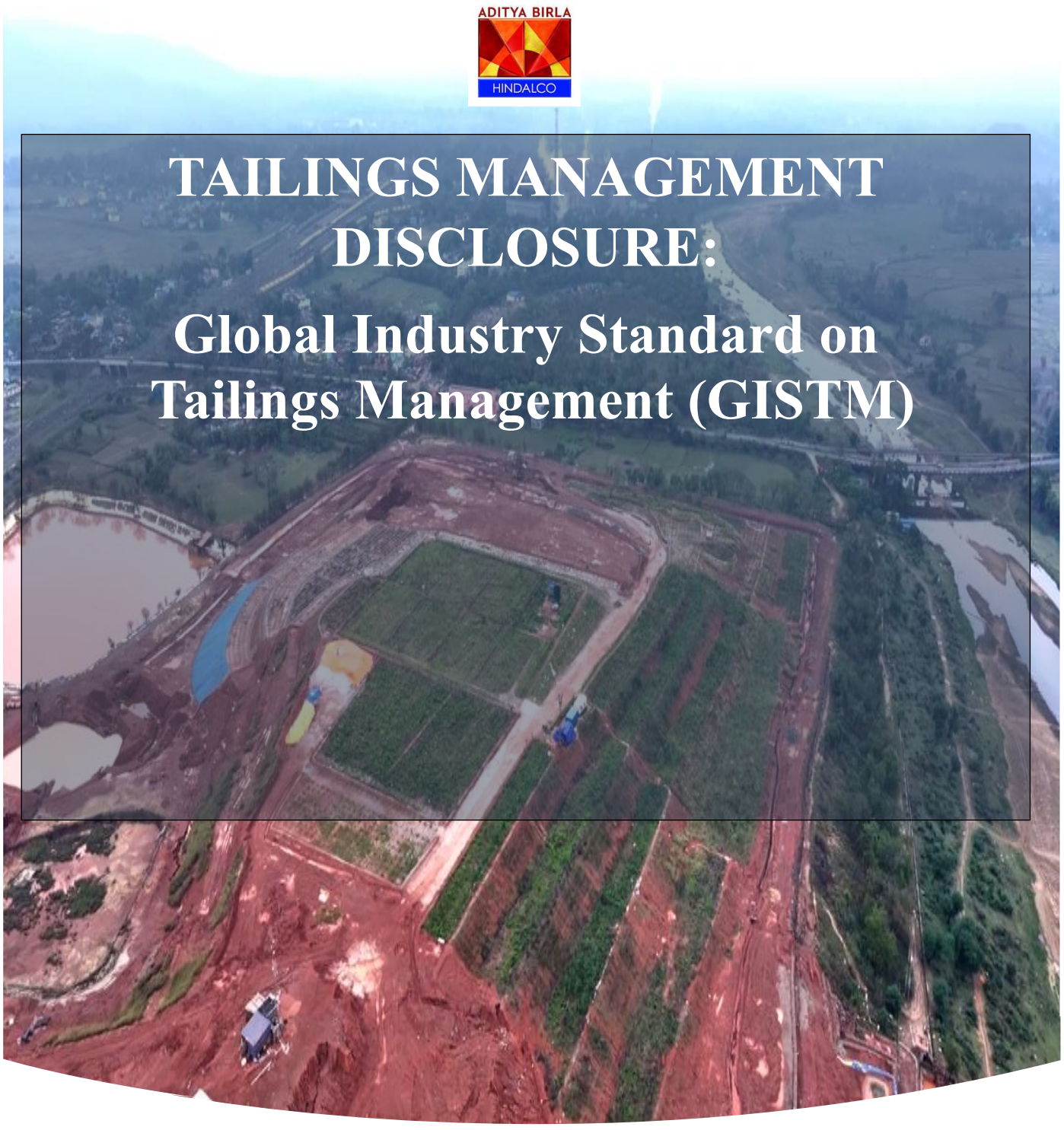


TAILINGS MANAGEMENT DISCLOSURE:

Global Industry Standard on Tailings Management (GISTM)

Hindalco Industries Ltd

2023-24

Introduction

At Hindalco, we believe that we have a responsibility to extract the full value from the minerals and materials we produce in the safest and most sustainable way possible. Our tailings storage facilities are regulated, permitted, operated and have been managed for many years by complying with local laws, regulations, internal standards, and other requirements.

We follow highest engineering standards, best-in-class safety and environmental management practices and reviews are conducted by reputed independent third parties. We religiously strive to cause no harm to nature and people and are continuously evolving our systems and processes. Our commitment to conform to GISTM is an opportunity to continuously improve our already comprehensive tailing management practices and provide a greater level of transparency.

This document is published in order to meet the 15th Principle of GISTM that suggests to *Publicly Disclose and provide access to Information about the Tailings Facility to support Public Accountability.*

Scope for GISTM adoption and disclosure

All Bauxite Residue Disposal Areas (BRDA), also called Red Mud Disposal Areas (RMDA) are included in the purview of this public disclosure.

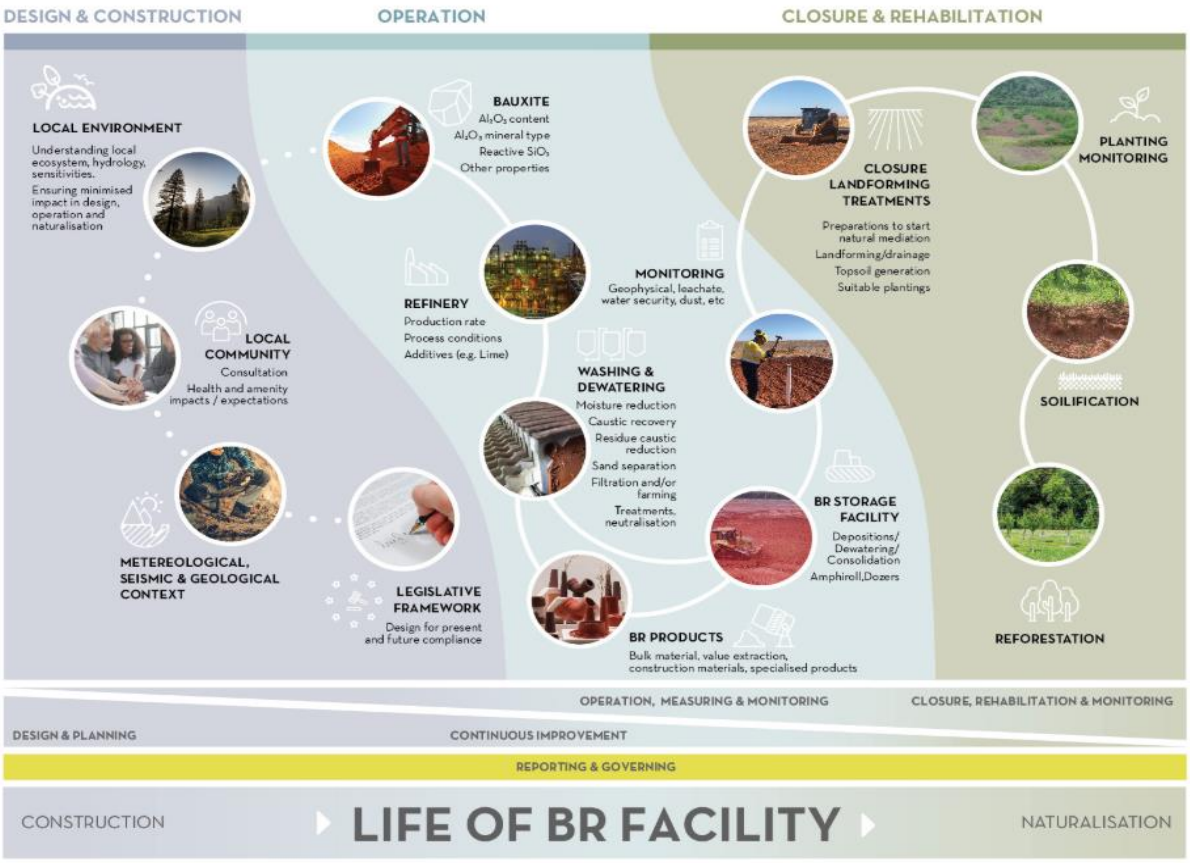
Each of our refineries have dry stacking facilities. Details of individual DSFs are captured and disclosed in the tailings inventory sheet (Hindalco Tailings Inventory Sheet) Mine overburdens only have temporary storage and are used in closure and progressive rehabilitation.

