THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF WATER

DAM SAFETY GUIDELINES

APRIL, 2020

FOREWORD

A Dam is any existing or proposed structure which is capable of containing, storing, or impounding water, including temporary impoundment or storage whether that water contains substance or not. Hence, Dam Safety is a science related to taking all necessary precautions to safeguard the dam in order to minimize the risk of failure. The precautions should be taken from inception to decommissioning stage of the dam project execution.

The National Water Policy (2002) highlights establishment of dams and reservoirs in a watercourse as an automatic introduction of element of risk through possible loss of lives and properties to the community living downstream due to possibility of dam failure. To reduce the possibility of dams' failure, these guidelines provides measures on how dams should be constructed, operated and maintained by the respective owners in accordance with established laws and regulations. The guidelines are made under the Dam Safety Regulations GN 237 of 2013 with its amendments GN 55 of 2020 made under Part X, Sections 94 (1) and 111 (1) of the Water Resources Management Act No. 11of 2009 to guide the development of dams for any purpose.

The safety of a dam manifests itself in being free of any conditions and developments that could lead to its deterioration or destruction. The margin which separates the actual condition of a dam or the conditions it is designed for, from those leading to its damage or destruction is a measure of its safety. The safety of dams depends more on other issues than engineering factors and the failure of a dam is a complex process that can include human error in planning, designing, construction, operation, maintenance, surveillance and decommissioning. Dam Safety Guidelines are intended as a tool for the implementation of active measures in safeguarding the public so that the overarching dam safety objective of protecting people, properties and the environment from the harmful effects of errors in planning, designing, construction, operation, maintenance surveillance and decommissioning of dams are minimized.

Therefore, these guidelines have been prepared with the intention of assisting all parties involved in the planning, designing, construction, operation, maintenance, surveillance and decommissioning of all types of dams. Also, the guidelines provide information on the procedures and requirements for registration of Approved Profession Persons (APPs), registration of dams with or without risk and granting of dam construction Permits. The parties include individuals, dam owners, consultants, contractors, Government institutions, Non-Governmental Organizations (NGOs) and other stakeholders of water dams and tailing dams.

Eng. Anthony Sanga
PERMANENT SECRETARY

EXECUTIVE SUMMARY

The Dam Safety Guidelines cover general aspects of planning, designing, construction, operation and decommissioning from which the design requirements are intended to cover both new dams and rehabilitation of existing water dams and tailing dams.In order for the dam owner to be granted a construction permit from the Director of Water Resources, pre-feasibility and/or feasibility study that justify the risks created by the dam should be submitted for approval.

A feasibility study is required for Class A and B dams to justify that the proposed location of the dam is the best for the type and configuration of the dam to be constructed. Hence in the feasibility report, geological and geotechnical investigation report for the dam site, reservoir area, spillways, outlet works, appurtenant works,and material sites should be submitted for verifications and approval.

In planning for dam construction, there are essential construction requirements which have to be considered like Construction Quality Assurance (CQA) and Construction Quality Control (CQC) which includes Construction Quality Assurance plan (CQA plan), the Owner 's CQA, Third-party CQA, Design Changes and Construction Completion Report. These have been set to control the quality of the construction work and assure its compliance with the drawings and specifications as required. Therefore, designing and construction requirements have been well elaborated in these guidelines including Tailings Storage Facility (TSF).

In order to comply with Dam Safety Risk Management, this document provides guideline on Operation, Maintenance and Surveillance (OMS) manual preparation which should be specific for each dam in categories A, B and C. It is also recommended that the OMS manuals should contain descriptions of unusual or infrequent conditions that are most likely to occur at the dam, like earthquake, and the operating procedures and inspections that should be implemented if those conditions occur.

Therefore, procedures to be followed for inspection and monitoring of water dams and tailing storage facilities which includes minimum inspection frequencies and periodicity of dam inspection under normal conditions are elaborated. Additionally, there are procedures for application of registration of Approved Professional Persons (APPs), registration of dams and tailing storage facilities and procedure for application of granting a permit for dam construction, rehabilitation or modifications.

Dr. George Lugomela
Director of Water Resources

LIST OF ABBREVIATIONS

AEP	Annual Exceedance probability
APP	Approved Professional Personnel
CQA	Construction quality assurance
CQC	Construction quality control
CRB	Contractors Registration Board
ECN	Emersion Class Number
ERB	Engineers Registration Board
ESA	Effective Stress Analysis
GN	Government Notice
MCE	Maximum Credible Earthquake
NGO	Non-Government Organization
NWL	Normal Water Level
OMS	Operation Maintenance and Surveillance
PMF	Probable Maximum Flood
TSF	Tailing Storage Facilities
TMF	Tailings Management Facility
USA	Undrained Strength Analysis

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1.0 GENERAL INTRODUCTION

1.1 Introduction

These guidelines are made under the Dam Safety Regulations GN 237 of 2013 made under Section 94 (1) and 111(1) of the Water Resources Management Act No. 11 of 2009 to guide the development of water infrastructures including dams for any purpose, also tailings dams on the best dam engineering practices in order to achieve the objective of the dam safety in restricting any damage that might be caused by dam failure and prevent loss of life, properties and damage to the environment in the event of an accident. The purpose of this guide is to outline some of the principle consideration that should guide development of water infrastructures unless the context otherwise requires.

These guidelines also have the intention to assist all parties involved in planning, design, construction, operation and maintenance of dams to be informed on the procedures and requirement for registration of Approved Profession Personnel's (APP's), Registration of Dams with or without risk and Granting of Dam Construction Permit. Will also give directives to individual dam owners, Registered Professional Engineers, Dam experts (other disciplines rather than Engineers), Engineers Registration Board (ERB), Contractors Registration Board (CRB), and Government institutions, NGOs and other stakeholders, investors such as Mining Company, development Partners etc.

It will be used for reference and guidance to the mentioned parties while executing their responsibilities regarding Dam Safety issues. Where necessary, the use of these guidelines shall be supplemented with information from the following documents: Water Supply and Sanitation, Design Manual and Dam Safety Regulations both of which were prepared by the Ministry of Water and Irrigation.

According to part X of Water Resources Management Act (WRM Act) No. 11 of year 2009 in line with Dam Safety Regulations Government Notice (GN 237) of year 2013 and its Amendment GN. 55 of 2020 requires a person who practice dam Safety activities to be registered as Approved Profession Person (APPs). With this regard, the guidelines shall therefore also have sections of Registration of Professional Persons (APPs).

Registration of Dams with and without Safety Risks and Granting of Construction Permits are the requirements stipulated in the Part X of the Water Resources Management Act (WRM Act) No. 11 of year 2009 in line with Dam Safety Regulations Government Notice (GN 237) of year 2013 and its Amendment GN. 55 of 2020 to be fulfilled by dam owners.

1.2 Definition of basic terms

"**Annual Exceedance probability**" means the probability that a given flood over a given duration will be exceeded in any one year;

"**Camber**" means Addition in height to the dam made to compensate for settlement;

"**Dam**'' means Water Dam and/or Tailings Dam;

"**Dam with Safety Risk**" any structure which can contain, store, impound or dam more than 50,000 cubic meters of water, whether that water contains any substance or not, and which has a wall of a vertical height of more than five meters, measured as the vertical difference between the lowest downstream ground elevation on the outside of the dam wall and the non-overspill crest level or the general top level of the dam wall;

"**Director**" means Director of Water Resources

"**Design Earthquake**" means a postulated seismic event, specified in terms of specific bedrock motion parameters at a given site, which is used to evaluate the seismic resistance of manmade structures or other features at the site;

"**Design flood water level**" means the highest water level that can occur in the reservoir at the design inflow flood and with the spillway arrangement in operation;

"**Design inflow flood**" means the inflow flood with a thousand-year return period, or other return period determined by the Division of Water Resources;

"**Design outflow flood**" means the outflow flood that the spillway arrangement is capable of diverting at the design flood water level;

"**Design load**" means characteristic load values multiplied by appropriate load coefficients;

"**Emersion Class Number**" means a measure of the dispersive characteristics of a soil when exposed to water;

"**Exceptional limit state**" means the state corresponding to a defined capacity set relative to the possibility of progressive failure due to exceptional loads;

"**Exceptional load**" means a load that can occur under abnormal circumstances, accidents or natural disasters;

"**External Risk**" means consequence that may occur downstream/ in case of dam failure or uncontrolled release of water from the reservoir. The categories of risk are listed under paragraph (a) to (d) of sub-regulation 2 and the meanings are provided in in the second schedule of Dam Safety Regulation of 2013 GN 237;

"**Freeboard**" means the safety height between the top of the structure and the relevant water levels, such as the height between the top of the impervious element and the design flood water level;

"**Height of dam**" means the height from the lowest point of the impervious element to the top of the dam;

"**Inflow flood**" means the flood into the reservoir from un-regulated part of the catchment, with additions of outflow flood from upstream reservoirs and interbasin transfers;

"**Load**" means a force, an applied deformation, or other form of influence those results in stresses or strains in the structure;

"**Load coefficient γi**" means the specified coefficient by which a characteristic load or standard load value shall be multiplied to obtain the design load;

"**Material coefficient γm**" means the specified coefficient by which the characteristic strength of a material or standard value for structural strength shall be divided to obtain the design strength of the material;

