MEMORANDUM CIRCULAR

TO : THE SENIOR DEPUTY ADMINISTRATOR, DEPUTY ADMINISTRATORS, REGIONAL/DEPARTMENT/PROJECT/DIVISION MANAGERS, CHIEF PLANNING AND DESIGN ENGINEERS AND ALL OTHERS CONCERNED

SUBJECT : NIA GENERAL GUIDELINES AND CRITERIA FOR THE PLANNING, DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF RESERVOIR DAMS.

In view of the current Agency’s thrust and program in Irrigation Infrastructure Development and Implementation through the Construction of RESERVOIR/STORAGE TYPE DAMS for Irrigation with other water related components coupled with the increased authority vested to NIA Officials under MC No.55 s.2017 particularly to the Field Managers (RIO’s/DEPT OFFICES/PMO’s/IMO’s) who are authorized to conduct contract procurement under outsourcing scheme of Consultancy Services in undertaking Feasibility Studies (FS), Detailed Engineering Studies/Design (DES/DED), Construction Supervision and Operations and Maintenance activities of Reservoir Type Irrigation Projects/Systems and respective Appurtenant Structures/Facilities including the review of Feasibility Study Reports (FSR’s), DES/DED Plans, Drawings and Reports, and the approval of same. Therefore, it is exigent and timely that NIA as an Irrigation Infrastructure Development and Implementing Agency, formulate and issue its own Guidelines, Policies, Regulations and Criteria on this aspect.

The NIA Central and Field Offices Managers, and Reservoir Dam Planners, Design, Construction, Operations and Maintenance Engineers (including the hired Engineering Consultants/Firms/Entities) shall be required to enforce and apply these Guidelines to ensure and maintain uniform Agency requirements for the preparation, undertaking and conduct of RESERVOIR DAM ENGINEERING AND RELATED ACTIVITIES.

This General Guidelines, Policies, Regulations and Criteria being formulated and issued under this Memorandum Circular shall serve as the Agency’s Regulatory tool, Guidance, requirements and reference for both the new practicing and experienced Planners, Design, Construction and Operations and Maintenance Engineers & Consultants.
in the field of **Reservoir Type Irrigation Projects/Systems** Engineering and Operations activities and undertakings.

Therefore, all concerned **Managers and RIO/PMO/IMO Chief Planning, Design, Construction, Operations and Maintenance Engineers** are obliged to observe application of this **General Guidelines, Policies, Regulations and Criteria** to ensure completeness, uniformity and compliance to AGENCY Requirements which are of vital and a valuable means and aide in the conduct of **Reservoir Dam Engineering and Operations related undertaking**.

This Memorandum Circular shall take effect immediately and shall remain in force unless otherwise supplemented, amended or revoked.

**GEN RICARDO R VISAYA (RET)**
Administrator

Date: 12-10-19
GENERAL GUIDELINES AND CRITERIA
FOR
PLANNING, DESIGN, CONSTRUCTION, OPERATION
AND MAINTENANCE
OF
RESERVOIR DAMS

1ST EDITION
(OCT. 2019)
NATIONAL IRRIGATION ADMINISTRATION (NIA)
EDSA, DILIMAN, QUEZON CITY

GENERAL GUIDELINES & CRITERIA
FOR PLANNING, DESIGN, CONSTRUCTION, OPERATION AND
MAINTENANCE OF RESERVOIR DAMS
(OCT. 2019)

By: JRPacolor/CE

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FOREWORD

In the 1890’s during the Spanish era in the Philippines, the Filipinos built various storage dams, in the selected Spanish settlement sites in the island of Luzon, Visayas and Mindanao. The dams were made of masonry rectangular (adobe) rock blocks, gravity type planned and designed using Spanish Dam Engineering (Guidelines and Criteria) Technology but constructed with the ancient Filipino expertise & ingenuity on similar masonry bricks Construction technique that built almost all Spanish Era Infrastructures.

The dam and reservoir structures were constructed for irrigation and domestic water supply purposes serving the Spanish Friar’s owned and controlled lands. At present these ancient dams and remaining irrigation facilities are still being use to irrigate hectares of rice land and sugarcane crops while the Dam and Reservoir area and perimeter are being developed by the LGU’s for local tourism and amusement parks.