Tailings Management Governance

At Hindalco, we have systems and processes in place to manage waste disposal facilities effectively and efficiently throughout the lifecycle from initial site selection and design, through construction and operation, to eventual decommissioning and closure.

Each of the tailing facilities are designed and constructed to the highest engineering standards and meet regulatory requirements. The ABG Technical Standard on Solid and Hazardous Waste Management outlines the requirements that need to be planned and established in relation to segregation, collection, storage, transportation, treatment, and disposal, leading to environmentally-sound management of hazardous and non-hazardous waste.

Mining Waste Management Guidance Note discusses the management of different types of wastes that are generated from mining sector operations, relevant regulatory requirements, international benchmarks, and industry good practices. A Sustainable Mining Charter is developed to drive sustainable mining practices across the life of the mines and help move towards adding net value to the ecosystem.



Lifecycle of a BR (Red Mud) facility (Source: BR Management guide by IAI)

Governance of the tailings sites refers to the processes, procedures and communication channels that are put in place to ensure the effective management, oversight, and accountability for tailings. The Tailings Governance Framework focusses on the key elements of management and governance necessary to maintain the integrity of TSFs and minimise the risk of catastrophic failures. The key elements of this TSF governance framework are:

1. Accountability, Responsibility and Competency
2. Transparency
3. Planning and Resourcing
4. Communication & stakeholder engagement
5 Risk Management
6. Change Management
7. Emergency Preparedness and Response
8. Review and Assurance

The Tailings Management System includes operation, maintenance, and surveillance (OMS) activities, information/data management, review system and Emergency preparedness and response plan (EPRP). Salient features of the tailing management system at Hindalco are discussed:

Site's Civil/operations team

Engineer of Record

RTFE (Responsible Tailing Facility Engineer)

Accountable Executive

Internal Standards
- Tailings Management Policy
- Waste Magement Technical Standard (ABG/SUST/TS/03, V-3, ABG/SUST/GN/53, V-1)
- Site specific SOPs, SWIs, Operational manuals

Regulations
- CPCB Red Mud Guidelines, 2023

International Standards
- GISTM
- ICMM's Tailing Management Standard &Tailing Management Good Practice guide
- Sustainable BR Guidance by IAI

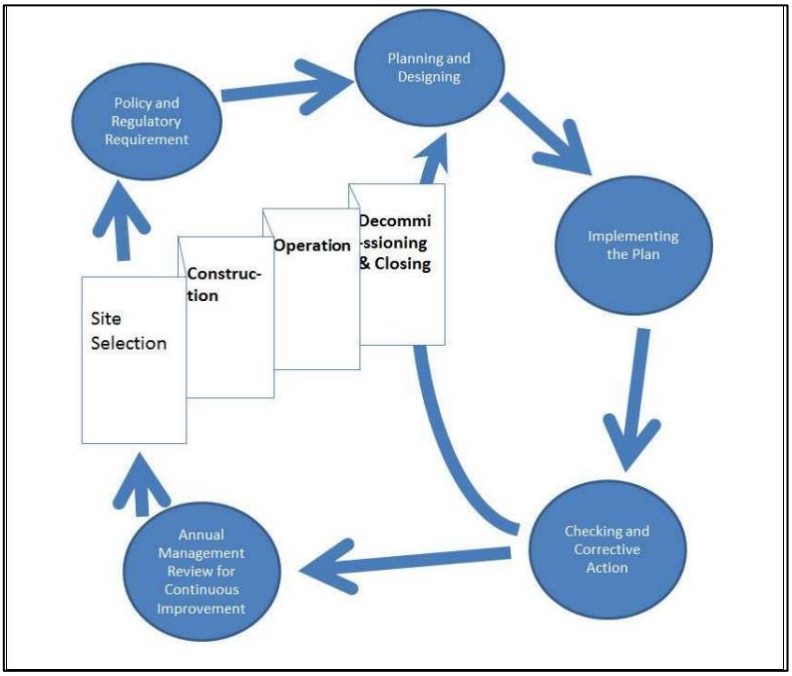
Internal Audit (Every 6 months) →Engineering firm audit (every year) → Independent External Audit (Every three years)

However, the frequency of audits can vary, specific to the site and its consequence classification category.

Continual Improvement

Our tailings management system is based on a management philosophy of Plan-Do-Check-Act cycle for attaining continual improvement in waste management performance across the different phases involved in the mining life cycle.

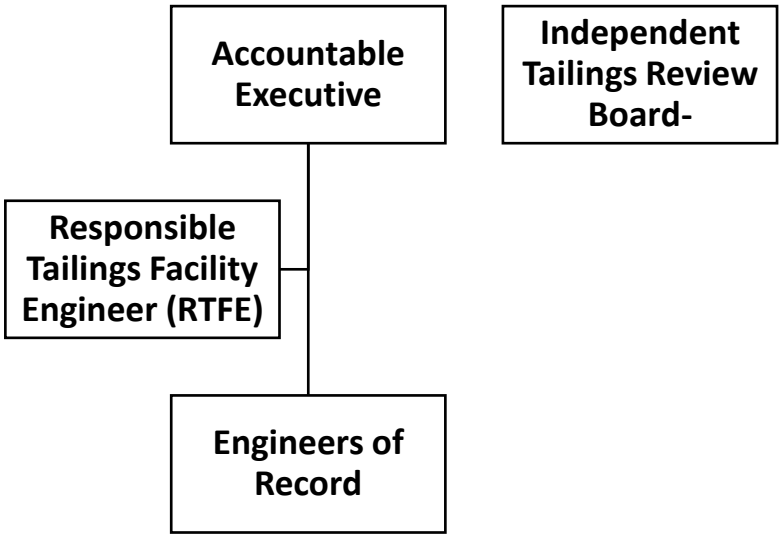
At each stage in the mining waste management facility life cycle, implementation of the management framework requires that actions be planned within the context of policies and commitments, implemented in accordance with plans, checked and corrected, and subjected to management review.



PDCA cycle for the tailing storage facilities

Clarity of role is critical to the safe management of tailings. From defining policy at the corporate level to implementing regular measurements in the field at the technician's level, and for every task in between, clear roles and responsibilities enhance individual ownership of

assigned scope. In accordance with the good practices guidance of GISTM and ICMM, we have formed tailings management teams at each of our refineries. Functions and responsibilities of Accountable Executive, Responsible Tailings Facility Engineer (RTFE), Engineer of Record (EOR) and Independent Tailings Reviewer/ Independent Tailings Review Board are defined.



Tailings Management Organisation structure

We have established mechanisms that promote cross-functional collaboration to ensure effective data and knowledge sharing, communication and implementation of management measures to support public safety and the integrity of the tailings facility. Environment and sustainability, operations, safety and enterprise risk management teams plays crucial and distinctive roles.

Community Engagement

Community engagement related to tailings management is integrated with broader community engagement activities. Community engagement helps to build trust and prevent the potential for conflicts with communities. It can help to ensure that communities understand the risks associated with tailings facilities, and how the operator is managing those risks, including the emergency preparedness measures that are in place. As an intrinsic part of establishing any Category A project in India, public hearing was conducted for each of the refineries and public concerns were addressed.

Community benefit is a factor in the identification of post-closure land-use objectives and closure development plans as well. At Muri, RMP 2 (rehabilitated in 2009) is used as a recreation spot by public. An 8-acre bio-park that will be a pleasant recreational spot for local residents is planned on RMP 3-4 area. Our emergency preparedness measures are focused on no-net harm to vulnerable communities.