"**Maximum Credible Earthquake"** means earthquake(s) associated with specific seism- tectonic structures, source areas that would cause the most severe vibratory ground motion or foundation dislocation capable of being produced at the site under the currently known tectonic framework. It is determined by judgments based on all known regional and local geological and seismological data;

"**Maximum flood water level**" means the highest water level that can occur in the reservoir at a probable maximum inflow flood and with the spillway arrangement in operation;

"**Normal water level"** means highest regulated water level;

"**Operation freeboard**" means the vertical height between the embankment crest and the crest itself;

"**Outflow flood**" means the flood from a reservoir;

"**Probable maximum inflow flood**" means the greatest inflow flood that can occur;

"**Probable maximum outflow flood**" means the greatest outflow flood that can occur at probable maximum inflow flood and maximum flood water level;

"**Risk**" the possibility that something bad or unpleasant (such as an injury or a loss) will happen. In other way is the product of probability of unpleasant event to occur and cost associated. "Serviceability limit state" means the state corresponding to a defined limit which shall not be exceeded by normal use of the structure or structural part;

"**Significant wave height**" means the average height of the highest one-third of the highest waves of a given wave group;

"**Tailings**" means fine-grained waste materials in suspension which are discharged from any ore concentrator or coal washing plant including tailings slurry, tailings slimes, tailings residue, tailings cakes, heap leaching, leachate originated from PAF materials; usually remaining after the metals and minerals extraction, particle size 10μm to 1.0mm;

"**Tailings dam**" means a structure constructed to create a tailings pond for storing mining tailings and process water or may be terms as Tailings Storage Facility;

"**Toe of dam**" means the part of the dam that is in contact with the foundation along the outer/inner surface of the dam;

"**Ultimate limit state**" means the state corresponding to a defined capacity of a structure or a structural part. This capacity is set relative to the possibility of failure or inelastic displacement or strain which may be regarded as failure;

Water Dam means a structure built across a stream, a river, or an estuary to retain water for difference water uses including water supply, irrigation, hydro power etc; and

"**Wave run-up**" means the difference in height between the still water level and the highest point on the dam that the waves reach up to.

2.0 GENERAL ASPECTS OF PLANNING, DESIGNING, CONSTRUCTION AND OPERATION

The design requirements are intended to cover both new dams and repair or rehabilitation of existing dams. The following sections cover the requirements for design of new dams but pertinent items can be used also for the design of repairs and rehabilitation of existing dams.

In order to start construction on a new dam or repair of an existing dam a Certificate of Approval to Construct a Dam shall be issued by the Director to the Dam Owner or developer of Class A, B or C dams. To obtain the certificate of approval, the Dam Owner or developer shall present a pre-feasibility and/or feasibility study that justify the risks created by the dam. The following general guidelines are recommended:

i. At least two or more alternatives, including the no-action alternative, should be considered;
ii. For a Class A, B or C dam one of the alternatives should include the potential economic and lethal impacts of a dam failure in the analysis;
iii. For Tailings Storage Facility a closure plan should be prepared and submitted; and
iv. An approved Environmental and Social Impact Assessment should be submitted.

2.1 Pre-feasibility studies

A pre-feasibility study should be required for Class A, B and C dams to justify that the proposed location of the dam is the best for the type and configuration of the dam to be constructed. The pre-feasibility study should consider the following aspects:

a) Type of dam;
b) Geology and hydrogeology of bedrock and overburden;
c) Construction material borrow sources;
d) Local and regional hydrology;
e) Local and regional seismic setting and faulting;
f) Opportunities for mitigation of dam break flood waves; and
g) Suitability for construction.

The pre-feasibility report should include the following drawings as a minimum:

- Profile view of dam along dam axis, showing elevation of the crest of the dam, locations and elevations of spillways and outlet works, and geological investigation information; and

- Cross section views of the dam at the maximum height, spillways, and outlet works, including elevation and width of crest, slopes of upstream and downstream faces, thickness of erosion control structures and zoned fills, locations of drains, cut-off walls, and any other important feature.

2.2 Feasibility studies

The following reports and details should be submitted in the feasibility report:

- Geological and geotechnical investigation report for the dam site, reservoir area, spillways, outlet works, appurtenant works, and material sites
    i. Location and geological maps;
    ii. Locations and logs of borings and test pits;
    iii. Geological cross sections along dam centerline and perpendicular to centerline;
    iv. Material analyses and laboratory test results;
    v. Recommendations for foundation treatment, stability analyses, and seepage control;
    vi. Seismic report;
    vii. Assessment of the regional and site seismicity;
    viii. Effects of seismicity on the stability and performance of the facility, including appurtenant structures, reservoir and associated equipment, including geologic, geotechnical, and structural engineering specialists;
    ix. Hydrology design report;
    x. Methods and references used to determine inflow design floods;
    xi. Drainage basin characteristics;
    xii. Stream flow and precipitation data;
    xiii. Reservoir inflow and outflow hydrographs;
    xiv. Estimate of flood event impacts on areas downstream, including an incremental damage assessment, if conducted and
    xv. Other relevant information.

- Drawings
    i. Plan and cross sections of the dam;
    ii. Spillway plan views and cross sections;
    iii. Design drawings for appurtenant structures;
    iv. Details of specific features of importance;
    v. Construction sequence drawings, when required; and
    vi. Other drawings as necessary.

2.3 Detailed design

With the feasibility study and the corresponding documentation approved; the detailed design of the selected project can continue to provide Tender Documents for the project's construction. The detailed design should be accompanied by a Final Design Report which should contain all information necessary to support the selected design features and should typically include the following items:

a) A description of all methodologies, references, formulas, and assumptions used in developing the design criteria and engineering evaluations;
b) An evaluation of the structural stability of the dam, foundation, and appurtenant features;
c) An evaluation of the performance of the dam, foundation, and appurtenant features during a seismic event;
d) Descriptions, physical analyses, and permeability analyses, as appropriate, of the materials used in the construction of the dam, a seepage analysis for the dam and foundation, including filter criteria to prevent piping of fine-grained materials;
e) Design criteria, calculations, and rating curves for the spillways and outlet works, including freeboard and other hydraulic evaluations such as energy dissipators;
f) A storage-versus-depth curve and a storage-versus-area curve for the reservoir;
g) Recommendations for diverting water during construction, as appropriate;
h) Recommendations for special construction considerations, first filling of reservoir, operations, maintenance, instrumentation, and monitoring; and
i) Design evaluations and recommendations for other features of the dam and appurtenant works.

2.4 Simplified studies

Simplified studies shall be conducted for Class C dams when falling in the category of dams with a risk in accordance with the Water Resources Management Act No. 11 of 2009. For dams in Class D only general layout drawings of the dam and outlet works together with material characteristics have to be provided.

2.5 Construction Requirements

2.5.1 Construction quality assurance and Construction quality control

A plan to control the quality of the construction work and assure its compliance with the drawings and specifications is required. In order to achieve the level of safety of the

dam set out in the design phase adequate quality assurance and control (CQA/QC) shall be implemented based on the hazard potential classification of the dam. The CQA/QC shall provide the inspectors and engineers with guidance for the supervision of the construction works and any design changes that may occur during construction.

2.5.1.1 *A Construction Quality Assurance plan (CQA plan)* is a document that outlines the measures and actions to be taken by the owner or operator of the dam, including retaining a qualified engineering consultant (if required), to ensure that the project is completed by the construction contractor in accordance with the approved plans and specifications. These actions may include approving construction materials, conducting independent field and laboratory testing, inspecting the work during and after construction, surveying, and documenting the construction process.

2.5.1.2 *A Construction Quality Control plan (CQC plan)* is a document that outlines the measures and actions taken by the construction Contractor to control the quality of work to meet the requirements of the approved plans and specifications. These actions may include surveying; borrow pit investigations, field and laboratory materials testing, construction methodology, scheduling, and documentation.

2.5.1.3 *The Owner´s CQA* can be provided by a team under an Approved Professional Person for dams in category C and D.

2.5.1.4 *Third-party CQA* can be provided or by an engineering consultant, independent from the owner or the contractor, who is qualified in the construction inspection of the type of dam and appurtenant works under construction. The third party could be the engineering design consultant.

Table 2.1 Summary of Construction Requirements

Required level of CQA/QC	Hazard Potential Category			
	A	B	C	D
CQA plan	Yes	Yes	Optional	*n/r*
CQC plan	Yes	Yes	Yes	Optional
Owner's CQA	Optional	Optional	Yes	Yes
Third party CQA	Yes	Yes	Optional	*n/r*

n/r = not required

2.5.1.5 *Design Changes*. All design changes that are proposed after a Certificate of Approval to Construct, Modify, or Repair a Dam is issued must be reviewed and approved by the Director. In some cases, depending on the nature of the proposed change, additional submissions may be required. In all cases, the design change must be approved in writing by the engineer who certified the design prior to the approval of the Director.

2.5.1.6 *Construction Completion Report*. A Construction Completion Report is required for Class A, B and C dams. The scope of the construction completion report will depend on the complexity of the project. The report content should include the following:

a. Description of how the plans and specifications were followed or deviated from, including the types of materials used for construction, brand names or catalogue sheets of components, and other descriptive information;
b. Description of unexpected conditions encountered;
c. Inspection reports;
d. Field and laboratory test results, including sample locations and test standards or methodologies;
e. Photographs documenting construction progress and final conditions;
f. Seal and signature of the construction inspection engineer defined; and
g. As-built drawings required for Class A, B and C dams with complete records of the construction, including actual elevations, changes in major design components or details, and appurtenant construction.