Philippines as a country in the modern time is still a neophyte in the field of modern dam engineering technology compared to industrialized countries but had at least 5 major reservoir dams constructed and operated by different agencies. NIA operates and manages 2 large multi-purpose reservoir/storage type Embankment Dams (Pantabangan and Magat Dams) made of Earthfill and Rockfill Materials with the spillway and outlet structures made of Conventional Mass Concrete (CMC).

More small to large scale Storage/Reservoir Dams are presently being planned and designed by (local and/or NIA) dam design engineers using various references from American (USBR/USACE/FEMA), European, Australian and other Asian design standards, guidelines and criteria.

Medium or Intermediate size Embankment and Concrete type storage dams (Classified & categorized by the USBR and ICOLD as Large Dams) were already constructed under the Small Reservoir Irrigation Project (SRIP) and the Southern Philippines Irrigation Sector Project (SPISP) adopting same foreign (references) design standards, guidelines and criteria.
In 2015, during my assumption as SRIP-PMO Acting Project Manager, and as concurrent Division Manager of the Design and Specifications Division under the Engineering Department, there are about 25 Storage type Irrigation projects with zoned Earthfill type of Embankment dams having heights more than 25.0 meters and storage capacities more than 3.0 Million Cubic meters (MCM) are undergoing construction while more are being scheduled for Feasibility Studies and Detailed Engineering Studies/Design (FS/DES/DED) and shall soon be constructed and be the focus of future dam infrastructure development in this country. Hence, it is exigent for NIA in establishing its own regulations, policy guidelines, standards and criteria on planning, design, construction, operation and maintenance of reservoir dams.

JOSIAS R. PACOLOR/*C.E.
DSD-ED Consultant
ACKNOWLEDGEMENT

This document has been prepared as initial Guidelines and Regulation formulated through the initiative and with the full support of the Administrator, Gen Ricardo R Visaya (Ret), Deputy Administrator for Engineering & Operations, Engr. C’zar M. Sulaik and the Manager of the Engineering Department, Engr. Lydia S. Esguerra.

Grateful appreciation is being conveyed to these top management officials for having concern and volition in addressing the future focus of reservoir dam infra development and in establishing this initial policy guidelines, regulations, criteria and standards in the planning, preparation and undertaking of detailed engineering design/studies, construction, operation & maintenance, integrity and safety monitoring and evaluation of Reservoir/Storage Dams under the NIA’s operational control, jurisdiction and mandate.

Design and Specifications Division Management and Staff under the leadership of Engr. Reyne B. Ugay, Division Manager, DSD–ED and Engr. Emilio M. Domagas, Jr., Chief, CWDS–DSD with the technical and logistics supports provided in the preparation of this document are highly appreciated.

Appreciation is also hereby extended to those persons who provided comments/suggestions for the inclusion of additional related and relevant topics and subject matters.

Further comments/suggestions are being solicited from other fellow dam engineering practitioners to continually improve this document.

*Jrp.
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SECTION 1.0 INTRODUCTION (PURPOSE, SCOPE AND CONTENTS)

1.1 PURPOSE

This NIA General Guidelines & Criteria intends to Supplement and complement existing agency Memorandum Circulars (MC’s) previously issued (Ref. 1,2,3 & 4) and local or National Policies, Laws and Regulations formulated and already in effect relative to the planning and design (Ref. 7), construction (Ref. 6), operation & maintenance including Integrity and Safety Monitoring, Surveillance, Assessment and Evaluation of Reservoir Dams (Ref. 8).

The Criteria has been developed based on the previous written documents from different authors, references on planning, design, construction, operations and maintenance of reservoir dams particularly publications from the USBR, USACE and ICOLD and other Storage/Reservoir Dam Engineering Practices documented within Asia, USA and European Countries.

Some aspect in the Guidelines & Criteria were derived based on the experiences gained by the author in Dam Design and Construction during his previous stint as Head, Civil Works Design Section, under the Design and Specifications Division of the Engineering department (CWDS-DSD-ED), as the Manager of DSD, as Acting Project Manager of the Small Reservoir Irrigation Project (SRIP-PMO), as Engineering (Planning, Design & Construction) Staff in various NIA Projects and as Dam Engineering Design Consultant in private financed projects locally.

