3	Is there any tendency for the water to undercut the ends of the walls?					
1.5.4	Is there any foundation erosion or scour noticed in the vicinity of such walls? If so, give the details of nature and extent of such damage.					
1.5.5	Is there any surface erosion/damage caused, to face or body of such walls?					
1.5.6	Do any of the walls show symptoms of unusual settlement, developments of cracks and tilting? If so, give details of the defects noticed.					
1.5.7	Is there any damage to guide bunds? If so, give details of the damage.					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
G-1.6	**End Weir**					
1.6.1	Is it accessible?					
1.6.2	Is there any erosion, pitting or spalling of the concrete or masonry surface? If so, give details					
1.6.3	Is there any scour noticed on the immediate downstream of such weir? If so, give details of location and extent of such damage.					
G-1.7	**Hydraulic Performance of Energy Dissipation Arrangements**					
1.7.1	Do the flow conditions in the stilling basin (or bucket) have a tendency to draw material into the bucket and cause its churning and abrasion damage to the surface of buckets baffle blocks, apron and end sill? Is the hydraulic performance in agreement with the results of model studies? (wherever applicable) Ascertain the performance from observed tail water rating curves and deficient observation, if any, such as sweep outs and excessive erosion under plunge pools and locations of secondary rollers and retrogression.					
G-1.8	**Trash Racks**					
1.8.1	Is the trash rack fixed or movable?					
1.8.2	What is the mode of cleaning? Is it manual or by TRCM?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.8.3	Is the welding work on Trash Rack in sound health?					
1.8.4	Any problems inspecting trash rack?					
1.8.5	Problems of excessive debris and/or inadequate cleaning?					
1.8.6	Any deterioration of trash rack (rust, corrosion, and damaged blades)?					
1.8.7	Any other issues?					
G-1.9	**Trash Rack Cleaning Machines**					
1.9.1	Any problems inspecting trash rack cleaning machine?					
1.9.2	Missing or inadequate spare parts (particularly requiring regular replacement)?					
1.9.3	Any deterioration of equipment (wheel trolleys, gantry structures, operating mechanism, connecting bolts, welds, surface, paint work?)					
1.9.4	Any wear or damage to wire cables and other moving parts?					
1.9.5	Any obstructions preventing or impairing smooth operation?					
1.9.6	Missing or inadequate provision of back-up/standby power supply?					
1.9.7	Any health and safety concerns (e.g. lack of "danger" sign during maintenance)?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.9.8	Any other issues?					
G-1.10	**Pumps**					
1.10.1	Any problems inspecting pump?					
1.10.2	Any obstructions preventing or impairing smooth operation?					
1.10.3	Any deterioration of pump and associated equipment?					
1.10.4	Any other issues?					
G-1.11	**Approach b r i d g e , operation platform and cabin (for outlets):**					
1.11.1	Are the decking, girders and structural supports of approach bridge structurally sound?					
1.11.2	Is the floor of the operating platform structurally sound and safe?					
1.11.3	Is there satisfactory arrangement to prevent unauthorized entry into the control structures of the outlet?					
1.11.4	Are the structural members and joints sound and free from corrosion?					
1.11.5	When were the steel components painted last?					
1.11.6	Is the surface of steel work and paint satisfactory?					
1.11.7	Is the parapet or railing over the control tower, operating platform and approach bridge sound and safe?					
G-1.12	**Outlet**					
1.12.1	Is the air vent periodically cleaned?					
1.12.2	Are there any structural damages to the intake well?					
1.12.3	Is there any leakage observed through the well proper and the conduit concrete or masonry? If so, give details of its location and extent.					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.12.4	Is there any damage noticed to the conduit concrete ,breast wall and gate slots?					
1.12.5	Is the bye-pass valve/filling-in-valve (wherever provided) operating satisfactory? **(a)** Take operation trials of the following as provided and record the observations and defects noticed, if any. **(1)** Service gate(s). **(2)** Emergency gate(s). **(3)** Stop-log gate(s). **(4)** Sluice valves. Note- (i) The operating trial for the emergency gate shall be taken with service gate in partially open position to test the capability of emergency gate for self-closing under these conditions. The trial for the operation of the emergency gate under balanced condition of water pressure also needs to be taken (ii) To guard against the possibility of outlet gate hoist being operated forcibly after closed position of gate a “Distinctive Mark” should be insisted or check the functioning of the limit switches.					
1.12.6	Aretherevibrationsandnoisenoticedinoperationofoutletgatesatanytime? If so, are any periodical observations taken to ascertain their severity?					
1.12.7	Is the energy dissipation arrangement working satisfactorily for all the discharges? Is there any structural damage to the energy dissipation structure? If					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
	so, give details of nature and extent of damage.					
1.12.8	Is the conduit structurally sound and reasonably leak proof? If not, give details of nature and extent of the defects.					
1.12.9	Is there any seepage noticed around the conduit as ascertained from the observations of the downstream conditions? If so, is it likely to cause (In case of earth dams) erosion and piping?					
G-1.13	**Outlet Gates**					
1.13.1	Is the surface of gates and the paint deteriorated?					
1.13.2	Are the connecting bolts of rubber seals properly tightened or damaged?					
1.13.3	Do the rubber seals show signs of weathering and damage and need replacements?					
1.13.4	Are the rubber seals of sides and bottom touching the bearing surface uniformly?					
1.13.5	Do all the rollers touch the track plates?					
1.13.6	Are the rollers well lubricated?					
1.13.7	Are the stem rods for lifting the gates perfectly straight?					
1.13.8	Is the operation of outlet gates smooth? Are the actual operations of lifting and lowering of the gates and hoist mechanisms adequate and smooth?					
1.13.9	Are all the gears and hoist mechanisms well lubricated?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.13.10	Is the storing arrangement for emergency gate leaves and the stop logs in satisfactory condition?					