2.6 Operation, Maintenance and Surveillance (OMS) Manual

2.6.1 Content of OMS Manual

An OMS manual should be required for dam categories A, B and C. It has to be specific for each dam. The preparation of an OMS manual shall be a requirement in the design of a new dam and it is the design engineer who shall prepare the OMS manual taking into consideration the design criteria for the dam. The manual shall be updated with information from the construction stage that is of importance.

Regarding existing dams, the Director shall ask the Dam Owner if his dam has an OMS manual and require a copy if the OMS manual exists. If a dam does not have an OMS

manual the Director shall inform the owner of his obligation to have such a manual prepared.

The content of the OMS manual depends on the complexity of the dam and its features. The OMS manual should be as simple as possible so that the operator of the dam clearly understands its contents and can implement its requirements. The OMS manual shall describe in detail how a dam will be operated inspected and maintained and should include the following items:

a) Physical description of the dam;
b) Any operating limitations on the dam;
c) Critical design criteria, including the Project Data Sheet;
d) Schedule and procedures for routine safety inspections, monitoring, and maintenance of the dam;
e) Detailed instructions and maintenance procedures for operating valves, gates, or other equipment;
f) Maintenance procedures, calibration information, and instructions for instrumentation and for monitoring and alarm systems;
g) Site-specific visual inspection checklists and monitoring data collection forms; and
h) Other necessary information to provide sufficient detail about dam operation, inspection, and maintenance for the protection of life, property and environment.

It is also recommended that the OMS manuals contain descriptions of unusual or infrequent conditions that are most likely to occur at the dam and the operating procedures and inspections that should be implemented occur under those conditions. An OMS manual should be reviewed on a regular basis and updated as necessary including date of revision and record of revisions.

2.6.2 Monitoring

Monitoring procedures and instrumentation may be required to accomplish the following:

- Confirm that the structure is performing in accordance with the design;
- Determine if a problem exists that may require remedial measures; and

- Provide timely notice of an adverse change in the state of the dam or reservoir. Changes in seepage character, abnormal settlement patterns and slope movements are often symptoms of deterioration in the embankment and foundations. Unusually high-water levels in piezometers can indicate that an immediate problem is developing. Baseline monitoring is useful to determine whether change is occurring. Instrumentation must be combined with responsible recording and analysis of the data to identify significant trends in the performance of the dam. This analysis should preferably be performed by a dam engineer acquainted with dam safety aspects. The following are key elements of a successful monitoring plan:

  - An OMS manual that requires the diligent implementation of the observation and data collection procedures;
  - The timely analysis and evaluation of inspection records and data for significant changes or adverse trends in anticipated behavior; and
  - Procedures in the OMS manual to follow when monitoring indicates significant changes or unusual conditions are occurring.

Effective tools for monitoring the condition of a dam include the following:

i. Visual inspection checklists with comments;
ii. Photographs of key features taken from a consistent perspective over time;
iii. Automatic data loggers connected to critical instrumentation;
iv. Alarm systems connected to full-time monitoring devices such as water level indicators; and
v. Internal review procedures to ensure that monitoring data are properly evaluated.

2.7 Determination of loads

2.7.1 General overview

Dams with appurtenant structures shall be designed for loads that are of significance for safety, performance and durability. Design loads shall be determined by multiplying characteristic values by the load coefficients specified for the different types. The characteristic values of loads shall be determined in accordance with the requirements of these regulations.

2.7.2 Dead load

The characteristic value of the bulk density shall be taken as being equal to the expected average value for the material. Variations in the bulk density during the construction period shall be taken into account if this is of significance for the stability of the dam.

2.7.3 Water pressure

Characteristic values of the water pressure shall be calculated from the design flood water level. In cases where waves and wind setups are of significance, additions shall be made for the rise in the water level that they may cause. Water pressure resulting from higher water levels is defined as exceptional loads. Lower water levels and variations in water level shall be taken into account when they are of significance to the stability of the dam.

External wave pressure against the dam and in open joints and the pore pressure in the dam and its foundations shall be taken into account. Pore water pressures shall be determined in accordance with accepted methods of calculation or on the basis of direct measurements. Where hydrodynamics loads are of significance, they shall be taken into account.

2.7.4 Earth pressure

Characteristic values for earth pressure shall be determined in accordance with relevant standards for the calculation of loads.

2.7.5 Effects due to the physical environment

Effects due to the physical environment are loads caused by the environment and, in the case of dams, include those caused by waves, wind and frost action.

2.7.6 Waves

The significant wave height shall be determined in accordance with accepted methods of calculation, based on the length of the fetch, the wind speed and the duration of the wind, combined in the most unfavorable manner. Characteristic values of the wind speed and duration shall be determined in accordance with meteorological data and assessment of local conditions.

2.7.7 Wind setup and standing waves

Characteristic values for wind setup, and standing waves in larger reservoirs shall be evaluated and determined on the basis of observations and calculations.

2.7.8 Frost action

The effects of frost action comprise deformations and pressures against load-bearing structures as a result of frost action in the structure or foundation. Characteristic values shall be determined by evaluating local conditions.

2.7.9 Deformation loads

Deformation loads shall comprise the effects of variations in temperature, shrinkage and creep. Characteristic values shall be determined using accepted methods taking into account the properties of materials, the structural design and climatic conditions.

2.7.10 Live loads

Live loads comprise traffic loads, loads from gates and lifting gears, and comparable loads occurring at individual installation. Characteristic values for the live loads shall be taken as being equal to standard values or assumed maximum values.

2.7.11 Exceptional loads

During planning the exceptional loads that may arise shall be accounted for and characteristic values shall be determined on the basis of local conditions. The Director shall then decide which exceptional loads and combinations of loads shall be taken into account.

For all dams the maximum flood water level and associated probable maximum outflow flood shall be regarded as an exceptional load.

Other exceptional loads may be:

a) A rise in water level above the design flood water level, as a result of:
   - Reduced capacity of the flood diversion works due to damage to sluicing devices or blockage of the waterway
   - Sudden outflows from dammed lakes
   - Uncontrolled discharge from upstream reservoirs resulting from damage or failure of dams or their appurtenant structures;

b) Waves caused by slides into the reservoir;
c) Slides hitting the dam;
d) Earthquakes; and
e) Explosion loads caused by accidents or other unforeseen events such as blasting to break up log jams.

2.8 Calculation of floods and flood water levels

2.8.1 Hydrological calculations shall be made to determine the design inflow flood, design outflow flood, probable maximum inflow flood and probable maximum outflow flood, with associated water levels in the reservoir:

a) The aim of the flood calculations shall be to determine the necessary data for the design of the dam and the outlet works, and shall also form the basis for determining the capacity, characteristics and operation of the spillway; and
b) The design inflow flood shall be used in the calculations of water levels and discharge that form the basis for the design of the spillways and outlet works, whereas the probable maximum inflow flood shall form the basis for calculations to check dam safety of the dam against failure.

2.8.2 *Calculation of the design inflow flood and Maximum Credible Earthquake.* The inflow flood is the flood to the reservoir from unregulated part of the catchment, plus discharge from upstream reservoirs and inter-basin transfers. The design inflow flood and design earthquake shall be based on the consequence's categories, **Table 2.2**

Table 2.2 Design with consequence's category

Dam Classification	**Design Inflow Flood**	**Design Earthquake**
Very High Risk "A"	Annual Exceedance Probability between 1/10000 and Probable Maximum Flood (PMF)	Annual Exceedance Probability of 1/10000 of Maximum Credible Earthquake (MCE)
High risk "B"	Annual Exceedance Probability between 1/1000 and 1/10000	Annual Exceedance Probability between 1/1000 and 1/10000 of MCE
Low Risk "C"	Annual Exceedance Probability between 1/100 and 1/1000	Annual Exceedance Probability between 1/100 and 1/1000 of MCE
Very Low Risk "D"	Annual Exceedance Probability of 1/100	Annual Exceedance Probability of 1/100 of MCE

The flood frequency analysis shall be performed to determine the relationship between the magnitude of inflow floods and their frequency. The design inflow flood is determined by extrapolating the distribution function to the specified return period.

2.8.3 *Calculation of the design flood water level and the design outflow flood*
The design flood water level is the highest water level in the reservoir during the design inflow flood with open outlet works. The design outflow flood is the corresponding outflow flood. In calculating the design flood level and corresponding design flood, the flood-damping effect of the reservoir may be taken into account. Unless otherwise specified, the water level at the start of the flood is assumed to be the Normal Water Level (NWL).

If the flood-damping effect of the reservoir is insignificant, the design outflow flood will be equal to the peak flow of the design inflow flood. It shall be demonstrated that the natural flood conditions in the river downstream of the dam will not be imparted, or that the flow will not exceed given limits.

2.8.4 *Calculation of the probable maximum inflow flood*. The probable maximum inflow flood is the greatest inflow flood that can occur from unregulated part of the catchment, plus discharge from upstream reservoirs and inter-basin transfers. The probable maximum inflow flood cannot be related to a fixed return period. It is based on an analysis of the most unfavorable combinations of meteorological and hydrological conditions possible.