Communication

Processes are established and implemented for two-way communication for personnel who have accountability or responsibility for tailings management, including reporting of significant information and decisions to senior management, regulators, and communities, as appropriate. In addition, mechanisms like Whistle Blower Policy is in place to protect from

retaliation, employees and contractors who report problems or identify opportunities for improving tailings facility management.

https://www.hindalco.com/upload/pdf/hindalco-whistle-blower-policy-19.pdf

Specifically, per the Standard, an operator is required to publish and regularly update information on its commitment to safe tailings facility management, governance framework, and its policies, or approaches to the design, construction, monitoring and closure of tailings facilities. We have published our Tailings Management Policy adopted in 2024, which is endorsed by the Board of Directors.

Grievance Mechanism

We have established an effective operational-level, non-judicial grievance mechanism that addresses complaints and grievances of project-affected people relating to the tailings facility. Village-level committees act as a interface between the company and the community to register their grievances and requirements.

Regulatory Requirements

In India, as per the newly-notified Hazardous Waste Management Rules 2016, the high-volume low effect wastes such as red mud and ore beneficiation rejects are excluded from the category of hazardous wastes. A range of information to meet various legal requirements is compiled and shared with regulatory authorities (CPCB/SPCB).

We are cognisant to respond in a systematic and timely manner to requests from interested and affected stakeholders for additional information material to the public safety and integrity of a tailings facility. In case the request for information is denied, we provide an explanation to the requesting stakeholder. We commit to cooperate in credible global transparency initiatives to create standardised, independent, industry-wide and publicly accessible databases, inventories or other information repositories about the safety and integrity of tailings facilities.

Stability Assessment

Dam Safety Review (DSR) or stability assessment is the independent review of the safety of a tailings facility covering technical, operational and governance aspects, conducted by an independent technical specialist according to established best practices. The major physical parameters for stability assessment are the angle of internal friction, cohesion, CBR, unit weight, optimum moisture content, and major operating parameter is FoS (Factor of Safety). Stability of the slope, liner system and temporary barriers need to be checked by geotechnical experts. There is a Standard Work Instruction (SWI) covering the steps related to slope stability analysis, geotechnical characterisation of the dump, site control, and monitoring of the area.

A breach analysis for the tailings facility using a methodology that considers credible failure modes, site conditions, and the properties of the slurry should be conducted. The results of the analysis shall estimate the physical area impacted by a potential failure. When flowable materials (water and liquefiable solids) are present at tailings facilities with Consequence Classification of 'High', 'Very High' or 'Extreme', the results should include estimates of the physical area impacted by a potential failure, flow arrival times, depth and velocities, and depth of material deposition.

Risk-informed decision-making is underpinned by risk assessment, which comprises a series of steps: risk identification, risk analysis, and risk evaluation. In turn, risk-informed decision-making improves and informs risk management (risk reduction) activities.

Risk management includes implementation of risk reduction measures, surveillance and review, risk communication, and risk recording and reporting. assessing risk involves consideration of both the potential consequences of an event and the likelihood of that event occurring.

Assessment of failure involves aspects like 1) Static Liquefaction of the Stacked Material (2) Dynamic Liquefaction of the Stacked Material (3) Seismic Effect (4) Slope Failure (5) Erosion Induced Slope Failure (6) Slope Instability (7) Foundation Failure (8) Overtopping (9) An estimation of the probability of the failure mechanisms that may occur (10) An indication of the route and geometry of a flow of water and liquefied Red Mud as a frictional granular flow following a breach in the DSF or SP or SNLP. (11) Details of procedures to mitigate the risk of the failure scenarios identified.

Monitoring & Surveillance mechanism

Ensuring the long-term stability and performance of tailings impoundments is paramount for mitigating risks and maintaining environmental safety. Routine monitoring and preventive maintenance play a crucial role in early issue detection, preventing structural failures, and controlling costs. All tailings storage facilities and associated pumping and pipeline systems should be inspected on a daily basis at a minimum. Observations should be recorded. -Any extraordinary observations or maintenance requirements must be documented, and appropriate action taken, including reporting to regulators and the community.

1. Visual Observation:

Regular visual inspections of the tailing's embankment are fundamental for identifying distress signals, Cracking, wet spots on the downstream face, and critical settlements indicate potential issues.

2. Instrumentation:

Piezometers, pressure gauges, and inclinometers should be strategically placed in the embankment and retention walls to monitor critical parameters affecting stability. Seepage

flows downstream can be monitored, collected, and measured, providing crucial data for evaluating potential piping issues.

3. Embankment Movements:

Simple methods like optical targets aid in rapid identification of horizontal movements. Advanced devices such as slope indicators, measuring slopes in two directions, offer precise calculations of horizontal movements. Inclinometers should be installed at strategic locations for real time monitoring of any surface/subsurface movements.

4. Surface Settling

Levelling or temporary benchmarks assist in measuring surface settling, allowing for the detection of any changes over time.

5. Monitoring Frequency:

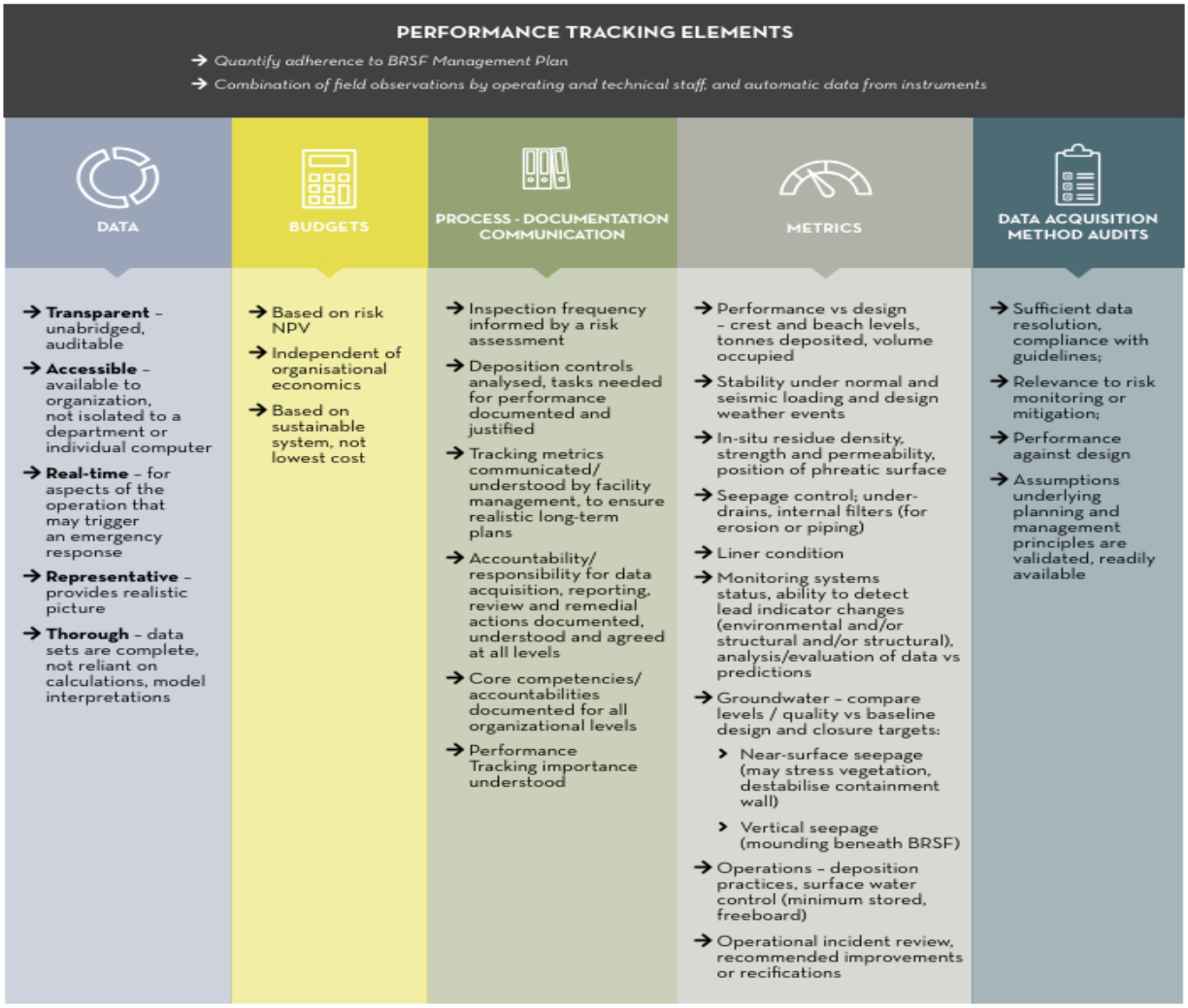
The frequency of monitoring should align with the critical nature of parameters and previous observations. Frequent observations during and immediately after construction phases are vital, with potential extensions during stable conditions. Unusual events such as heavy runoff, floods, or seismic activity may warrant additional measurements.