1.13.11	Are the seal plates / seats in sound condition?					
1.13.12	Is the full length of wire rope (wherever applicable)of the hoist in serviceable condition and free from any broken strands?					
1.13.13	Are all the nuts of connecting bolt and anchors properly tightened?					
1.13.14	Are all the lifting beams in proper working order and in levelled condition.If not, ascertain the nature and extent of problems. Do any of the mechanical or structural parts of the gate, fasteners of hoist show signs of excessive wear? If so, please give details.					
1.13.15	Is there any tendency for recurring damage to any particular component or components? If so, please give details.					
1.13.16	Is sufficient stock of spares, which need frequent replacement, maintained at the site?					
G-1.14	**River Outlet/River Sluice**					
1.14.1	Is the overall condition of river outlet works/river sluices satisfactory? Is the operation of the gate (Service/Emergency/Stop-log) satisfactory as ascertained by taking operating trial? If not, indicate the defects noticed.					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.14.2	Are the trash racks (wherever provided) cleaned before monsoon?					
1.14.3	Is there excessive silting on the upstream of the sluice?					
1.14.4	When were the gates last opened for desilting, etc.?					
1.14.5	Please indicate the approximate quantity of the leakage through the gates, if any.					
1.14.6	Is there any seepage or leakage through the conduit surface?					
1.14.7	Is there any damage to the upstream and downstream convergence of the conduit?					
1.14.8	Is the condition of energy dissipation arrangement satisfactory? If not, indicate nature and extent of damage. Is there any retrogression noticed in the downstream channel? If so, give details of nature and extent of damage.					
H-1	**Access Road**					
H-1.1	**General Condition**					
1.1.1	Any problems ensuring security of dam site (including gates and fencing)?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.2	Is there a properly constructed and well maintained all weather access road to the dam site?					
1.1.3	What is the type of the pavement of the access road and its condition?					
1.1.4	Are there properly constructed and well maintained access road arrangements to the following components for inspection, maintenance and repairs? Top of Dam Spillway Gates and hoisting arrangement Drainage gallery, adits and exits Bridge structure Downstream stilling basin Junction and abutments Outlet control tower Outlet gates Toe of earth dam, downstream drainage arrangements and berms. All saddle dams.					
1.1.5	What is the general condition of all the masonry structures on various access roads?					
1.1.6	Are all the structures on the access roads adequately safe for allowing passage of plant machinery for emergent repairs?					
1.1.7	Any obstructions along or at entrance to access road (temporary or long-term)?					
1.1.8	Any slope stability issues (road embankment or adjacent slopes)?					
1.1.9	Profuse growth of weeds/grass on or in vicinity of access road?					
1.1.10	Any drainage problems (standing water on or adjacent to road)?					
1.1.11	Any other degradation to road surface (ruts, potholes, cavities, cracking)?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.12	Any other issues?					
I-1	**Instrumentation**					
I-1.1	**General Condition**					
1.1.1	Are all the instruments installed accessible? (Attach separate list). Are all the locations properly lighted, ventilated and adequately protected from possibilities of damage?				As per Annexure-I	
1.1.2	Any problems inspecting instrument (obstructed/unsafe access)?					
1.1.3	Is the instrument vulnerable to damage or theft (inadequate protection)?					
1.1.4	Any problems ensuring correct functioning of instrument (lighting, ventilation)?					
1.1.5	Any evidence of degradation to condition of instrument (rusting, vandalism)?					
1.1.6	Are all the instruments in working order? Ascertain the cases of instruments going out of order and indicate.					
1.1.7	Are all the registers of observations posted up-to-date? Please take test observations and initial the register.					
1.1.8	Are all the plotting of the instrumentation data completed up-to-date? Are sufficient stocks of spares, gauges, master gauges, stationary items etc., maintained at the site for uninterrupted data collection?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.9	Operator or public safety issues?					
1.1.10	Any other issues?					
I-1.2	**Communication Facilities**					
1.2.1	Are following facilities available at dam site? (1) Wireless Telephone / mobile/Fax/Internet					
1.2.2	Any other issue (please indicate part, location, etc., as necessary)					
K-1	**Emergency Preparedness**					
K-1.1.	**Emergency Action Plan**					
1.1.1	Is the Emergency Action Plan (EAP) prepared for the dam as per the national guidelines? If not, the expected date of preparation of guidelines					
1.1.2	When EAP was last updated?					
1.1.3	If not, are any dam staff unaware or insufficiently conversant with the EAP?					
1.1.4	Any concerned authorities unaware or insufficiently conversant with the EAP?					
1.1.5	Are communication directories/contact details and other dynamic information are being updated annually?					
1.1.6	Any problems accessing or operating the communication/ warning system?					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.7	Are inundation maps updated and available to concerned authorities?					
1.1.8	Are the concerned authorities informed about the system of emergency reporting procedures and warning?					
1.1.9	Are available safety spots on the downstream of the dam identified and made known to the concerned authorities? Are adequate warning devices and facilities provided at the dam?					
1.1.8	Are proper arrangements made for security of the dam and preventing cases of unauthorized trespass, vandalism and sabotage to the dam works?					
1.1.9	Date of last annual stakeholder consultation meeting along with mock drill exercise conducted					
1.1.10	Does the EAP disseminated to all the concerned stakeholders?					
1.1.11	Any other issues?					
K-1.2	**Inspection of Records**					
1.2.1	Whether following Dam Safety Documents are prepared and approved by the competent authority? I. As Built Drawings II. EAP III. Completion Report IV. Data Book V. O and M Manual					

S. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory/Poor/Fair/ Satisfactory)
		Y	N	NA		
1.2.2	Are the relevant documents reviewed and updated from time to time?					
1.2.3	Are all the members of the maintenance staff adequately trained and fully conversant with their responsibilities concerning. **(a)** Designer's Operation Criteria. **(b)** Standing Operating Procedures. **(c)** Maintenance and Vigilance Procedures of the dam. **(d)** Maintenance and operation of all control equipment's. **(e)** Reservoir Operation Schedules, Gate Operation Schedule **(f)** Maintenance and Operation of all instruments. **(g)** Identification of signs of deficient behaviour. **(h)** Reporting Procedures of emergency situations. **(i)** Emergency repairs					
L-1.1	Inspection Photographs					
1.1.1	Information to be furnished as per Annexure – II					

[a]Respond either yes (Y), no (N) or not applicable (NA).

[b]Condition: Please rate the condition as either Satisfactory, Fair, Poor or Unsatisfactory as described below:

1. Satisfactory - No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.
2. Fair - No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.
3. Poor - A dam safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary. Poor may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency. Further investigations and studies are necessary.
4. Unsatisfactory - A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.

Part 2b – Consolidated Dam Health Status Report:

SN	Observations/Significant Deficiencies Noticed	Remedial Measures Suggested
1.		
2.		
3.		
4.		
5.		
..		
..		
10.		

Overall condition of dam based on above inspection – Unsatisfactory/Poor/Fair/Satisfactory (tick appropriate)
Overall Safety Category* of the Dam -

*Category I– deficiencies which may lead to failure;
Category II – major deficiencies requiring prompt remedial measures;
Category III – minor remedial measures which are rectifiable during the year

Name of Official(s) and Signature(s)

Appendix-II: Checklist of Various Instruments Installed on Large Dams

Name of Dam:

Location:

Sl. No.	Name of Instruments	Nos.	Location	Since when installed (Month/ Year)	Whether in working condition (Yes/No)	Date last calibration / Date for next calibration	Observations maintained (Yes/No)	Agency responsible for data collection and processing	Analysis of data done at field level (Yes/No)	Data sent to DSO regularly? (Yes/No)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
HYDRO-METEOROLOGICAL INSTRUMENTS											
1.	Raingauge on Dam										
2.	Raingauge in the Catchment										
3.	Pan Evaporimeter										
4.	Wind Velocity Recorder										
5.	Wind Direction Recorder										
6.	Wave Height Recorder										
7.	Wet and dry bulb Thermometer										
8.	Barometer										

Sl. No.	Name of Instruments	Nos.	Location	Since when installed (Month/ Year)	Whether in working condition (Yes/No)	Date last calibration / Date for next calibration	Observations maintained (Yes/No)	Agency responsible for data collection and processing	Analysis of data done at field level (Yes/No)	Data sent to DSO regularly? (Yes/No)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
9.	Thermometers for air Temp.										
10.	Thermometers for Reservoir Water Temp.										
11.	Automatic Weather Station										
12.	Reservoir level gate **(i)** Staff gate **(ii)** Automatic										
13.	Other Hydro-meteorological Instruments, if any (i) . (ii) . (iii) .										
GEO-TECHNICAL INSTRUMENTS											
1.	Piezometers (i) Stand pipe (ii) Casagrande (iii) Twin Tube (iv) Vibrating wire										

Sl. No.	Name of Instruments	Nos.	Location	Since when installed (Month/ Year)	Whether in working condition (Yes/No)	Date last calibration / Date for next calibration	Observations maintained (Yes/No)	Agency responsible for data collection and processing	Analysis of data done at field level (Yes/No)	Data sent to DSO regularly? (Yes/No)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
2.	Uplift pressure cell (i) For permeable foundation (ii) For Rock foundation										
3.	Strain Gauge (i) Mechanical Strain Gauge (ii) Electrical Strain Gauge										
4.	Strain Meter (i) Vibrating wire										
5.	Thermometers (i) Resistance (ii) Vibrating Wire										
6.	Stress Meter (i) Mechanical (ii) Electrical										
7.	Seepage Measurement (i) V-Notch (ii) Other devices										
8.	Automation (i) Data logger										

Sl. No.	Name of Instruments	Nos.	Location	Since when installed (Month/ Year)	Whether in working condition (Yes/No)	Date last calibration / Date for next calibration	Observations maintained (Yes/No)	Agency responsible for data collection and processing	Analysis of data done at field level (Yes/No)	Data sent to DSO regularly? (Yes/No)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	(ii) Data Acquisition system (iii) Computers										
9.	(i) Plumb Bob – Direct (ii) Plumb Bob – Inverted (iii) Detachable Gauges for Surface Displacement (iv) Joint meter for internal joint movement (v) Tilt Meter (vi) Foundation Settlement Deformation Meter (vii) Inclinometer										
10.	Other Geotechnical Instruments, if any (i) . (ii) . (iii) .										