2.8.5 *Calculation of the maximum flood water level and the probable maximum outflow flood*. The maximum flood water level is the highest water level that can occur in the reservoir during the probable maximum inflow flood with open outlet works. The probable maximum outflow flood is the corresponding outflow flood. The calculations should be carried out in the same manner as for the design flood water level and design outflow flood (see 2.8.3).

2.9 Design of spillways and diversion works

Dams shall be provided with spillway and diversion facilities, designed to accommodate the discharge to be conveyed past the dam structure or to the power plant or to other location for water assumption. It shall be possible to lower the water level in the reservoir, to the extent necessary to permit inspections and repair works. Discharge of flood water and the draw-off from the reservoir shall not influence the dam safety. Full control shall be maintained of the discharge in the river downstream, possible erosion damages and lowering of the water level.

2.9.1 Spillway Capacity requirement

The spillway system shall be designed to handle the design outflow flood with the water level in the reservoir equal to the design flood level in the reservoir:

a. The design of the spillway system shall ensure that, to the extent possible, the negative effects of floods in the river downstream do not increase or the flood discharge shall not exceed set limits;
b. Spillways shall normally be of the un-gated, free surface flow type, or the gated type. The discharge to the power plant and the capacity of the bottom outlets is, as a general rule, not included in the capacity requirements for the spillway system;
c. Hydraulic design calculations shall be provided with respect to capacities, water levels and corresponding gate openings, and if necessary verified through hydraulic model studies. The spillway system is here defined as the entire floodwater conveyance facilities, between the reservoir and the river downstream; and
d. In the event of extraordinary high water level in the reservoir as a result of possible maximum inflow flood or other causes listed under2.8, an account of expected flood discharge, highest water level and provision for handling the flood shall be presented. In order to avoid unacceptable consequences, additional flood discharge conveyance facilities may be needed.

2.9.2 Un-gated spillways

The inflow section shall be shaped as an overflow ogee crest, designed on the basis of the outflow flood. Other design may be used if acceptable design calculations are

provided, possibly supported by hydraulic model studies. The water depth at the spillway crest shall be sufficient to prevent floating objects, such as peat, from blocking the spillway inlet.

2.9.3 Gated spillways

Gated spillways shall only be used when possible malfunctioning of the mechanical components will not cause unacceptable consequences with respect to overall dam safety. Selection of mechanical equipment, design and operational procedures shall be based on an assessment of all possible extraordinary conditions, which may occur. Such extraordinary conditions may be sudden fall-out of the power station, climatic conditions causing problems, or exceptional loads, which in accordance with the requirements set forth in 2.7.11, may occur.

2.9.4 Conduit spillways

Conduit spillways, flowing full or with a free water surface, and siphon spillways shall be designed and constructed with special care. Comprehensive analyses will be required as to capacity and ability to withstand all possible loads and stresses the spillway system may be exposed to. The consequences of a flood exceeding the design flood shall be investigated, likewise the consequences of a possible reduction of the estimated spillway capacity.

2.9.5 Submerged bottom outlets and diversion works

Bottom outlets and diversion works shall be designed for maximum pressure which may occur and due consideration shall be given to minimize the risk of vibration and cavitation. The inflow control devices, normally gates or valves, shall meet the highest possible performance standards. The possibilities for damage or failure shall be considered and the consequences of uncontrolled discharge of water due to mechanical failure, assessed. Local corrosion conditions shall be taken into account in the selection of materials.

3.0 DESIGN AND CONSTRUCTION OF EMBANKMENT DAMS (DEFORMABLE DAM TYPE)

3.1 General Overview

In these guidelines, an embankment dam is defined as a dam consisting mainly of placed and compacted earth, gravel or blasted rock. Dams, with appurtenant structures, shall be located, designed and built to satisfy reasonable water-tightness requirements, and to withstand with adequate degree of safety the loads and deformations of significance to stability, performance and durability. For determination of the loads, refer to the requirements contained in guideline 2.7.

The dam shall be demonstrated to be capable of withstanding relevant exceptional loads without failing, but it is generally acceptable that damage may be incurred.

3.2 Foundation

An embankment dam shall be founded on ground that is or will be made adequately watertight. The design of the dam shall be adjusted to the ground conditions. If necessary, the foundation of the dam shall be drained to prevent build-up of pore pressures and seepage that may result in instability.

The surface of the foundation shall be adjusted to provide favorable interaction between the foundation and the structure of the dam. Concrete structures connected to embankment dams shall be founded on rock where technically and economically feasible, and they shall be designed to provide favorable interaction between the concrete and the fill.

3.3 The impervious element

The impervious element shall be designed with acceptable dimensions of recognized materials of adequate quality, and properties for construction, to ensure a manageable seepage that jeopardize the stability of the dam or result in unacceptable large losses of water.

3.4 Filters, transition zones and drainage

Material zones in a dam designed to protect adjacent zones against erosion shall be of sufficient width and shall consist of material that satisfies acceptable filter criteria.

3.5 Shoulders

The dam shoulders shall be designed so that the dam stability is adequate. This shall be demonstrated by acceptable methods of calculation. The material coefficients listed in table 3.1 shall be applied to all loads, with the exception of exceptional loads. In the case of earthquake loads, a material coefficient of ym=1.1 shall be used when the earthquake effect is introduced into the calculation with static forces. The load coefficient, y_f, shall be taken as 1.0 for all loads.

Table3.1 material coefficient, ym; which shall be used for characteristic material properties in the form of cohesion, c, and friction, tan φ.

Condition	**Slope slip**	**Reservoir level**	**Material coefficients**
Construction and Initial filing of the Reservoir	Upstream and downstream	Empty	1.3
		Most unfavorable Water level	1.5
Steady seepage	Downstream	Design flood Water level	1.5
Rapid drawdown	upstream	Most unfavorable Water level	1.3

3.6 Slope protection

Slope protection on the upstream slope shall be designed to withstand the effects of waves, frost action and other possible forces. Where slope protection is made up of stone, stones of adequate size and durability shall be placed stably on the slope. The stones in the slope protection must include stone sizes act as a filter for the underlying material. Slope protection may also be needed to protect natural slopes against the damaging effects of waves. The downstream slope shall provide protection against erosion caused by surface water or wind.

3.7 Top of dam

The width of the top of dam shall be sufficient to ensure that the required quality in construction of the different zones of materials can be achieved. The dam may be linked to existing road network in the area. If traffic is allowed to drive on the top of the dam the width of the dam shall be adequate and guardrails should be installed. Special requirements apply to embankment dams capable to withstanding exceptional loads (see 2.7.11).

3.8 Camber

The dam shall be built with a camber to allow for anticipated settlement.

3.9 Freeboard

The top of dam or the top of any wave screens shall have sufficient freeboard above the design flood water level, to avoid water splashing over the dam through a combination of wave run-up, wind setup and standing waves. The following characteristics shall apply:

a) For dams with impervious facing, the freeboard of the top of the facing shall be the same as that of the rest of facing;
b) For dams with a central impervious core, the freeboard of the core shall be sufficient to prevent overtopping when the water level is at the designed water level, with an addition for wind tide and setup. For a dam where the freeboard is of significance for safety of the dam, the freeboard shall be minimum 0.5 meter; and
c) For exceptional loads, the water may be permitted to rise above the top of the impervious element or splash or flow over the top of the dam, provided that the design has taken this into consideration and that safety against failure is adequate (see 3.10 and 2.7.11);

The freeboard requirements do not apply to overflow dams that are designed for overtopping.

3.10 Special measures against exceptional loads

Exceptional loads may result in water splashing or flowing over impervious element or the top of dam. The top of dam, the downstream shoulder, the toe and foundation of

the dam shall be designed for such effects (see 2.7). For embankment dams where the responsible authorities require the dam to be capable of withstanding sabotage, the freeboard, the top of dam, slopes and downstream toe shall be designed in accordance with the safety requirements laid down in each individual case.

3.11 Construction specifications

Detail drawings and specifications shall be prepared for execution of the work. The specification shall include requirements for foundation and preparatory works. They shall also include specifications of qualities of materials to be used and how the work shall be carried out and the required quality of work to be obtained.

3.12 Site inspection and laboratory testing

Quality control including site inspection and laboratory testing shall be performed in accordance with the requirements set out in section 2.5 of Dam Safety Guidelines.

4.0 DESIGN AND CONSTRUCTION OF CONCRETE DAMS (RIGID DAM TYPE)

4.1 General overview

The requirements stated in this part apply to concrete dams and to concrete structures included as parts of dams of other type. Dams, with appurtenant structures, shall be located, designed and built to satisfy water tightness requirements, and to withstand with adequate degree of safety the loads and deformations of significance to stability, performance and durability. For determination of loads, the reader is referred to requirements set out in guideline 2.7. 4. The dam shall demonstrate capability of withstanding relevant exceptional loads without failing, but some degree of damage can be accepted.

4.2 Design principles

The design shall be based on the checking of three limit states which are ultimate limit state, exceptional limit state and serviceability limit state. For each of the limit states, it shall be shown that the load effects do not exceed the design capacity, or limit values of stress, strain or crack width.

The design load effects shall be determined by structural analyses carried out in accordance with accepted methods and based on realistic assumptions on the structural behavior. If the dam is to be checked for earthquake or explosion loads, the dynamic properties of the dam shall be taken into account in determining load effects.