Author’s research works/notes on Dam Engineering aspect were also included in this document with the desire to share for the common use of the interested user. It is also intended to cater and address the needs of the young and new dam engineering practitioners, including in particular the NIA dam planners, designers, construction and operations engineers and also to aid the private practitioners, consultants and interested or concerned stake holders as reference and guide in formulating viable alternative technical solutions and applications to some storage dam engineering issues under NIA’s jurisdiction and control.

This document is envisioned to lay the basis in formulating and developing improved, safe, economically designed, constructed, operationally sustainable, viable and socially acceptable Reservoir/Storage Dam structures to be constructed and operated by NIA.
The author had been inspired to prepare this document being the first NIA-General Guidelines and Criteria being formulated and developed for guidance and basis of the Agency’s Planners, Dam Design and Construction Engineers, Dam Operators, Consultants, Contractors, and other private practitioners as reference in the field of dam engineering for application in the Philippines under NIA’s jurisdiction and mandate taking into considerations the prevailing local conditions and setting.

1.2 SCOPE

This General Design Guidelines and Criteria covers the Guidelines and Policies for the preparation of preliminary, Conceptual and Detailed Engineering Studies (DES) & Detailed Engineering Design (DED) of proposed New Storage Dams (Ref. 7) including construction requirements, operation and maintenance and the preparation of rehabilitation, modification, decommissioning, hazard and risk assessment, integrity and safety inspection, assessment and evaluation of existing dams (Ref. 9) constructed, operated and maintained by NIA.

Adoption of the SI-Metric System of Units and Measures as prescribed under (Ref. 8) the Agency’s MC No.58 s.2017 has been applied in this Guideline through conversion of the end results of non-SI unit of Formulas to comply with the Agency’s legal and newly required System of Units for application on planning/design/construction and all other undertaking and transactions requiring the use of Unit/Measures.

1.3 CONTENTS

The document contents include General Guidelines and Criteria for Planning, Design, Construction, Operation and Maintenance for the following storage dams:

- Embankment (Earthfill & Rockfill) Dams
- Conventional Mass Concrete (CMC) Dams
- Mass Masonry Construction (MMC) Dams
- Roller Compacted Concrete (RCC) Dams
- Hard Fill Dams
- Guidelines for Rehabilitation, Modification and Decommissioning of Existing Dams
- Guidelines for the development and formulation of O & M Manual for storage dams
- Guidelines for the Conduct of Dam Safety Surveillance, Inspection & Evaluation
- Supplemental and complimentary guidelines to other NIA existing Policies/Guidelines related and pertaining on Reservoir/Storage Dam Detailed Engineering Design or Studies (DED/DES) aspects.
- Formulae/Equations converted from other Units of Measures to SI-Metric System of Units and Measures as the Agency's legal and newly required System of Units (Ref. 8) for application on planning/design/construction and all other undertakings and transactions requiring the use of measures.
SECTION 2.0         DEFINITIONS, ACRONYMS AND ABBREVIATIONS

2.1 DEFINITIONS

**Agency** refers to the National Irrigation Administration (NIA) unless otherwise specifically named, mentioned and defined in this document.

**Appurtenant structures** are structures or materials built and maintained in connection with dams. These can be spillways, low level outlet works, tunnels, covered conduits and others.

**Arch Dam** is a concrete or masonry dam which is curved in plan so as to transmit the major part of the lateral/horizontal (water) load to the abutment.

**Auxiliary spillway** is a secondary spillway designed to operate only during large floods.

**Borehole** is a hole driven by boring.

**Boring** is an action of driving a hole in ground other than rock by means of a boring rig for exploratory or other purposes (such as water supply, sub-surface exploration for the foundation of dam structures). The rig operates mainly by percussive action and uses augers, clay cutters, bailers and chisels.

**Buttress Dam** is a dam consisting of a water-tight part supported at intervals on the downstream side by a series of buttresses. A Buttress dam can take many forms.