Sl. No.	Name of Instruments	Nos.	Location	Since when installed (Month/ Year)	Whether in working condition (Yes/No)	Date last calibration / Date for next calibration	Observations maintained (Yes/No)	Agency responsible for data collection and processing	Analysis of data done at field level (Yes/No)	Data sent to DSO regularly? (Yes/No)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GEODETIC INSTRUMENTS											
1.	Total Station										
2.	Survey Markers										
3.	Settlement Plates										
SEISMIC INSTRUMENTS											
1.	Seismograph										
2.	Accelerograph										

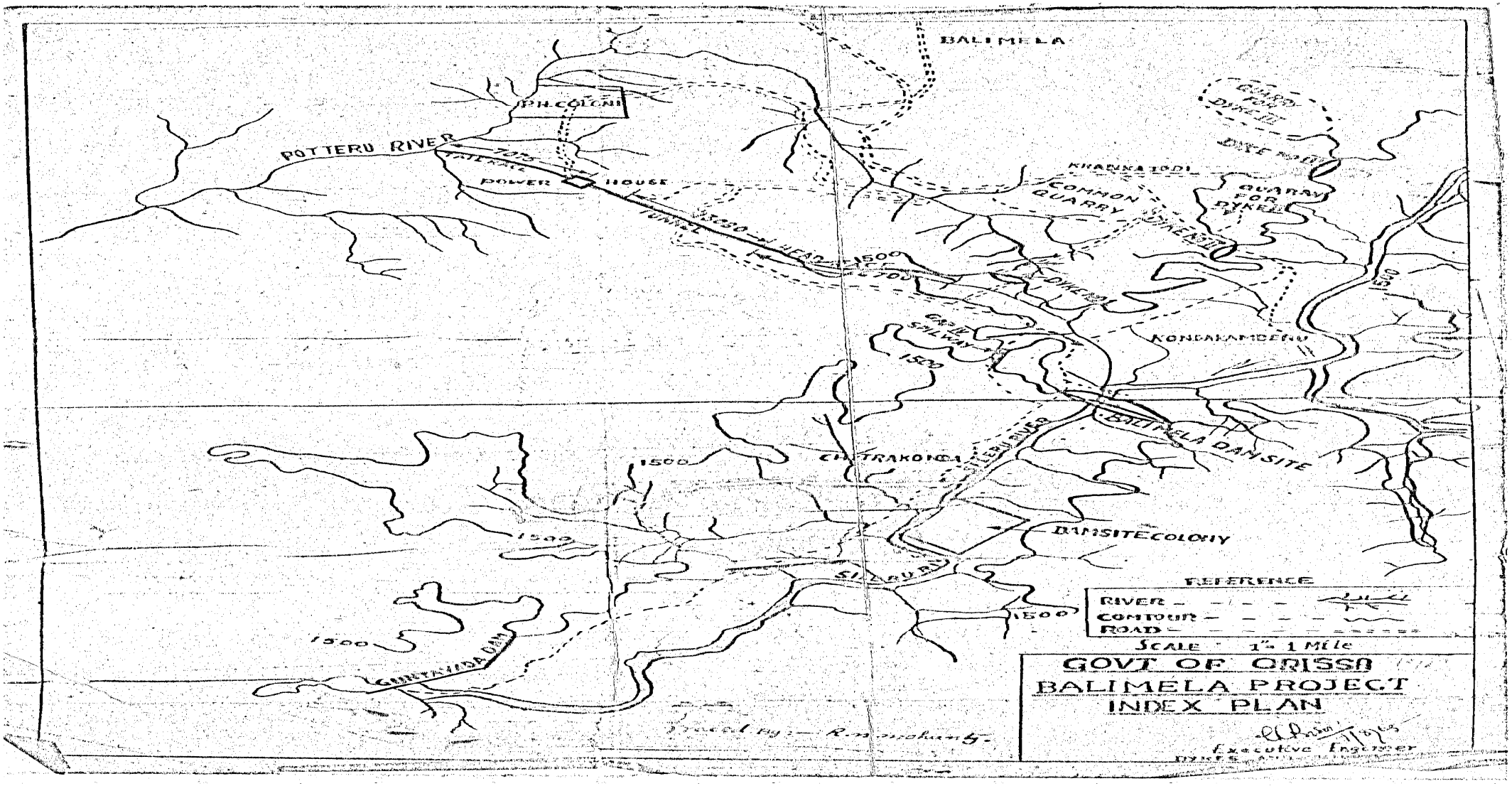
Appendix III: Summary Table for Annual O&M Budget

NO.		BUDGET ITEM	PREVIOUS YEAR COST (Rs)	CURRENT YEAR BUDGET (Rs)	REMARKS
		A. ESTABLISHMENT			
1		SALARY OF REGULAR STAFF INCLUDING ALL OTHER BENEFITS			
2		TRAVEL EXPENSES			
3		OFFICE EXPENSES			
4		MOTOR VEHICLE EXPENSES			
5		MAINTENANCE OF OFFICE & COLONY COMPLEX			
		SUB-TOTAL – A			
		B. WORKS			
1		CIVIL WORKS			
1.1		CONCRETE / MASONRY DAM			
1.2		EARTHEN DAM			
1.3		INTAKE & OUTLETS IN EARTHEN DAMS/ ABUTMENTS			
1.4		SLUICES IN CONCRETE / MASONRY DAMS			
1.5		APPROACH / INSPECTION ROADS WITHIN DAM AREA			
2		HYDRO-MECHANICAL WORKS			
2.1		SPILLWAY GATES & HOISTS			
2.2		SPILLWAY STOP-LOG & GANTRY CRANE			
2.3		OUTLETS IN EARTHEN DAMS - SERVICE / EMER-			