Static and dynamic analyses can normally be based on linear theory. In the event that non-linear effects of geometry or materials have a significant influence on the safety of the structure; these effects shall be taken into account. Plasticity theory may be used in checking the exceptional limit state. In this case, the structure shall be shown to be capable of deforming so that the assumed failure lines can develop.

4.2.1 *Load combinations and load coefficients.* For the ultimate limit state all possible loads that can be imposed shall be considered, with the exception of exceptional loads. Deformation loads may be ignored, provided they are not of significance to capacity or stability. The loads shall be combined in the most unfavorable manner, provided that the combination is physically possible. In the ultimate limit state, a load coefficient $\gamma f=1.2$ for all loads shall be used, with the exception of earth pressure, where the load coefficient will be $\gamma f=1.0$. Where the dead load acts favorably, the load coefficient $\gamma f=1.0$ shall be used for the dead load. The load coefficient $\gamma f=1.0$ may also be used for internal water pressure (pore pressure) and for water pressure between the dam and its foundation (uplift).

For the exceptional limit state, relevant exceptional loads shall be considered. For combinations of loads refer to 2.7.1 and 2.7.10. For the exceptional limit state, the load coefficient $\gamma f=1.0$ shall be used.

For the serviceability limit state all operating loads that can be imposed shall be considered. The loads shall be combined to extent it is probable that they can occur simultaneously. For the serviceability limit state a load coefficient $\gamma f=1.0$ shall be used.

4.2.2 *Strength of materials and material coefficients*. The design strength of materials shall be determined by dividing standard values of structural strength by a material coefficient.

4.2.3. *Ultimate limit state.* For the ultimate limit state, it shall be shown that the design load effect does not exceed the design capacity, design strength of materials or permissible strain and that the structure or part of it, regarded as a rigid body, is in static equilibrium.

4.2.4 *Exceptional limit state.* For the exceptional limit state, it shall be shown that the dam is safe against failure when subjected to exceptional loads. The occurrence of local damage may be accepted, provided that the damage does not develop into a progressive failure of the structure. This shall be checked by investigating whether the essential part of the structure complies with the general ultimate limit state requirements where load coefficients and material coefficients for exceptional limit state are used.

4.2.5. *Serviceability limit state.* For the serviceability limit state, it shall be shown that the serviceability and durability of the dam is not reduced as a result of cracking of the structure.

4.3 Structural design

The structural design of the dam shall be such that it acts in a simple static manner, providing transfer of loads to the foundation in a manner that ensures overall stability of the dam and its foundations.

4.3.1. *Foundation.* Where it is technically and economically feasible, concrete dams shall be founded on rock. In special cases, a soil foundation with acceptable bearing capacity may be used provided the soil is or is rendered satisfactorily watertight. If necessary, the foundation of the dam shall be drained to prevent build-up of pore pressures and seepage that can result in instability. The surface of the foundation shall be adjusted to provide favorable interaction between the foundation and the structure of the dam.

4.3.2. *Dilatation joints.* The dam shall incorporate dilatation joints, located so that cracking is avoided to the greatest possible extent. The joints shall be watertight and designed to transfer the forces that can occur. They shall be adequately durable, without the need for maintenance.

4.3.3. *Freeboard.* The dam shall have a freeboard above the design flood water level sufficient to prevent water flowing over the dam thereby causing damage to the dam or the downstream area. Traffic across the dam shall be taken into account. For the exceptional loads causing higher water level, overtopping of dam and gates may be accepted. In such cases the foundations of the dam shall be given adequate protection against erosion.

4.4 Material

4.4.1. *Concrete.* The concrete strength shall be adequate for the required structural performance. The concrete shall be adequately watertight and resistant to chemical attack by water. These requirements shall be satisfied by a concrete that provides minimum risk of cracking.

4.4.2. *Reinforcement*. The reinforcement shall meet the requirements of relevant Tanzanian Standards. Reinforcement of structures subjected to water pressure shall be adequately protected against corrosion.

4.4.3. *Construction specifications*. Construction shall be carried out under conditions which ensure that the quality of the structure will be in accordance with the specifications. Detail drawings and specifications shall be prepared for the execution of the work. The specification shall include requirements for foundation work, for materials, for the completed structures and for the individual items of work.

4.4.4. *Quality control and testing.* Quality control shall be performed in accordance with the requirements set out in 2.5 of the Dam Safety Guidelines.

5.0 DESIGN AND CONSTRUCTION OF TAILINGS DAMS

In these guidelines, the tailings management facility (TMF) is a set of structures required for handling of tailings such as Tailings Storage Facility (TSF) which may include a tailings dam (impoundment or pond), decants structures and spillways. A TSF can also be open pits, dry staking or underground storages. Tailings dam encompasses embankments, dam walls or other impounding structures, designed to enable the tailings to settle and be retained the process water, is decanted for further treatment. The impounding structure must be constructed in a controlled manner.

Tailings impoundment is the storage/volume created by tailings dam or dams where tailings are deposited and stored. Tailings management facility shall be located, designed and built to satisfy established criteria for stability of downstream slope, seepage, overtopping, and earthquake and landslides resistance.

5.1 Design variables

The design of tailings dam shall use tailings-specific variables (tailings composition) and other characteristics of the tailings which affect stability and seepage quantity. Design analysis for tailings dams shall include both undrained strength analysis (USA) and effective stress analysis (ESA).

The design of an impoundment shall consider site specific factors, such as area required for the projected volume of tailings, environmental impact requirements, flood control, ground water and surface water contamination.

Other variables are mill location, topography, hydrology, geology and groundwater, foundations, Emersion Class Number (ECN) and seismicity.

5.2 Starter dam

The internal and external geometry of the starter dam shall be designed and specified for drainage, seepage control, and in some cases liner systems are required to maintain embankment stability and control release to the environment should be included.

The starter dam shall serve as a starting point for continuous embankment construction throughout the active life of impoundment. The construction shall be in accordance with the design requirements set out in the originally approved design and any changes during the time of construction shall be checked and approved by competent professionals.

5.3 Stability

Stability analysis shall be carried out from the initial trial embankment design to final site closure. The dam shall be checked for liquefaction which may result from earthquakes, mine blasting and movement of heavy equipment. The rate of raising/lifting of the embankment shall not endanger the dam stability.

5.4 Decant systems

Decant systems of a TMF shall be designed to cope with the day to day management of the supernatant pond as well as storm condition surges. Decants shall be designed to allow for high surge capacity of storm water to compensate for future storm events and shall be effective in removing ponded water from a tailing facility.

5.5 Freeboard

In these guidelines the total freeboard of a TSF is defined as the vertical height between the waterline and the top of the embankment crest (internal).

- Total freeboard= beach freeboard +operational freeboard

Beach freeboard is defined as the vertical height between the waterline and the beached tailings against the embankment facility. The freeboard shall be designed by water balance calculations taking into account average and extreme conditions to prevent loss of freeboard during operation. The minimum freeboard shall be designed based on rainfall of annual exceedance probability of 1/1000 of a 72 hours duration storm.

5.6 Seepage

Tailings dam shall be designed to take into account seepage control methods to ensure the facility remains perpetually stable but where large settlements are likely to occur; the design should incorporate clay and/or synthetic liners. Synthetic liners should be given priority for seepage control.

The pore pressure profiles and hydraulic gradients shall be well defined for the tailings dam. The regulations made under the Environmental Management Act. No. 4 of 2004 shall not be compromised. The downstream slope of the embankment shall be designed as permeable zones to reduce the height of the phreatic surface in the embankment.

5.7 Embankment construction

Construction shall be carried out under conditions which ensure the required stability and quality of the structure in accordance to the specifications. The upstream slope of tailings dam shall be raised at slopes of 4H: 1V or flatter. Detail drawings and specifications shall be prepared for the execution of the works, from the starter dam followed by subsequent stages of embankment raising. All drainage zones shall be installed during tailings embankment construction and be adapted to the tailings characteristics.

The specification shall include requirements for foundation work, for materials, for the completed structures and for the individual items of work. Any restriction in the rate of raising the impoundment and the tailings dam shall be specified.

5.8 Material

Coarse tailings shall be used in portions of the dams (particularly the starter dam). Waste rock material shall be checked for acid-forming before used to construct embankment. Overburden excavated during open-pit stripping may be used to construct embankment if the soil properties are suitable.

6.0 DESIGN AND CONSTRUCTION OF STEEL STRUCTURES

6.1 General overview

The requirements described in this part apply to steel structures as load bearing and water retaining elements in dams, spillways and diversion works and in other secondary structures in all types of dams, with associated installations, such as intakes. Steel structures shall be designed and constructed to satisfy established requirements as to safety, performance and durability.

6.2 Design

Design loads shall be determined by multiplying characteristic loads by the load coefficients γf specified in part 3.5. In the design of gates and other hydraulic structures, hydrodynamic loads and the dynamic properties of the structure shall be taken into account:

i. If dynamic analyses are not performed, in the ultimate limit state, a load coefficient γf not less than 1.4 shall be used in determining the design water pressure;
ii. For loads on steel linings a load coefficient of γf=1.1 shall be used; and
iii. In calculating the necessary lifting gears, a load coefficient of γf=1.0 may be used for water pressure.