6. Long-Term Maintenance:

Continuous inspection and maintenance are imperative throughout the dam's life. Changes in crest levels, water levels, embankment slopes, and material characteristics must be tracked. Liners, drainage systems, and seepage can be evaluated through monitoring wells, ensuring overall dam integrity.

Performance Review

The performance of the tailing's storage facility should be reviewed annually by the Engineer of Record or an independent geotechnical engineer experienced in tailings management. These reviews typically involve visual inspection, review of construction and operation practices and review and assessment of the instrumentation monitoring data. The review should critically assess the actual performance against the design and make recommendations for improvements and risk mitigation actions. Also, monitoring of both the physical structure and water quality of leachate/ runoff during operation and decommissioning phases should also be done. Deviances from the design intent should be recorded.



Source: Sustainable BR by IAI

Operation & Maintenance Manual

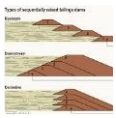
An operating manual for every tailings storage facility should be maintained. The manual should be aligned with the facility's design objectives to guide daily operation and forward operations and maintenance planning. The manual will describe, and the operators will receive training on the facility's daily operation, residue deposition procedures, water management, dust control, critical operating practices such as pump and pipeline management and facility equipment maintenance, along with reporting requirements. It covers all development phases from planning, design through construction, operation, closure and, post-closure where applicable.

Tailings Management System for new facilities

For tailings management at new facilities, incorporate the outcome of the multi-criteria alternatives analysis including the use of tailings technologies in the design of the tailings facility.

Site selection

- The area shall be located preferably on non-mineral bearing formation;
- The subsoil condition including type of soil, its permeability, compressibility and strength, etc., up to 10-15 m below the base;
- Fertile soil, subsoil having high permeability and low compressive strength should be avoided.
- Site should not be underlaid by shallow unconfined aquifers;
- Site should not be located in virgin forest, grassland or prime agricultural land



Desinging the Dump

- The area, height and slope of the waste rock dump to be designed having regard to the area of land available, the general topography of the area;
- Their outer ultimate slopes must be gentle, preferably not more than 28 degrees,
- All completed surfaces of the waste dumps should be stable and be able to resist long term erosion;

Management

- Stabilization of dumping site - Physicingal stabilisation- mainly involving a control on the height, slope, terracing; periodical compaction as per plan; provision for artificial cover
- Appropriate garland drains and drains at individual terrace should be provided to guide the rain water to the main drainage channel without wash off of the dumps.
- Appropriate retaining walls comprised of walls/stone barriers at the toe of the dumps should be provided for arresting eroded materials;

This includes developing and updating as appropriate the following systems, information and plans: — Site characterisation, Risk assessment, Multi-criteria alternatives analysis Performance objectives, indicators and criteria, Risk management plan, Documentation of the design of the tailings facility, including the design intent and basis, Water management plan, Tailings transportation and deposition plan, Closure plan, OMS manual, Emergency preparedness and response plan (EPRP), Competencies for key roles related to tailings management, Plans for managing: - Change - Conformance – Information, Construction, Resources for tailings management, Programme for reviewing tailings safety, including Independent Review.

For expansions to existing tailings facilities, investigate the potential to refine the tailings technologies and design approaches with the goal of minimising risks to people and the environment throughout the tailings facility lifecycle.

Closure of facilities

Upon completion of the operational life of the DSF or upon the exhaustion of its capacity, the DSF should be closed or capped. Designing and operating for closure requires a long-term view. Tailings facilities should be planned, designed, constructed, operated and closed on the assumption that they will be permanent landforms. Tailings facilities, designed for closure, are true future engineered landforms, intended to remain physically and chemically stable for the long-term. The cover system should be designed, constructed, and installed to achieve the following:

a) Prevent precipitation from infiltrating into the closed DSF.
b) Facilitate drainage of surface water accumulated on the cover.
c) Minimise erosion of the cover.
d) Withstand or accommodate settlement of the cover to maintain its integrity.
e) Have permeability equal to or less than that of the liner system.
f) Ensure drainage of water trapped within the DSF and allow subsidence of solids to the maximum extent possible.
g) Maintain the slope of the DSF to prevent ponding on the top or anywhere on the capped DSF.
h) Ensure the system functions with minimum maintenance for a post-closure period of 30 years.
i) Change management should remain robust as transitions occur in processes and personnel from the Operations phase to the Closure and Post-closure phases.
j) Independent review, risk assessment, operational manual and EPRP should be updated for closure and implemented to meet the requirements for the Closure and Post-Closure phases.

The approach to RMDA rehabilitation mainly follows one of two main strategies namely, (i) providing a cap or cover of soil or soil-like material to provide a plant growth medium and (ii) natural rehabilitation which refers to improving of the physical and/or chemical properties of the residue using amendments (e.g. gypsum, bio solids, or compost) followed by direct vegetation of the red mud surface. Also, key is to look for opportunities to execute progressive reclamation (when/where possible) to test closure concepts, ensure regulatory acceptance and integrate stakeholder engagement into the process.

For new tailings facilities or major expansions, the development of closure plans and performance objectives for closure and post-closure should begin during the project conception phase. The closure plan and objectives should be considered in the multi-criteria alternatives analysis conducted during the project conception phase of the tailings facility and should be a key consideration in the facility design and location, and in the technology decisions of the facility.

In contrast to the closure phase, the post-closure phase begins when the changes from the closure phase have been fully implemented, and the facility enters a period of long-term maintenance and surveillance. During post-closure phase also the accountability and responsibility should remain intact. Update the OMS manual, risk assessment, EPRP and review periodically through the post-closure phase.

Impact Assessment

A full assessment of the potential social, environmental and local economic impacts of the tailings facility and of any credible failure modes throughout its lifecycle should be undertaken, to inform the design process. It is advisable to conduct full assessment of potential impacts during design stage of the project. It should be part of Environmental Impact Assessment (EIA) conducted to obtain Consent to Establish from regulatory authorities. A socio-environmental impact assessment should be conducted for at least once during the operational phase of the facility and in case of any material change.

Mitigation of Impacts

In accordance with Guidance Principles, i.e. ABG's Environmental Policy, Hindalco's Sustainability Policy and Tailings Management Policy, each mining site shall develop management plan based on three hierarchal principles: minimise the generation of waste, re-use and recycle the waste where technically and economically feasible and prevent/control pollutants from entering the receiving environment.