NO.		BUDGET ITEM	PREVIOUS YEAR COST (Rs)	CURRENT YEAR BUDGET (Rs)	REMARKS
		GENCY GATES, HOISTS& GANTRY CRANE			
2.4		SLUICES IN CON-CRETE / MASONRY DAMS – SERVICE / EMERGENCY GATES, HOISTS& GANTRY CRANE			
3		ELECTRICAL WORKS			
3.1		ELECTRICAL FIT-TINGS, MOTORS, CONTROLS FOR ALL GATE HOISTS			
3.2		POWER SUPPLY LINES			
3.3		ELECTRICAL FIT-TINGS ON DAM TOP, DAM GALLER-IES, ETC.			
3.4		STANDBY POWER / DIESEL GENERA-TOR			
3.4		REMOTE CON-TROL/CCTV			
4		INSTRUMENTATION			
5		MISCELLANEOUS WORKS			
		SALARY OF WORK-CHARGED STAFF INCLUDING ALL BENEFITS			
7		MATERIALS TO BE STORED BEFORE MONSOON			
		SUB-TOTAL – B			
8		CONTINGENCY (10%) ON SUB-TOTAL OF A & B			
9		TOOLS & PLANTS			
		SUB-TOTAL- C			
10		TOTAL ANNUAL COST			

Appendix-IV: Basic Drawings of the Dam & Spillway

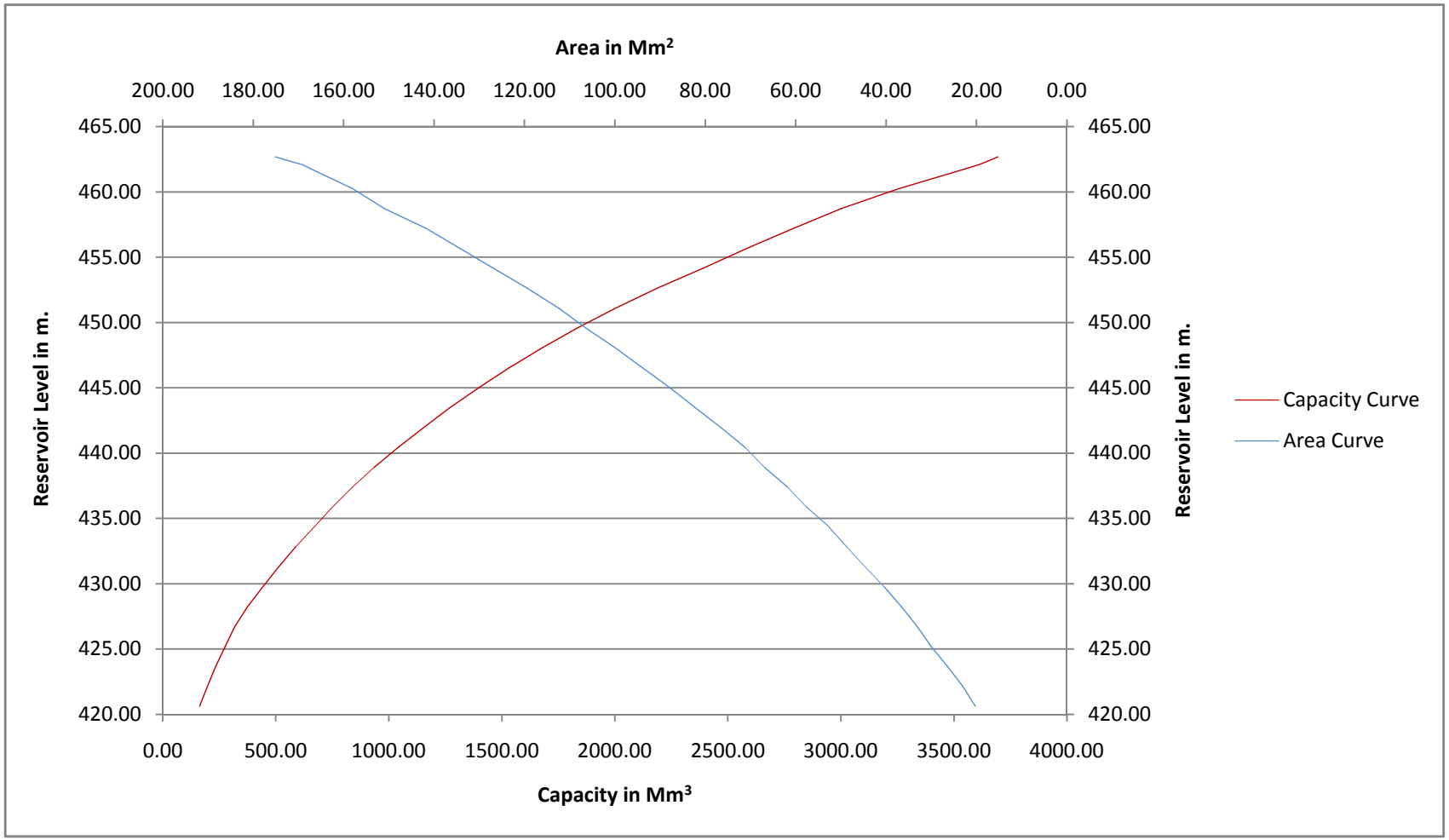
1. Index Map (Clear Drawing is under preparation. It will be replaced soon.)