6.3 Structural design

Structures shall be designed taking into consideration the possibility of inspection and maintenance. Hydraulic structures shall be designed so as to avoid cavitation and vibration in the elements exposed to water flow.

6.4 Materials

The steel to be used shall meet the requirements of relevant Tanzanian Standards with adequate strength and corrosion resistance properties for the required structural performance.

6.5 Construction specifications

Construction shall be carried out under conditions which ensure that the quality of the structures will be in accordance with the approved specifications.

6.6 Corrosion protection

Structures exposed to corrosion shall be protected against corrosion and shall be maintained to avoid corrosion damage which can affect the load-bearing capacity, safety, durability or serviceability of the structure.

6.7 Quality control and testing

Quality control shall be performed during fabrication, erection and subsequent concreting of structures.

7.0 INSPECTION AND MONITORING OF DAMS AND TAILINGS STORAGE FACILITIES

Dam owners shall generate a report with minimum content on the instrumentations installed and shall use the guidelines indicated in tables in this section.

7.1 Minimum Inspection Frequency

The inspection/monitoring of dam shall be based on downstream consequences classification which is based on potential hazardous to public safety, the infrastructure or works, other properties or the environment as illustrated in Table 7.1.

Table 7.1 Summary of Minimum Inspection Frequency

Item	Very high risk	High risk	Low risk	Very low risk
Site Surveillance*	Daily	Weekly	Monthly	Quarterly
Formal inspection	Quarterly	Semi-Annually	Semi-Annually	Annually
Instrumentation	As per OMS manual	As per OMS manual	As per OMS manual	N/A

Test operation of outlet facilities, spillway gates and other mechanical component	semi-annually	Annually	Annually	Annually
Emergency preparedness	Update communication directory Semi-annually	Update communication directory	Update communication	N/A
Operation, maintenance and surveillance (OMS)	3 years	5 years	5 years	5 years
Dam safety review	5 years	5 years	5 years	N/A

N/A =Not Applicable

* Measures include but not limited to:

a) Inspection of visible parts of Normal or Tailings dam structure;

b) Checking of internal inspection galleries and wells;

c) Visual inspection of collection wells and discharge points of dam filter;

d) Reading the stand pipes, measuring weirs and other gauges; and

e) Inspection of drains in the downstream area.

7.2 Periodicity of dam inspection under normal conditions

The periodicity of inspection of dams by type based on dam age, starting with the initial filling up to when the dam is over five years after initial filling for embankment dam and for concrete dam once in ten years as illustrated in Table 7.2.

Table 7.2 Periodicity of Embankment dam inspection under normal condition

AGE OF DAM	**Dam Classification**			
	Very high risk	**High risk**	**Low risk**	**Very low risk**
First Filling	Once a day or several times a day (depending on degree of fullness	Once a day or several times a day (depending on degree of	N/A	N/A

	and water level)	fullness and water level)		
Five first years after the first filling	During Rain Period: Once a week During Dry Period: Once a month	During Rain Period: Once a week During Dry Period: Once a month	During Rain Period: Once after flood	During Rain Period: Once after flood
Over five years after the first filling	Frequency of inspection is determined on the basis of monitoring data. If less frequent monitoring is justified, an amendment of the monitoring program shall be approved by the Director.			

Table 7.3 Periodicity of Concrete dam inspection under normal condition

AGE OF DAM	**Dam Classification**			
	Very high risk	**High risk**	**Low risk**	**Very low risk**
First filling	Daily	Daily	Daily	Daily
Once a year	Visual inspection of structures and waterline when water as low as possible including leakages and seepages when water as high as possible.	Visual inspection of structures and waterline when water as low as possible. Inspection of leakages and seepages when water as high as possible.	N/A	N/A
Once in five years or after great releases	Inspection of the bottom downstream from flood gates either visually or with measurements	Inspection of the bottom downstream from flood gates either visually or with measurements	Visual inspection	
Once in ten Years	Submerged structures with the help of a diver	Submerged structures with the help of a diver	Visual inspection when water as low as possible	
When Necessary	Waterways of powerhouse in connection with maintenance	Waterways of powerhouse in connection with maintenance	N/A	N/A

Table 7.4 Periodicity of Tailings/slime dam inspection under normal condition

AGE OF DAM	**Dam Classification (Risk)**
First deposition	Daily
First embankment raising	Weekly
Subsequent embankment raising	Monthly

Table 7.5 Instrumentation for dam safety monitoring

Instruments	**Location**	**Purpose**	**Remarks**
Survey monuments	Along cross sections starting from crest to downstream toe and near the abutments. One line of instruments on deepest section of the dam	Vertical, horizontal and inclined deformation measurements. Surface settlement.	All dams
Subsurface settlement point	Along cross sections starting from crest to downstream toe and near the abutments. One line of instruments on deepest section of the dam	Vertical deformation measurement and subsurface settlement	Should be installed in tailings storage facility or where soils are compressible
Inclinometers casings: vertical	Along cross sections starting from crest to downstream toe and near the abutments. One line of instruments on deepest section of the dam	Vertical, horizontal and rotational deformation measurements	Should be installed in tailings storage facility or where soils are compressible
Piezometers: standpipe, vibrating wire, resistive pneumatic	On downstream slope one line of instruments on maximum section	Pore water pressure measurement	All dams

Instruments	Location	Purpose	Remarks
Digital Accelerographs, Peak reading accelerometers	Crest, abutment and downstream of toe (at a distance of thrice the dam height from the toe) along deepest	Digital accelerometer	Three or more digital accelerographs and one peak-reading for dams in high earthquake areas
Automatic seepage weir	Downstream of toe at appropriate location	Seepage measurement	All dams
Other instruments: Extensometers	For that with high damage potential and dams that exhibit unusual behavior	Vertical, horizontal and inclined deformation measurements, subsurface settlement	

7.3 Dam inspections under emergency conditions

The emergency inspection of dams on potential emergency situation requiring an immediate decision for immediate action for any type of dam once happen are as stipulated in the Table 7.6 below:

Table 7.6 Instrumentation for emergency dam safety monitoring

Actions to be taken	Sub activities	Purpose
Access to the files and information specific to that dam; such information typically kept by the owner of the dam	i. Review of Summary information ii. Review of Design/ As built Drawings iii. Review of Previous inspections report iv. Review of Operations and maintenance manuals v. Review of Emergency Action plan	To determine area of concentration with high risk
Assess potential threats to public safety	i. Evacuation of downstream flood wave impact areas ii. Determining the risk	Establish Limits of Potential Downstream Impacts

	to downstream areas	
In assessing the state of a dam, particularly one which is under stress from a potential failure-inducing condition, it is critically important to know how conditions are changing. Therefore, baseline conditions must be established quickly so that change can be identified and quantified	i. Mark and Record Water Level ii. Measure Seepage and if is of concern, then a means of measuring seepage flow must also be created and compared to allowable seepage. iii. Instrumentation Readings	Establish baseline conditions quickly so that change can be identified and quantified
To develop an understanding of how far the reservoir will rise and/or how much additional flow the spillway will experience	i. Conduct dam break analysis ii. Conduct frequent visual assessment of conation of the dam	Estimating Watershed/Reservoir Response
Proper equipment to access and document the situation	i. GPS Unit, ii. Laptop, iii. Digital Camera, iv. Measuring taps, v. Calculator, vi. Stake or ruler for staff gauge, vii. Personal safety gear	Proper data collection

8.0 REGISTRATION OF APPROVED PROFESSION PERSONS (APP'S)

In dam safety regulations Part I Section 4 (1-2) and section 6 - 8 of the same part, it is clearly stated that any person engaged in dam safety activities should be registered by the Director of Water Resources as APP. Therefore, a person shall not design, construct, rehabilitate, raise, extend or modify any dam without engaging APP(s) registered in accordance with the WRMA and the said Regulations. The APPs shall be

engaged in dam design, construction, operation, inspection, monitoring, maintenance and decommissioning.

The Director has a responsibility to set minimum requirements for registration of APPs and keep a Register or Database. The list of APPs will be supplied to the dam owner upon their request in the specified duration of time as stated in the Regulations or the Director shall approve the nominated APP by the dam owner.

8.1 Procedure for registration of APP's

The following are the procedures for registration of APPs:

i. The applicant shall collect the registration form from the Director or the Ministry of Water website and dully filled, signed and submit to The Director for approval (**refer annex 1**);
ii. The Director may make consultation with Engineers' Registration Board (ERB) and Contractors Registration Board (CRB) to get evidence on the applicant for her/his engagement in engineering activities and any relevance of the information submitted by the applicant;
iii. The Director will nominate a technical team with various disciplines (Engineers, Hydrologists and Geologists) to evaluate the submitted applications. The team shall submit the technical report signed and stamped by the team leader to the Director for approval;
iv. The Director will issue certificate of registration for the qualified applicant after payment of registration fee;
v. The Director shall keep the register of the APP's and will be supplied to the dam owners upon their request;
vi. The APP will remain to be registered by the Director of Water Resources untill there is a technical offence or do not practice in Dam Safety related activities for duration of three (3) years;
vii. After three years, the registered APPs will have to renew the application by submitting the updated CV to the Director;and
viii. The Register of APPs established by the Director is presented in **annex 2**.