**Catchment Area** is the area which drains naturally to a particular point of a river. Similarly defined with drainage area.

**Catchment Boundary** is the boundary or perimeter of a catchment area.

**Clays** are fine grained soils having particle size smaller than 2.0 microns (0.002 mm)

**Cofferdam** is a temporary or permanent structure enclosing all or part of the construction area so that construction can proceed in the dry. A cofferdam may become a permanent structure when designed to be integrated as permanent part of a major structure.

**Compaction** is a mechanical process and action which increases the density and reduces the voids of a material

**Conduit** is an enclosed channel used to convey flows through or under a dam.
**Consolidation** is a natural settlement or action which tends to solidify, strengthen or increase the density of a material.

**Dam** is a structure or any artificial barrier and its appurtenances constructed for the purpose of diverting or holding water, other fluids, sediments including debris for any or whatever purpose.

**Detention Basin** is any structure that functions as a reservoir/storage dam.

**Diversion Cofferdam** is a temporary structure which diverts a river into a pipe, channel or tunnel.

**Drainage Area** is the area which drains naturally to a particular point on a river.

**Drill hole** is a hole driven by drilling action.

**Drilling** is an action of driving a hole in hard ground by means of a drilling rig for exploratory or other purposes. The rig uses a rotary tool armored with diamond bits, hardened steel or other materials. The rotary tool is usually cooled by water or air which also removes the drill cuttings.

**Earthfill Dam** is structure made by compacting excavated earth obtained from borrow area/s. It is an embankment dam in which more than 50% of the total volume is formed of compacted fine-grained materials obtained from borrow areas.

**Embankment Dam** is a hydraulic structure made by compacting excavated natural earth and/or rock materials obtained from borrow area/s. Embankment Dam can be constructed as an Earthfill Type, Rockfill Type and/or the combination of both.

**Energy Dissipator** is an appurtenant structure constructed in combination with major hydraulics structure for the purpose of reducing the energy of high velocity flowing water or fluid.

**Epicenter** is that point on the Earth’s surface which is directly above the **Focus** of an earthquake.

**Flood Hazard** is the potential loss of human life or property damage downstream of a dam from flood water, floating matter or sediments released from a dam or discharged from a dam-break.

**Flood Routing** is the computation done which is used to evaluate the interrelated effect of the inflow hydrograph, reservoir storage, spillway or diversion conduit discharge from the
reservoir. It is also defined as the attenuating effect of storage on a flood passing through a valley, a channel or reservoir by reason of a feature acting as control.

**Fetch** is the distance over which the wind can act on a body of water in a reservoir and generally the normal distance from the windward shore to the structure being designed.

**Freeboard** is the vertical distance between the design high water level and the top or crest of the dam.

**Freeboard (Minimum)** shall be defined as the difference in elevation between the crest of the dam and the Maximum Reservoir Water Surface that would result the Inflow Design Flood (IDF) occur and should the Outlet Works and Spillway functions as planned.

**Freeboard (Normal)** shall be defined as the difference in elevation between the crest of the dam and the Normal Reservoir Water Surface requirement as fixed by design requirement.

**Gravity Dam** is a dam constructed out of concrete and or masonry which relies on its weight for stability.

**Hazard-Threat** Condition which may result from either an external cause (e.g. earthquake, flood, or human action/intervention) or an internal vulnerability with the potential to initiate a failure mode; a source of potential harm or situation with a potential to cause loss.

**Height (Hydraulic)** is the difference in elevation between the maximum controlled upstream or reservoir water surface level and the lowest point in the original stream bed at the dam axis or the lowest downstream tailwater surface level. It is defined further as the difference between the upstream and downstream water surface level in a dam.

**Height (Structural)** - is the difference in elevation between the top or crest of the dam and the lowest portion in the excavated foundation level or the lowest point at the toe of the dam.

**Hypocenter** is the point within the earth which is the center of an earthquake and the origin of its elastic wave. Having similar definition with **Focus**.