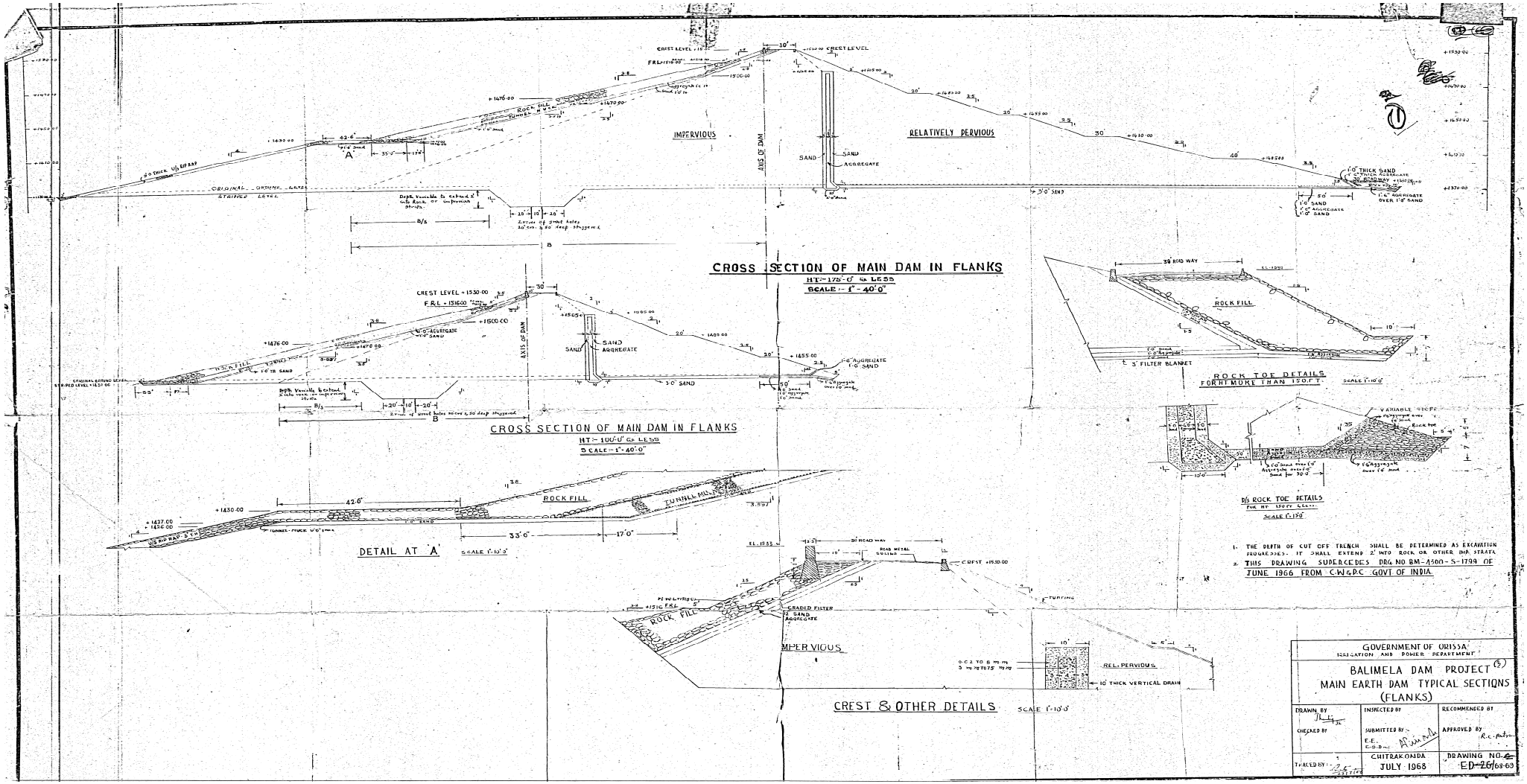
2. Google Map


Balimela Dam
Legend
Balimela Reservoir
Balimela Reservoir
Dyke-III
Dyke-II
Dyke-I
Spillway
Balimela Dam
Google Earth
Image © 2019 CNES / Airbus
Image © 2019 Maxar Technologies
Image Landsat / Copernicus
N
10 km