9.0 REGISTRATION OF WATER DAMS AND TAILINGS DAMS

The dams with or without safety risks will be registered by the Director of Water Resources. To facilitate such task, the dam owner will have to fill and sign form No. 1 of Dam Safety Regulation of 2013, GN 237 and its Amendment GN. 55 of 2020.

9.1 Procedure for registration of water dams and tailings dams

The following procedure will be followed by the dam owner to register water dam or tailings dams.

i. The dam owner will have to dully fill and sign either water dam or tailings dam registration form, and submit to the Director for consideration (**Annex 4 (1));**
ii. The dam owner shall pay the application fee and Registration fees as stipulated in the Six Schedule of the Regulation to the respective Basin Water Board's Bank Account and submit the copy of the receipt to the Director of Water Resources for registration processing;
iii. The Director will appoint a technical team comprised of Engineers, Environmentalist and Sociologists, Hydrologist and Geologist to review the application (s);
iv. The review team, on behalf of the Director will consult the local authorities to seek the community opinion pertain the dam registration;
v. The technical team will submit a technical report dully filled, signed to the Director for approval;
vi. The Director Within three weeks will notify the dam owner on registration decision. If the application is accepted the dam owner will have to pay for registration fees for water dam and tailings dam depending on the risk category as classified in in part III of Dam Safety Regulations No. 12 (1-4) to the respective Basin Water Board's Bank Account;
vii. The registration will depend on established four risk categories of dams namely; A, B, C and D which are classified as very high risk, high risk, low risk and very low risk respectively (**Annex 3**). The dam registration cost required to be paid by the dam owner should as stipulated in the dam safety Regulation Six Schedule;

viii. The Director will issue a certificate of Registration of Dams with or without safety risks to the owner of the dam;

ix. The Director will gazette in the public newspaper the registered dams; and

x. As it is stipulated in the Water Resources Management Act of 2009 Section 93 (1) the dam owner is required to carry out Comprehensive Facility Review (CFR) after five years. After that period the dam owner will have to apply for registration of the dam by attaching the CFR report of the dam and pay the registration fees as stipulated in the sixth schedule of Dam Safety Regulations.

The dam will be entitled for re-registration after carrying out modification or rehabilitation of Water dam or tailings dam. At this stage the Director of Water Resources will have to verify the application through consultation with the local authority and the cost related will be paid by the dam owner to the respective Basin Water Board's Bank Account.

10.0 GRANT OF CONSTRUCTION PERMIT FOR WATER DAM OR TAILINGS DAM CONSTRUCTION AND REHABILITATION

It is stated that the dam owner shall have a water dam or tailings dam construction or rehabilitation, permit prior to construction rehabilitation, raising, extending or modifying the facility. In order to fulfill the requirements of the law, the dam owner through the engaged APP should be guided on how to carry application for construction permit.

10.1 Procedure for Construction Permits Application and Granting.

The following are the procedures required to be fulfilled by the dam owner during application for construction permit of water dams or tailings dams:

i. The dam owner will fill either water dam or Tailings Dam namely; form number, 1 and 2 respectively with their attachments and submitted to the Director. The Director will conduct a partial review of the submitted document and officially informed the applicants on the date and time to conduct site verification and detailed review of the report. The Dam owner will facilitate the technical team on site verification and detailed review which includes night out allowance, transport, communication and stationary;

ii. Review team should conduct a detailed review in relation to the actual site condition and provide technical advice to the Dam owner accordingly. The engaged APP should ensure that all the raised issues prior to grant of the construction permit at satisfaction of the Director;

iii. The number of days for review and site verification will depend on the project complexity, distance, size and social issues related. However, it is estimated to be at least 7 days for completion of the task; and

iv. Follow up and monitoring of the construction will be conducted by the technical team from Ministry of Water and respective Basin Water Board's on the cost of the dam owner. The cost involved will be as per Tanzania Government rates which include night out allowances, transport, stationaries, contingency[3] (10% of total budget cost) as specified by the Director of Water Resources.

[3]Means car maintenance and emergencies

Annexes

Annex: 1

MINISTRY OF WATER

Application Form for Approved Professional Persons as Per Dam Safety Regulations, 2013
Reg. 4(1)-(3) and 5 (1) – (3)

Name:	
Gender	
Professional Registration Number	
Date for PEng. Registration	
Field Category	
Specific (in years) and attach Curriculum Vitae (CV).	
Over role experiences (in years) and attach Curriculum Vitae (CV).	
Contacts	
• Physical Address	
• Postal Address	
• Mobile Number	
• Other phone number (if any)	
• Fax Number	
• Email address	
Date of Application	
Signature	

For official use only

Approved by:
The Director of Water Resources,
Ministry of Water.
Signature…….
Approved date……

Annex 2

MINISTRY OF WATER

A Register of Approved Professional Persons as Per Dam Safety Regulations, 2013 Reg. 4(1)

S/N	Name	Gender	Professional Reg. No.	Date for Peng. Reg.	Field Category	Specific Experience (Years)	Overall Experience (Years)	Physical Address	Postal Address	Mobile No.	Other phone No. (if any)	Fax No.	Email Address	Date for APP approval
1														
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Annex 3

MINISTRY OF WATER

SECOND SCHEDULE

[Regulation 12 (1)]

CRITERIA FOR CATEGORIZATION OF DAM

Rating (category) [1]	Loss of life	Economic and Social loss	Environmental and Cultural loss
Very high "A"	Large potential for multiple loss of life involving residents and working, travelling, and/or recreating public. Development within inundation areas (the area that can be flooded if the dam fails) typically included communities, extensive commercial and work areas, main highways, railways, and locations of concentrated recreational activity. Estimated loss of life greater than 100.	Very high economic loss affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to larger residential areas (cities and municipals), concentrated commercial land uses, highways, railways, power lines, pipelines, and other utilities. Estimated direct and indirect (interruption of services) costs greater than Tshs. 13 billion	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and/or practicality of restoration and/or compensation is low
High "B"	Some potential for multiple loss of life involving residents and working, travelling, and/or recreating public. Development within inundation area typically includes highways and railways, commercial and work areas, locations of	Substantial economic losses affecting infrastructure, public and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to concentrated commercial land uses, highways,	Loss or significant deterioration of nationally or provincially important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique

[1] **Rating category is based on external risks downstream as a consequence of dam failure**

Rating (category)[1]	Loss of life	Economic and Social loss	Environmental and Cultural loss
	concentrated recreational activity and scattered residences. Estimated fatalities less than 100.	railways, power lines, pipelines, and other utilities. Scattered residences may be destroyed or severely damaged. Estimated direct and indirect (interruption of services) costs are greater than Tshs. 1.5 billion.	landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high.
Low "C"	Low potential for multiple loss of life, Inundation area is typically underdeveloped except for minor roads, temporarily inhabited or non-residential farms and rural activities. There must be a reliable element of natural warning if larger development exists.	Low economic losses to limited infrastructure, public and commercial activities. Estimated direct or indirect (interruption of services) costs could exceed Tshs. 14 millions.	Loss or significant deterioration of regional important fisheries habitat, (including water quality) wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/ or compensation is high, includes situations where recovery would occur with time without restoration
Very low "D"	Minimal potential for any loss of life. Inundation area is typically undeveloped.	Minimal economic losses typically limited to owners' property and do not exceed Tshs 14 million. Virtually no future development of other land uses within the foreseeable future.	No significant loss or deterioration of fisheries habitant, wildlife habitat, rare and/or endangered species, unique landscapes or site of cultural significance.

Annex 4 (1)

MINISTRY OF WATER

FOURTH SCHEDULE

[Regulation 18(2)]

FORM NO. 1

APPLICATION FOR REGISTRATION OF DAM

(To be completed in quintuplicate)

FOR OFFICIAL USE

Application No:…….
Region:……
Basin:……
Catchment:……
Dam Type:……..……

To: The Director of Water Resources,
Ministry of Water
P.O Box 456
Dodoma

1. Name of applicant…….
2. Postal Address…….
3. Physical Address……
4. Email……..Telephone……
   cellphone……
5. Particulars of land in respect of which application is made-

LOCATION AND PURPOSE

(a) Basin…….
(b) Region:……..District:…….
(b) Location or Village:……
(c) Name of Dam: ……..……..
(d) [2]Latitudes:…….....Longitudes: ……..…….
(e) Land Office No:…….
(f) Hectarage……
(g) Leasehold/right of Occupancy for.....years
(h) Title of applicant:……
(i) Name and address of owner of reversion, if any, other than the President (if none, state none):
6. Water Use Permit number :……..
6. Details of land on which a dam is constructed/intended to be constructed: Title No:……

[2] At dam axis where the measured level as the vertical difference between the lowest downstream ground elevation on the outside of the dam and non-overspill crest level or the general top level of the dam wall is the highest

7. Purpose of construction of dam
   (a) Irrigation:
   (b) Fish Farming:
   (c) Industrial:
   (d) Mining:
   (e) Public Supply:
   (f) Hotels:
   (g) Waste Disposal:
   (h) Recreation:
   (i) Power generation
   (j) Others (specify):
   Omit which ever inapplicable
8. Dam characteristics:
   (a) Dam height
   (b) Dam capacity (Mm^3)
   (c) If tailings dam, describe the sealing materials
   (d) Size and capacity of spillway
   (e) Size and capacity of tailrace
9. Particulars of possible pollution:
   (a) Source of pollution:
(b) Measures to be taken to avoid pollution:

Date: …….Signature of Applicant……..