Strategy	Actions
Produce less waste	Hindalco has established filter presses to reduce caustic consumption with mud and reduce mud footprint with increased solids. Usually, Plate & Frame type filter press is used in the mud filtration unit. Moisture content is less than 28% at each of our units.
Reuse & recycle of waste	109.44 %[1] utilisation of red mud is achieved by establishing multiple avenues of recycle/reuse like dispatching to cement industries, backfilling, road construction, brick manufacturing. Many innovative projects like carbonation of red mud by sequestering CO_2 into it, using red mud for construction of road, backfilling of bauxite mine voids, mixing with plastic waste to make paving blocks etc are ongoing.
Manage waste properly	Dry stacking, Conveyors for carrying red mud from decanter to filter press, covered sheds for loading, periodically stability and risk assessment, monthly environmental monitoring near the periphery, closure and rehabilitation of the pond

ICMM Tailings Management Good Practice Guide: Section 2.7.2 (Assessing Credible Potential Consequences)

[1] Excluding UAIL (utilization rate is 50.5%, including UAIL)

GISTM DISCLOSURE

15.1.b.1 : A description of the tailings facility

15.1.b.5: A description of the design for all phases of the tailings facility lifecycle including the current and final height – Refer Hindalco Tailings Inventory Sheet)

Our alumina refineries are located at Utkal, Renukoot, Muri and Belagavi. Alumina produced from these facilities is largely utilised for our internal operations to manufacture aluminium.

Excess alumina beyond our internal requirements is sold to third parties both in the form of standard alumina and specialty alumina. Details of each of the facilities are given in the Tailing Inventory Sheet.

Belagavi's Alumina plant started operations in 1969. The 1182-acre plant has become a predominantly export-oriented unit of specialty alumina and alumina hydrates for non-metallurgical applications. 477180 MT Red Mud was generated in FY 24 and 568073 MT was utilised (sent to cement industries) leading to a utilization ratio of 119.05%. It has two Red Mud Disposal Areas (RMDAs) where a legacy volume of 12.3 million MT Red mud is stored and is used as temporary storage for residue generated during ongoing operations, before dispatching to users.

Leachate & surface runoff is collected in settling ponds and recycled back into the process.

The Renukoot complex is in Sonbhadra district, Uttar Pradesh state. The plant is in operation since 1962, developed near the Rihand Dam with Son and Rihand rivers in the vicinity. 1077335 MT Red Mud was generated in FY 24 and 1101549.87 MT was utilised (sent to cement industries, brick manufacturing etc.) leading to a utilisation ratio of 102.25%. It had 11 Red Mud Disposal Areas (RMDAs), out of which only RMP 8 is active and is used as temporary storage for residue generated during ongoing operations, before dispatching to users. A legacy volume of 30 lakh MT is stored at RMP 8. RMP 3, 9 and 10 are inactive dumps with a stored quantity of 93.8 lakh MT of red mud.

Muri Works of Hindalco Industries Limited is India's first alumina refinery commissioned in 1948. Installed capacity of Muri is 450 KPTA. 809048.34 MT Red Mud was generated in FY 24 and 917166.8 MT was utilised (sent to cement industries, etc.) leading to a utilisation ratio of 113.36%. It had 4 Red Mud Disposal Areas (RMDAs), out of which only RMP 4 is active and is used as temporary storage for residue generated during ongoing operations. 68.9 Lakh MT of red mud is stored at RMP 3 and 4

Utkal Alumina International ltd. (UAIL) is a 100% subsidiary of Hindalco with a capacity of 1.5 MTPA in Rayagada district of Orissa. 2891323 MT Red Mud was generated in FY 24 and 67382.16 MT was utilised leading to a utilization ratio of 2.33%. Unavailability of cement industries in vicinity has rendered utilisation of red mud challenging for the largest refinery of Hindalco. However, UAIL is developing numerous novel avenues of utilisation like backfilling, road construction, brick manufacturing etc. It has two active Red Mud Disposal Areas (RMDAs), storing 298 Lakh MT of red mud.

Risk Assessment

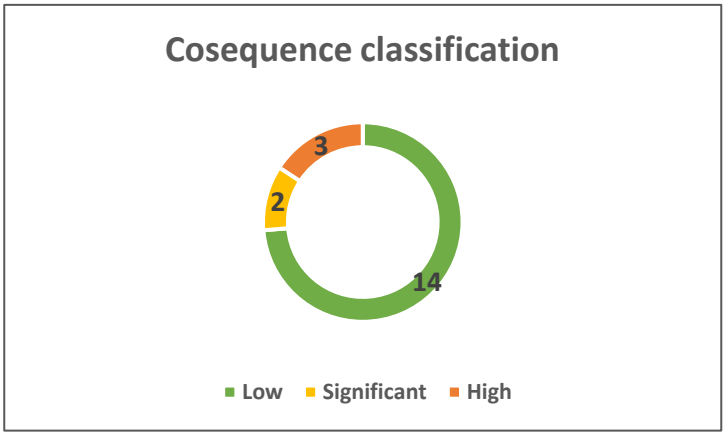
GISTM Requirement: 15.1.b.2 - Consequence Classification

GISTM Requirement: 15.1.b.3 A summary of risk assessment findings relevant to the tailings facility

Requirement: 15.1.b.6 A summary of material findings of annual performance reviews and DSR, including implementation of mitigation measures to reduce risk to ALARP

Requirement 15.1.b.9 Dates of most recent and next independent reviews

The important factors that cause instability in a slope and lead to failure are: Gravitational force, Force due to seepage of water, Erosion of the surface of slopes due to flowing water, Sudden lowering of water adjacent to a slope, forces due to earthquakes and rapid loading in short period of time. Consequence classification of the tailing facilities is done by the tailing management teams at the sites lead by the respective RTFEs. The classification is based on the GISTM consequence matrix. Out of total 19 Red mud storage facilities of Hindalco, 3 are High risk, 2 are Significant risk and others are low risk.



The geotechnical characteristics of each soil type are crucial inputs for numerical simulations and modelling to ensure a comprehensive understanding of the site's behaviour. Geotechnical parameters at each of the RMPs are regularly assessed by Genstru Consultants Pvt Ltd. External geotechnical experts like TPF and Institutes of national repute like IISc Bangalore, IIT BBSR, IIT BHU are roped in for periodic stability assessment of each of the red mud storage facilities. Dates of the most recent independent review are given in the Tailings Inventory Sheet.

TPF, Portugal & M/s Genstru had been appointed for conducting topographical survey and Stability Assessment at RMP-8 & RMP-11 at Renukoot. Boreholes are dug in both the sites upto 3m depth below the bedrock to check the soil conditions at different levels. Total 28 borewells each were dug at RMP 8 and RMP 11 and the locations of borehole for installing Piezometer & Inclinometer was decided by M/s TPF Team after analysing the Bore-log Data received from the site. Additionally, BHU did stability assessment of the active ponds in 2020. A careful evaluation of the various factors were carried out that were related to the safety of the embankment viz., final height, sign of distress, rain water cutting, drainage, proximity to habitation, dust during summer etc. According to IIT-BHU's study, an RMD is considered to be safe if the factor of safety is >1.3 in static analysis, and >1.0 in pseudo-static analysis. The FoS values obtained indicate that RMP 8,9,10 and 11 are stable.