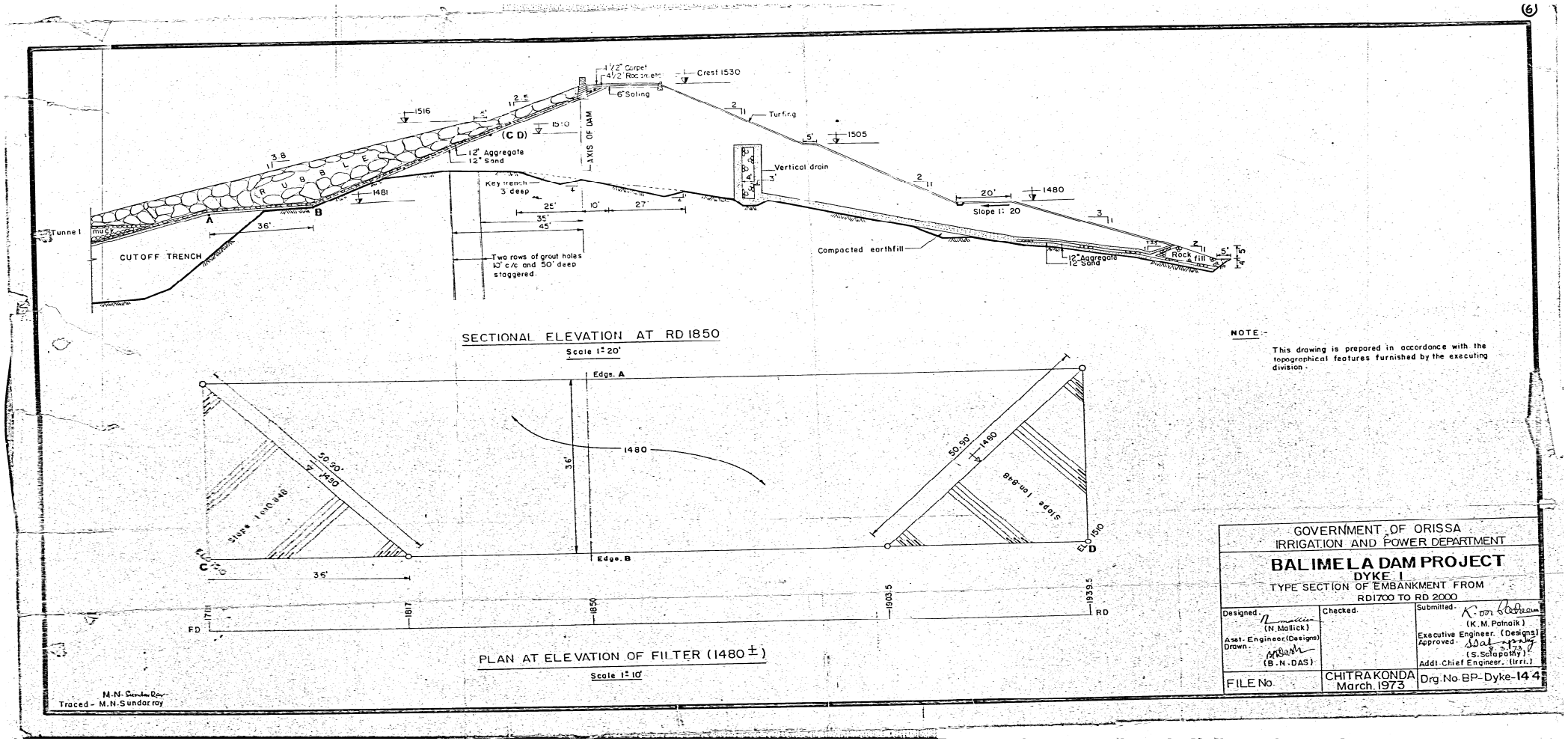
3. Area-Capacity Curve



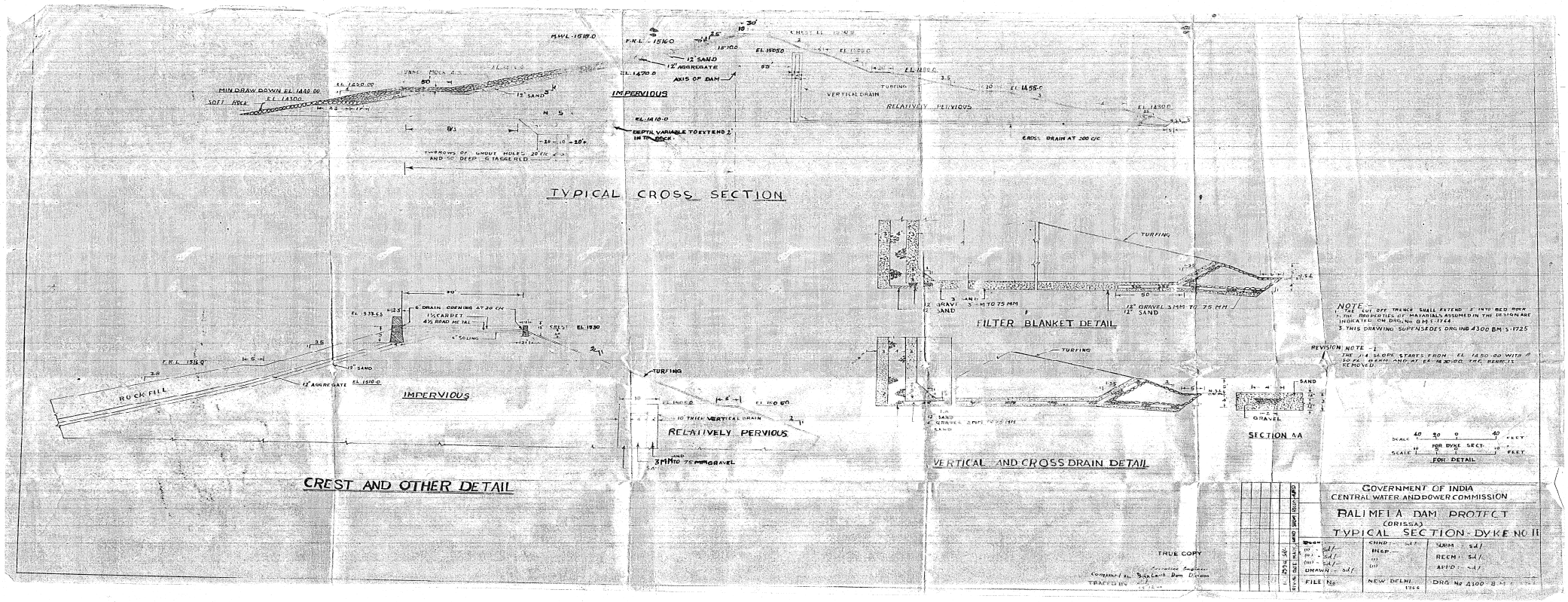
4. Cross Section of Dam (Clear Drawing is under preparation. It will be replaced soon.)