Fee paid in Tshs……. Vide Control No…….. Date……..
Use a separate paper for a ***SKETCH MAP*** which must contain the following particulars:-
(a) The sketch of the property and the adjoining properties;
(b) Installations for dam safety monitoring
   (c) Important features on the land where the facility or the property is located
   (d) The true North
If possible use a tracing from the plan attached to your title deeds.

NOTE:-
   (a) The applicant is required to give the distance in Kilometres and simple description of the road to the property from the turn-off on a main road, or any well-known landmark, to facilitate inspection.
   (b) In case the application is made after the review of the dam, submit the review report

Annex 4 (2)

FORM NO. 2

THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF WATER

CERTIFICATE OF
REGISTRATION OF DAM WITH OR WITHOUT SAFETY RISK

Registration No.: ……..

Pursuant to sections 90 (1) of the Water Resources Management Act. No. 11 of 2009, this registration is hereby issued to:

Name:……

Description:…….

Region:…….....

Basin:…….

Catchment:……..

Latitudes:……..Longitudes:……

Dam Type:……..

Purpose:……

Effective Date: From……..……to…….

This Registration Certificate is granted subject to the provisions of the Water Resources Management Act, 2009 and to conditions in the Dam Safety and Prevention of Flood Risk Regulations of 2010 and special conditions overleaf.

Subject to the following special conditions

…….

…….

…….. **……**

Date **Director of Water Resources**

Annex 5 (1)

MINISTRY OF WATER

FIRST SCHEDULE

[Regulation 9(2)]

FORM NO. 1

APPLICATION FOR WATER DAM CONSTRUCTION PERMIT

(To be completed in quintuplicate)

To: The Director of Water Resources,
Ministry of Water
Government City,
Maji Street,
P.O Box 456,
DODOMA.

1. Name of applicant:…….....
2. Postal Address:…….
3. Physical Address:…….
4. Email:……..Telephone:……..cell phone:……..
5. Particulars of land in respect of which application is made-

The following is a general description of the design, including the various factors involved, the general plans, sections and specifications. Included in the drawings are vicinity maps and curves showing the hydraulic capacities, Items not pertinent to this project are deleted.

LOCATION AND PURPOSE

(a) Basin:……..
(b) Region:……..District:……...……..
(c) Location or Village:…….
(d) Name of Dam:……..
(e) [3]Latitudes:…….Longitudes:……
(f) Land Office No:……
(g) Hectarage:……
(h) Leasehold/right of Occupancy for.....years (h) Title of applicant:……
(i) Name and address of owner of reversion, if any, other than the President (if none, state none):……
(j) Stream/River:……

[3] At dam axis where the measured level as the vertical difference between the lowest downstream ground elevation on the outside of the dam and non-overspill crest level or the general top level of the dam wall is the highest

(k) Purpose: …….
(l) Topographic map (1:5000) (attachment)

SUMMARY OF DESIGN

1. Drainage Area:……....Square kilometers
2. Storage Capacity: ……..….Million cubic metres
3. Maximum Height of Dam: …….....Metres
4. Spillway Capacity: ……..……...Cubic metres per second
5. Top of Dam Elevation: ……..….Metres a.m.s.l.
6. Normal Water Surface Level: …….……..Metres a.m.s.l.
7. Maximum Water Surface Level: ……..…….Metres a.m.s.l.
8. Minimum Water Surface Level: …….Metres a.m.s.l.
9. Freeboard Above Maximum Water Surface Level: …….…..Metres a.m.s.l.
10. Power Capacity: …….....Megawatts
11. General Plans and Sections: ……..…(Attach one copy)

DESIGN DATA

1. Geological/geotechnical Site Report, Author and Date (Attach one copy)
2. Log of test pits and drill holes (Attach one copy)
3. Hydraulic data, capacity requirements
   (a) Storage (Irrigation……**Mm^3**, Flood…….**Mm^3**, Water Supply..….**Mm^3**, Power Generation…….**Mm^3**, Etc.)
   (b) Spillway……m^3/s
   (c) Outlet……m^3/s
   (d) Diversion……m^3/s
   (e) Area-Storage Capacity curves for various Elevations of Water surface
4. Designed by ……
5. Hydrological data
   (a) Hydrographs ……
   (b) Maximum Recorded runoff……..m^3/s
   (c) Maximum anticipated……. m^3/s
   (d) Discharges m^3/s (Probable maximum discharge, 10,000 yr., 1000yr, Etc.)
   (e) Design value and Method
6. Right of way information

RESERVOIR

1. General dimensions:
2. Existing Structures:
3. Proposed Structures:
4. Nature of land flooded and clearing required
5. House elevations and distance from structure or proposed site
6. Relocation required (Railroad, Highway, Telephone, Power, pipelines Etc.)

7. Geology
   (a) General information
   (b) Factors relating to reservoir losses
   (c) Contributing springs
   (d) Deleterious minerals and salt deposits

DAM SITE

1. Geological features, formations:
2. Nature of stream bed and abutments:
3. Interpretation of test pits and drill holes:
4. Percolation tests, groundwater:

DAM

1. Features governing design and location:
2. Water surface elevation, storage capacities, freeboard:
3. Grouting requirements:

SPILLWAY

1. Requirements:
2. (a) Factors governing design and location
   (b) Maximum spillway velocity
3. Type
   (a) Controlled or uncontrolled
   (b) Lining
   (c) Dimensions
   (d) Elevation
4. Gates, gate structures
   (a) Dimensions
   (b) Operation
5. Stilling basin
   (a) General description
   (b) Dimensions
6. Approaches ……..

Owner: ……Date: …….
I certify that the above statements are true and correct
Engineer……
Date……
PE Number……..

SEAL

Annex 5 (2)

MINISTRY OF WATER

FORM NO. 2

APPLICATION FOR TAILINGS STORAGE FACILITY CONSTRUCTION PERMIT

(To be completed in quintuplicate)

To: The Director of Water Resources,
Ministry of Water
Government City,
Maji Street,
P.O Box 456,
DODOMA.

1. Name of applicant: ……..
2. Postal Address: ……..
3. Physical Address: ……
4. Email……..Telephone……..cell phone……..
5. Particulars of land in respect of which application is made-

The following is a general description of the design, including the various factors involved, the general plans, sections and specifications. Included in the drawings are vicinity maps and curves showing the hydraulic capacities, Items not pertinent to this project are deleted.

LOCATION AND PURPOSE

(a) Basin……
(b) Region:…….District:……..……
(c) Location or Village:……
(d) Name of Dam: …….....
(e) [4]Latitudes:……....Longitudes: ……
(f) Land Office No:…….....
(g) Purpose:……
(h) Topographic map (1:5000):…….

SUMMARY OF DESIGN

1. Storage Capacity:……...Million cubic metres
2. Starter Dam height: …….....Metres
3. Footprint Area: ……...Square Metres
4. Design Free Board: ……...Metres
5. Top of Starter Dam Elevation: ……..Metres a.m.s.l.

[4] At dam axis where the measured level as the vertical difference between the lowest downstream ground elevation on the outside of the dam and non-overspill crest level or the general top level of the dam wall is the highest

6. Proposed Stage One Embankment raising…….. Metres[5]
7. General Plans and Sections …….. (Attach one copy)

DESIGN DATA

1. Geological/geotechnical Site Report, Author and Date ……..…(Attach one copy)
2. Site Evaluation, Field Exploration and Laboratory Tests ……..(Attach one copy)
3. Geochemical characteristics of tailings:
4. Stability Analysis:
5. Seepage Flow Analysis and control:
6. Liquefaction assessment of tailings:
7. For Upstream Tailings Dam design analysis of:
    - Undrained strength analysis (USA)
    - Effective stress analysis (ESA)
1. Construction Method:
2. Raised slope for upstream construction:
3. Hydrometrological data
    (a) Isohyets
    (b) Maximum Recorded rainfall
    (c) Maximum anticipated rainfall over 72 hours
    (d) Rainfall (Probable maximum rainfall, 10,000 yr., 1000yr, Etc.)
    (e) Design value and Method
4. Right of way information

TAILINGS RESERVOIR

1. General dimensions:
2. Type of Impoundment:
3. Type of deposition :
4. Minimum beach width:
5. Existing Structures:
6. Proposed Structures:
7. Nature of land flooded and clearing required
8. House elevations and distance from structure or proposed site
9. Relocation required (Railroad, Highway, Telephone, Power, pipelines Etc.)
10. Geology
    (a) General information
    (b) Factors relating to tailings reservoir losses
    (c) Contributing springs
    (d) Deleterious minerals and salt deposits

[5] Subsequent embankments perimeter raising shall require filling the construction permit with updated information on stability analysis, fact of safety and design parameters.

TAILINGS DAM SITE

1. Geological features, formations:
2. Nature of footprint area:
3. Interpretation of test pits and drill holes:
4. Percolation tests, groundwater:

TAILINGS STORAGE FACILITY

1. Features governing design and location:
2. Storage capacities, freeboard:
3. Liners requirements:
4. Under-drainage materials:

DECANTS

1. General description
2. Dimensions
3. Requirements:
4. Factors governing design and location:

Owner: ……Date: ……..
I certify that the above statements are true and correct
Engineer……
Date……
PE Number……..

SEAL