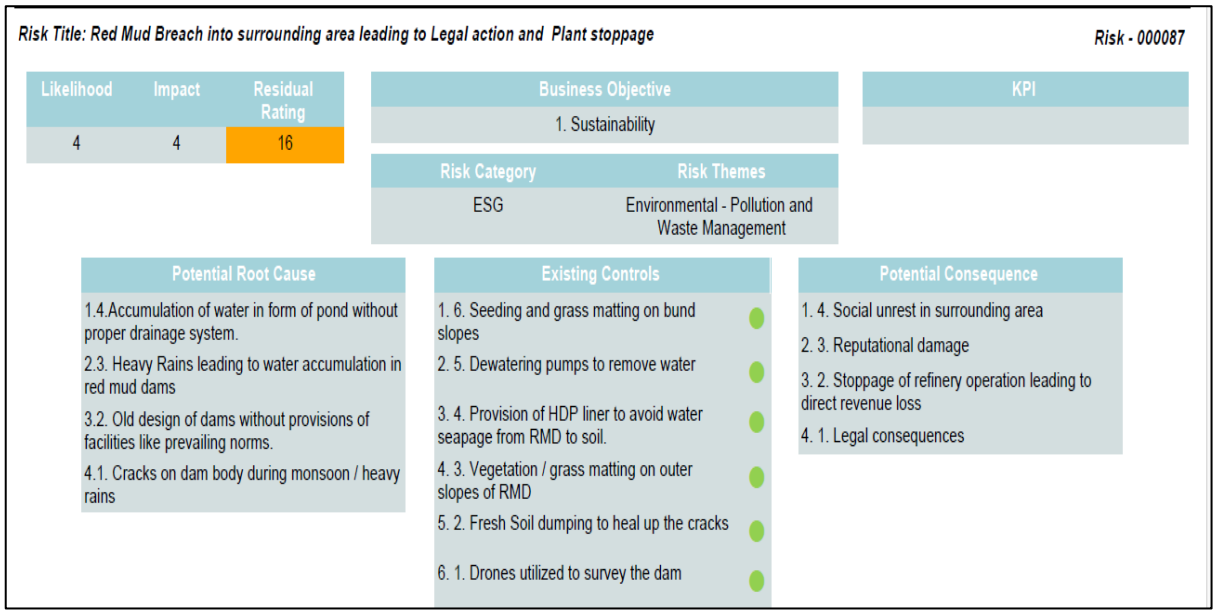
At Belagavi, IISc-Bangalore evaluated the potential of static liquification, dynamic liquification, seismic effect, slope failure and slope instability, considering various factors influencing stability conditions and identifying potential areas of concern. FOS values in static and earthquake conditions (1.816 and 1.523 respectively) suggest that the embankment remains in a stable condition. Also, A probabilistic analysis was done by GEO Studio modelling to characterise the risk of failure due to variability in material properties, pore-water pressure conditions, surcharge and point loads, and reinforcement parameters. Results of Probabilistic Analysis indicate that there is 100% certainty that the factor of safety will not fall below 1.0 given the variability of the inputs. The minimum factor of safety is 1.1616. Overall, IISc concluded that the stability of the bund section and red mud pond heap is satisfactory.

Stability analysis considering global and internal stability conditions was carried out at 12 different locations covering each side (North, South, East and West) of RMP at Muri by IIT BBSR. The analysis was performed for determining the FoS value to analyse the stability of existing dikes. Based on the analyses, it is noticed that the structural safety of the RMP dikes are stable against global failure mode and local static failure modes. However, events like earthquake that causes seismic forces are an instantaneous processes and care may be taken against these kinds of incidents.

Based on the analyses by IIT BBSR, it is noticed that the structural safety of the RMP-A and B dykes of Utkal are stable against global failure. However, the analysis pertinent to local stability of Pond-A only incorporated with the unconsolidated sediments of slurry red mud showed excess settlement. Decanting of the caustic from the pond-A by using PVD (Pre-fabricated vertical drain) in order to avoid seepage induced failure of the slope was suggested by the inspecting team.

Tailing Facilities at	Latest Review by Independent external auditor	Independent external audit agency	Engineering firm audit	Engineering firm auditor
Belagavi	Feb-24	IISc Bangalore	2022	Genstru
Muri	Apr-24	IIT Bhubaneswar	2023	Genstru
Utkal	May-23	IIT Bhubaneswar	Feb- 24	Genstru
Renukoot	2021	IIT BHU Varanasi	Ongoing	Genstru & TPF

Additionally, *sliding or slippage of red yard beyond the storage area* is identified as a risk and a credible hazard in the Enterprise Risk Management and Hazard Identification and Risk Assessment (HIRA) systems at each of our refineries and mitigation and control measures are put in place.



Inclusion of Red Mud breach in Enterprise Risk Management

A summary of the mitigation activities ongoing currently at each of our sites is given in the adjoining table.

Mitigation Measures for Stability (FY 24)	
At every RMDA	Height Reduction through continuous dispatch
	Drone Survey for monitoring surface cracks, height profile
	Red Mud Heap, embankment and slope stability study is being done regularly by independent geotechnical experts and remedial measures are taken accordingly.
	Pore Pressure and inclination profiles are being monitored using piezometer and inclinometer
	Execution of drainage trenches along the platforms and main berms of the stack, to collect and convey the accumulated surface water.
Belagavi	Maintaining garland drains dry throughout the year and RMP-2 mini pond free board >12ft
	Gabion wall constructed across the RMP-2 Bund for 320m to strengthen the existing dyke base
	Reduced water sprinkling by using chemical aid

Mitigation Measures for Stability (FY 24)	
Renukoot	The method of placing red mud in such a way that lift thickness does not exceed 200 mm
	28 Boreholes dug by Genstru for conducting topographical survey, geotechnical investigation and stability assessment
	Site activities are in progress as per Geotechnical experts' recommendations at all RMDAs
Muri	The deposition height of mud, especially, over the gabion reinforced walls is marginally high. It is therefore suggested to reduce the height where appropriate. The recommended height of bench is 5-7 m.
	Online real time data for any water pressure and dump inclination
	Sloping and benching followed by Rehabilitation to ensure stability
Utkal	Protection of Embankment slope by dressing rain cuts and grass tufting
	PVD installation for decantation of caustic from the pond-A
	Buttressing (west side embankment) with toe drain and rock toe
	Designing sub-surface drainage system to drain the leachate to settling pond for monsoon water management

Slope correction for smooth water flow in monsoon at RMP B of Utkal

Emergency Response Plan

Requirement 15.1.b.8 A summary version of the tailings facility EPRP for facilities that have a credible failure mode(s) that could lead to a flow failure event that:

(i) is informed by credible flow failure scenarios from the tailings facility breach analysis;

(ii) includes emergency response measures that apply to project affected people as identified through the tailings facility breach analysis and involve cooperation with public sector agencies

Spreading of Red Mud outside the embankment is identified as a credible hazard scenario by site-specific risk assessments. Red mud, after filter press where most of water is squeezed, contains 75% solid, and hence allows dry stacking. Since this material is stored since long, good natural compaction has occurred and there is a very rare possibility it to get dislodged and spreading outside the embarked area. If it spreads it may spill over to the nearby area and can cover the nearby land area. Emergency Preparedness and Response Plan is prepared, implemented, and periodically reviewed to manage probable emergency scenario. The EPRP rests on the three pillars of prevention, control, and recovery.

Prevention

- New Technology opted as Filter Press to make around 73-75% solid for dry stacking which allows to stack the material in layers and as per the approved design.
- Regular monitoring of dumping area and compaction test to check the stability.
- Monitoring of slope of red mud dumping site on regular interval.
- Regular monitoring through inclinometer and piezometer to detect any early signs of disturbance

Control

- Barricade the mud spillage area and observe all the corners of the spilled area to assess the impact
- Inform all the statutory bodies like Factory Inspector, Pollution Board, DM, Local Police
- Inform the local residence to stay away from the affected area
- Prepare the approach road for vehicle movement to reach up to affected area
- Take all precautions to avoid any contamination in nearby river stream

Recovery

- Deploy the manpower to supervise the evacuation activity in 24 Hour basis
- Recover the spilled mud from outside boundary and shift to safe place inside the boundary
- Testing of samples of ground water of nearby village area to ensure no contamination
- Soil testing of affected areas to assess impact and action plan. Engage competent consultant for desired solution
- Drone survey to be done for monitoring progress of rescue plan
- Facilitate the local residence with Water and Electricity if required
- Regular review on progress of mud evacuation
- Complete evacuation process within definite time framework
- Restore the affected soil as per the guidance of soil experts or agencies after complete evacuation of spilled mud.

This Emergency Response Plan (ERP) is designed to help plant team to respond quickly and effectively to all emergency scenarios. There is also a SOP for response to breach of red mud ponds –

- Raise Alarm (Modalities to suit the site needs)
- Inform WMC, S&F Dept., Admin & Security & Time Office, and Fire department.
- Evacuate the people to a safe distance.
- Inform the client & the concerned departments such as the Energy / Environment / Crisis Management, Fire Services Dept. & Safety Dept. of the factory.