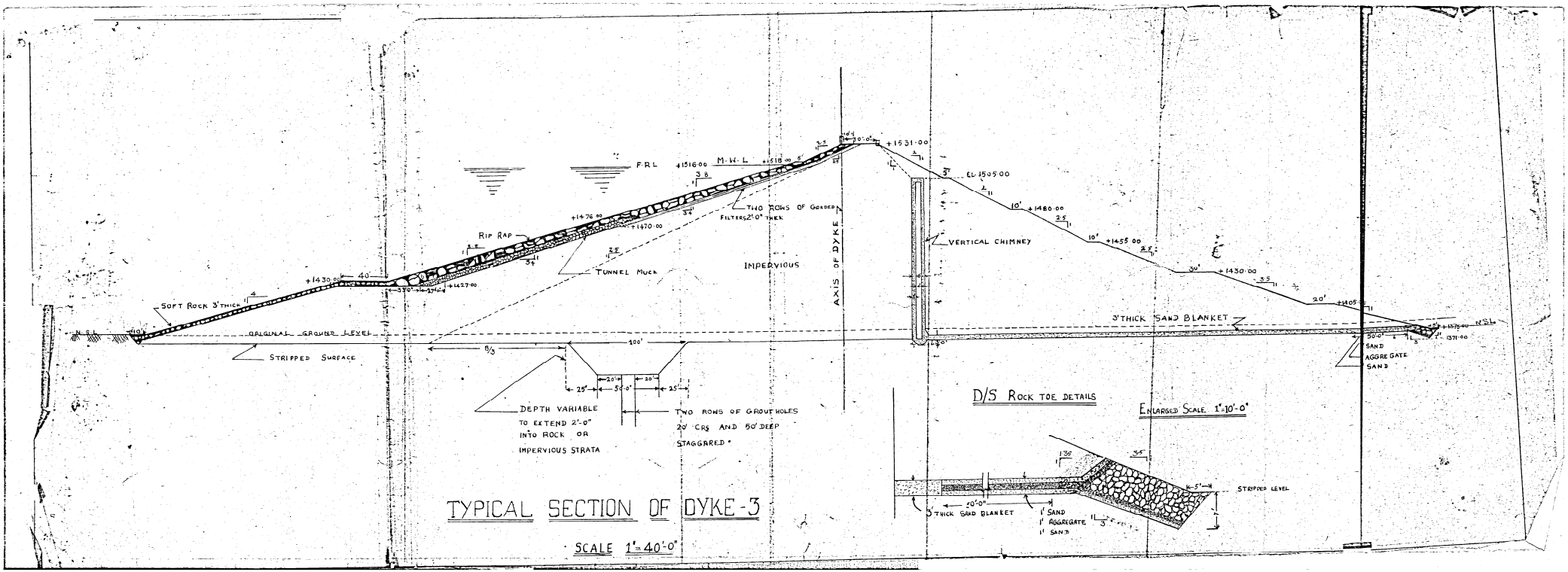
5. Cross section of dyke 1 (Clear Drawing is under preparation. It will be replaced soon.)



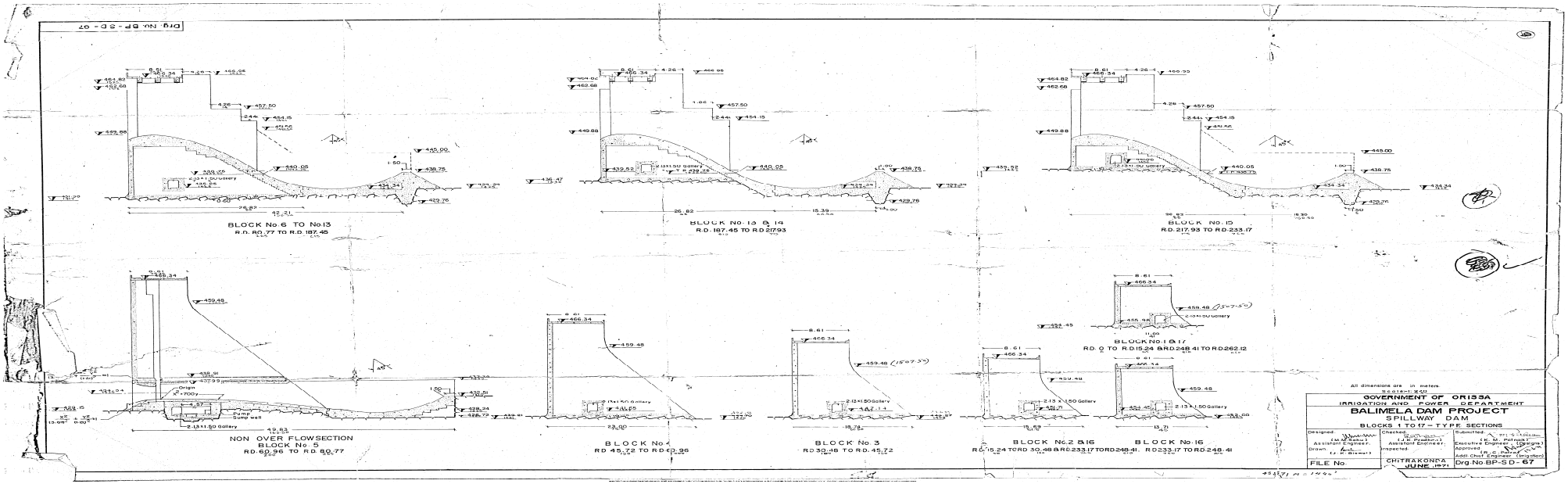
6. Cross section of Dyke 2(Clear drawing is under preparation. It will be replaced soon.)



7. Cross section of Dyke 3 (Clear drawing is under preparation. It will be replaced soon.)



8. Spillway Section(Clear drawing is under preparation. It will be replaced soon.)



PHOTOGRAPHS OF BALIMELA DAM, CHITRAKONDA:

MAIN EARTH DAM

SPILL WAY OF BALIMELA DAM

TOP ROAD OF BALIMELA DAM

SLUICE BLOCK AT NOF SECTION

D/S APRON OF SPILLWAY

RESERVOIR AREA WITH SPILLWAY

SLUICE OF BALIMELA DAM

D/S OF SPILLWAY AND SLUICE