- Assess the situation immediately in and all around the RMP yard. Check the impact towards, river, railway track side, and village and highway side.
- Immediately deploy resources like excavator machine, Hywa, Pay loader, Sandbags, manpower etc.
- Barricade the river side immediately by sandbags or soil heap to stop spread over of the red mud material in the river.
- Make a temporary drain and pit with pumping arrangement to divert the leachate water or contaminated water to Mini Yard.
- Similar barricading and pumping arrangement will be done in spread area in open land to divert rainwater to mini yard
- Immediate actions to remove the debris by deploying heavy vehicles in faster mode.
- Visit village areas to assess the damages and accordingly initiate actions as per the requirement.
- Remove red mud traces from the land and check the feasibility for re-use of land for agriculture purpose.
- Investigate jointly along with experts, locate the leakage or overflow areas & measure the impacts.
- Take all necessary remedial measures as per the extent of damage.
- Ensure that the leakage is stopped, and area is cleaned.
- After complete investigation take necessary actions to ensure that the similar incident should not happen in future.
- Re-build the dyke as per the advice of experts.
- Assess the environment, whether safe to work – measure the concentration and then allow the people for coming back to the work area.

Requirement 15.1.b.7: A summary of material findings of the environmental and social monitoring programme including implementation of mitigation measures

All tailings storage facilities are monitored on regular basis and any extra ordinary observations are documented and appropriate actions are taken. Monitoring of tailings storage facilities includes-

- The installation of piezometers to monitor groundwater mounding beneath and surrounding the facility.
- Surface and groundwater quality sampling both upstream and downstream of the facility
- The tailing and monitoring of closure strategies, including slope treatments and covers.
- Frequency, instrumentation, locations, design and maintenance of monitoring points, quality control, recording, protocols, assessment reporting, procedures for compliance for surface & groundwater monitoring., Leachate monitoring, mud stability, levels and void monitoring., Meteorological monitoring etc.
- In-situ density checks are critical to achieving BRSF operations objectives. After placement, rolling and compaction, density is tested using either a Nuclear Density Meter (NDM) or sand cone.
- Slope is monitored for minor and major cracks though visual and camera inspections.
- SOP for stacking and levelling of fresh mud and dispatch process of red mud from the facility are also inspected.

At Belagavi, physical rounds are being done on daily basis by the area owners. Digital instruments like Drone, CCTV cameras, Piezo, Inclinometers are being used for monitoring the stability aspects. RMP-2 mini pond free board level is maintained >12ft.

At Muri, 4 inclinometers are installed to monitor the deformation and lateral movement of red mud deposition at various strategic locations. Data is collected from these inclinometers on hourly and daily basis and is analysed to interpret stability of dykes. The data indicated minimal change in readings over time, suggesting that the heaps and embankments are stable.

To monitor the water levels within dyke area, 6 nos. of piezometer are installed at Muri and water levels in these wells are collected on daily basis and analysed to understand the possible change in water levels. The readings exhibit normal ranges of water levels, suggesting that the embankment and the dyke are stable.

At Renukoot, 3 Piezometer and 3 Inclinometers are installed at RMP 8, which is the only active site and 2 piezometers are installed to monitor RMP 11.

There are 2 inclinometers that give real time data and 3 piezometers installed at RMP A & B of Utkal. Water level through piezometers is monitored every month whereas daily inspection of inclination data is done.

AAQMS stations on site provide data on dust particle loadings (PM10) upstream and downstream of the RMDAs.

Seepage control

Control of any seepage of alkaline residue water to the underlying soil, geological structures and water table is an important objective. The hydraulic characteristics of the RMDA foundation and storage walls are key factors, as is the presence and value of groundwater under and nearby to the RMDAs. Boreholes are usually drilled around the storage facility and ground water is tested regularly to monitor and identify any seepage.

There are three 3 piezo wells near RMP area, at Renukoot half-yearly monitoring of groundwater is done by a third party. At Utkal, groundwater level is monitored, every three months by analysing data from three piezometers installed at strategic sites. Quarterly monitoring of groundwater is done at Utkal & Muri.

Dust Suppression

To arrest the dust issue in RMP during summer a suppression system is installed at Muri. Adequate numbers of spray nozzles are provided to the entire affected areas. These nozzles are connected with a water pump with pipelines. Fixed water sprinklers are installed at Utkal. Dust suppressant chemical is spread at the exposed surface of RMPs at Belagavi to control fugitive emissions.

Tractor mounted water sprinkler is used on the approach/haul roads in the vicinity of the RMPs and wheel washing system is also installed at each of our refineries. The collected runoff is sent to treatment facilities for recycling and reuse.

Wheel washing system

Fixed Sprinklers on RMDA

Truck mounted moving sprinkler

Runoff Management

For stability of RMPs, one of the crucial factor is the careful control and management of water which induces pore water pressure. In simpler terms, ensuring the success and safety of the tailing's containment involves focusing on how water is handled. Inside red mud yard there is one collection pond where all leached or monsoon water gets accumulated through garland drains or natural/artificially shaped contours. The settling ponds or Supernatant Liquid ponds (SNLP) are HDPE lined and the water collected over there is pumped back to be used in the process. The pond level is kept as minimum as possible, and water is used in washer circuit directly. Garland drains are ensured to be dry, ensuring no water logging in and around the pond and Water channelling is done to avoid rain cuts. A separate checklist is available and reviewed every year as monsoon preparedness.

Requirement 15.1.b.4 - A summary of impact assessments and of human exposure and vulnerability to tailings facility credible flow failure scenarios

Red mud, after filter press where most of water is squeezed, contains 75% solid and hence allows dry stacking. Since this material is stored since long, good natural compaction has occurred and there is a rare possibility of it getting dislodged and spreading outside the embarked area.

At Renukoot, there is no habitation for nearly 1 km from the site of RMP # 8 and within 3 km from RMP 11.

Red Mud Disposal areas in Belagavi are surrounded by three villages. There is no major impact to the communities, infrastructure, and environment as adequate measures are taken for dust suppression during non-monsoon period and storm water management by providing additional pumping facility during monsoon period.

Around 90% area of RMP 3 at Muri is rehabilitated. Three-tier plantation is providing strength and stability to the heap, preventing dust & considerably reducing the alkalinity of runoff. There could be no significant impact on the biodiversity and neighbouring communities, rather

the area had been made ecofriendly by restoration activities. Potential impacts of RMP 4 are also reduced to a great extent after reducing the height, sloping & benching.

The failure of a red mud pond can have far-reaching impacts on communities, infrastructure, and the environment, highlighting the importance of robust risk management measures, environmental monitoring, and community engagement to mitigate risks and minimize adverse effects. We are planning to conduct a formal assessment of socio-environmental impact of RMDAs on the neighbouring communities, local flora and fauna.

Climate Change Risk Assessment

Climate change risk assessment was conducted for each of the Hindalco sites. On the basis of multi-peril score, Belagavi, Renukoot, and Muri are at extreme risk and Utkal is at High risk. The perils contributing to the risk score are Heat index, flood, heat, energy, drought, geophysical, wildfire, wind, and precipitation.

Chronic Risk	Acute Risk
Medium Term	Short Term
Erratic monsoons, rise in global temperatures and increasing usage by industries and domestic users, will impact the availability of water.	Increasingly pervasive extreme weather patterns like heavy rain fall, torrential storms etc.

The assessment should influence the 5, 10, 25-year conceptual lifecycle management plans for the tailing facilities, consider rise/fall in temperature and the impacts on hydrogeological cycle, tailings dust generation, stability.

Some of the Steps adopted for climate change Adaptation at Hindalco are-

- Enhanced inspection and maintenance regimes.
- Altered working hours to protect workers from extreme heat.
- Heat action plan to protect workers from heat-induced illness
- Increase shadings by planting trees or constructing shade structures.
- Implement Nature-Based Solutions taking into account biodiversity risk screening to protect and preserving ABG assets the local environments essentials.
- Drainage and watershed management to reduce flooding and erosion risks
- Adopting a strategic business planning which considers climate change impact and integrates risk management and sustainability goals.
- Engaging employees through workshops to have leaner and more sustainable manufacture processes.

Requirement 15.1.b.10: Annual confirmation that the Operator has adequate financial capacity (including insurance to the extent commercially reasonable) to cover estimated costs of planned closure, early closure, reclamation, and post-closure of the tailings facility and its appurtenant structures (Requirement 10.7)

Financial Capacity

Asset Retirement Obligation (ARO) is a legal or constructive obligation associated with the ash ponds, red mud ponds, ash pipeline and coal transportation system in refineries and mining land where the land needs to be restored back to a usable condition after closing of activities. This is a statutory requirement in which the timing or method of settlement may be conditional on one or multiple future events, the occurrence of which may not be within the control of the entity.

Particulars	Assets Retirement Obligations
Balance as at 01/04/2021	**99**
Provision made during the year (d)	6
Reclassified	-
Provision utilised during the year	(1)
Provision reversed during the year	-
Unwinding of discount	6
Balance as at 31/03/2022	**110**
Provision made during the year	-
Reclassified	-
Provision utilised during the year (c)	(4)
Provision reversed during the year	-
Unwinding of discount	6
Balance as at 31/03/2023	**112**

Asset Retirement Obligation (in Crs)

Closure/ Partial closure through rehabilitation work has been done at TSFs at Muri (RMP 2 & RMP 3), Renukoot (RMP 11) and Belagavi (28 Acres of RMP 1).

Unit	RMP Monitoring & Stability Assessment (FY 24)	Rehabilitation work (FY 24)	Total budget Planned for Rehabilitation
Belagavi	7.45Cr* [RMP 1 & 2]	0.52 Cr	-
Muri	1.39** Cr [RMP 3] 0.79 Cr [RMP 4]	2.87 Cr	Around 7 Cr for RMP 3 and 12.5 Cr for RMP 4
Renukoot	2.86 Cr	1 Cr	7.62 Cr for RMP 9 & 10
Utkal	4.78 Cr (2) for RMP A and 40 lac for RMP B	-	-

Conformance Assessment

The conformance of each of the tailings facilities with the 77 requirements of GISTM has been confirmed through a self-assessment in accordance with the ICMM conformance protocol. We have scanned the relevant practices on each of the sites and available systems to assess the implementation level (whether it meets, partially meets, does not meet or not applicable) in line with the 15 Principles and 77 requirements. Conformance with GISTM is a continuous process and we are formulating systems, processes and collaborations required to reduce the non-conformities gradually.

Closure and Rehabilitation of Red Mud Disposal Areas

Three refineries viz. Belagavi, Renukoot, and Muri have undertaken rehabilitation projects to close and restore inactive Red Mud Disposal Areas.

RMP 1: Before rehabilitation project at Belagavi (2004)

RMP 1: After rehabilitation project at Belagavi

RMP 11: Before rehabilitation project at Renukoot

RMP 11: After rehabilitation project at Renukoot

Case Study: Project Red to Green at Muri

A large scale rehabilitation project is ongoing at RMP 3 across 90 acres at Muri. 36 acres is already restored (reported till April ’24) and lush greenery is flourishing on the site along with visible sightings of quite a few of squirrels, birds and other animals showing the evidence of growth of biodiversity at once barren stretch of land.

The rehabilitation plan is a blend of physical, chemical and biological treatment of red mud. The major steps are levelling, benching, sloping, chemical treatment by amender mixing, and three tier plantation of trees, shrubs and grasses. Contour terracing was constructed along the bench slope to reduce surface runoff. Benching and sloping with compaction up to 95% ensured stability and inclinometer provided information about any deviation/ slight movements. Gully plugging and stone check dams were constructed to restrict runoff and prevent erosion. Amenders were mixed on the surface and into the pits to reduce alkalinity, increase porosity and organic content, improve water retention capacity, decreases heavy metal toxicity, and improve other physicochemical properties of red mud to support vegetation. The combination and ratio of amenders, species of grasses, shrubs and trees were identified by TERI after exhaustive experiments and research work.

An in-house nursery, hardening unit and compost plant was also set-up on the site. Drip irrigation system will be installed for efficient water management. Continuous monitoring system is established, covering three major aspects-health and growth rate of planted saplings, changes in physio-chemical characteristics of red mud and pH of runoff water from the yard. Major benefits of the eco-restoration work are neutralisation of Alkalinity of red mud top layers. pH of surface runoff became normalized in the range of 6.5 to 8.5. Vegetation growth in red mud areas provided stability to red mud yard and reduced erosion. Green vegetation also reduced the dust emission from red mud yards which used to be a major challenge during summer. There are also plans to develop the RMP area as a hub of knowledge and recreation for local communities by developing a biodiversity park over there.

RMP 3 & 4 : Before rehabilitation project at Muri

RMP 3 at Muri: After rehabilitation (March 2024)

Innovative Projects

- In-situ neutralisation of Bauxite Residue – Joint project with IIT Bombay- is getting piloted at Utkal and Belagavi. pH at surface, shallow and deeper level is observed to get reduced by 13% in the initial results and CO2 adsorption of 1.3 &1.5 mmol-CO2/ g-RM is noted at 27 C and 250 kPa at both the sites respectively. Another experimental

set-up of developing polymer composites from bauxite residue and plastic waste at Belagavi in collaboration with IIT-M is also in progress. It will make bricks and paver blocks for use in our plants.

Polymer composite brick manufactured at Belagavi

- Utilisation of red mud in road construction – A pilot project in association with NHAI, CSIR-CRRI, IMMT is ongoing on a loop road section of NH 130 near Koraput. Subgrade and embankment are being constructed using red mud and fly ash of UAIL. Another pilot project of backfilling of mine voids with red mud is also ongoing at Baphlimali Bauxite mines. Approval for the pilot study is received from MoEFCC and OSPCB. It is being carried out under technical guidance of NEERI/IIT and with periodic inspections of SPCB regional office.

Pilot project of Road construction using Red Mud near Koraput

Backfilling of mine void at Baphlimali

- Brick manufacturing – We developed an alternative to conventional fired clay bricks by manufacturing bricks from red mud and total ash. Hindalco Renusagar patented this process in 2020. Utkal Alumina has manufactured bricks from red mud and fly ash as per process developed at Hindalco Renusagar. Toxicity characteristics, leaching potential, caustic leaching identification and other tests were carried out, the concentrations of all the elements are within the limits.

- Construction aggregates from red mud - Development of the technology for large scale utilisation of bauxite residue in manufacturing of construction aggregates is in

progress in collaboration with Greenwich University, UK. The experiment aims to establish a pathway for CO2 utilisation using bauxite residue and lime grit.

- Phospho-gypsum(acidic) and red mud (alkaline) admixtures for low-lying area filling for land development at Paradip, Odisha; - Lab study was conducted by IIT Bombay and observed the neutralisation of phosphogypsum on mixing with Red Mud and its compatibility as a fill material for land development. Discussions are ongoing for setting up a pilot project at Paradip.

Annexure

Abbreviations

AAQMS- Ambient Air Quality Monitoring Station

CPCB – Central Pollution Control Board

EOR - Engineer of Records

IAI- International Aluminium Institute

ICMM- International Council of Metal & Minerals

GISTM- Global Industry Standard on Tailing Management

MoEFCC- Ministry of Environment, Forest and Climate Change

OSPCB- Odisha State Pollution Control Board

RMDA- Red Mud Disposal Area

RTFE – Responsible Tailing Facility Engineer

RMP- Red Mud Pond

SP- Settling Ponds

SPCB – State Pollution Control Board

SNLP – Supernatant Liquid Collection and Recycling Pond

TSF- Tailings Storage Facility