**Intensity Scale** is an arbitrary scale to describe the degree of earth shaking at a particular place. The scale is not based on measurement but an assessment by an experienced observer. (e.g. Modified Mercalli Scale, the Rossi-Forrell Scale)

**Low-Level Outlet** is an opening at a low level used to drain or lower the reservoir water level.
**Magnitude** is a rating of a given earthquake independent of the place of observation. It is calculated from measurements on seismographs and it is properly expressed in ordinary numbers and decimals based on logarithmic scale.

**Phreatic Surface** is the free surface of a seeping ground water at atmospheric pressure.

**Probable Maximum Precipitation (PMP)** is the maximum amount of precipitation that can be expected over a drainage basin.

**Probable Maximum Flood (PMF)** is the flood that can be expected from the severest combination of critical meteorological and hydrological conditions possible for the particular region. It is the flow resulting from Probable Maximum Precipitation (PMP).

**Reservoir** is an artificial body of water or lake formed due to development of obstruction on a natural waterway or the construction of a barrier or dam on a river channel.

**Risk** the likelihood of unwanted events (such as catastrophic failures or unsatisfactory performance) and their associated consequences; the probability of a particular undesirable outcome occurring within a specified period; a measure of the probability and severity of an adverse effect to life, health, property and the environment.

**Richter Scale** is a seismic scale devised by C. F. Richter to describe the magnitude of an earthquake by measurements made in a well-defined condition and with a given type of seismograph.

**Rocks** are materials which include fragments produced by quarrying or occurring naturally as talus and sub angular or rounded fragments such as coarse gravel, cobles and boulders.

**Rockfill Dam** is a hydraulic structure that relies on rock, either dumped in the lifts or compacted in layers as a major structural element. It is an embankment dam in which more than 50% of the total volume comprises compacted or dumped pervious natural or crushed stone or hard rock material.

**Seismic Intensity** is the subjective measurement of the degree of earth shaking at a specified place by an experienced observer using a descriptive scale.

**Silts** are fine grained soils with size range between 2.0 microns and the No.200 sieve size (0.002 mm – 0.074 mm)

**Spillway** is a hydraulic structure or an appurtenant structure of a storage dam which discharges flow or function as an outflow/outlet structure.
**Spillway Design Flood (SDF)** is the largest flow that a given spillway structure is designed to pass safely.

**Small Reservoir Dam** is a dam having a height of **15 meters and below (less than 15m height by USBR & ICOLD definition, less than 30 meters height by Indian/Turkey countries definition)** and or with a reservoir capacity below 1.25 Million Cubic Meters (MCM).

**Surcharge Head** is the difference between the Normal and Minimum Freeboard.

**Toe of Dam** is the junction of the downstream face of a dam and the natural ground surface, also referred to as downstream toe. For an earth dam the junction of the upstream face with the ground surface is called the upstream toe.

**Watershed** is the boundary between catchment areas or drainage areas.

### 2.2 ACRONYMS

- **ASEP** Association of Structural Engineers of the Philippines
- **CMC** Conventional Mass Concrete
- **CMD** Construction Management Division
- **DBE** Design Basis Earthquake
- **DENR** Department of Environment and Natural Resources
- **DSD** Design and Specifications Division
- **FEMA** Federal Emergency Management Agency of the USA
- **GFC** Good for Construction
- **ICOLD** International Commission on Large Dams
- **IEC-NIA** Irrigation Engineering Center-NIA
- **IDF** Inflow Design Flood
- **IDR** Irrigation Diversion Requirement
- **IMO** Irrigation Management Office
- **IP** Indigenous People
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>MCC</td>
<td>Mass Concrete Construction</td>
</tr>
<tr>
<td>MCE</td>
<td>Maximum Credible Earthquake</td>
</tr>
<tr>
<td>MDE</td>
<td>Maximum Design Earthquake</td>
</tr>
<tr>
<td>MMC</td>
<td>Mass Masonry Construction</td>
</tr>
<tr>
<td>NAMRIA</td>
<td>National Mapping and Resource Information Authority</td>
</tr>
<tr>
<td>NCIP</td>
<td>National Commission on Indigenous People</td>
</tr>
<tr>
<td>NIA</td>
<td>National Irrigation Administration</td>
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<tr>
<td>OBE</td>
<td>Operating Basis Earthquake</td>
</tr>
<tr>
<td>O &amp;M</td>
<td>Operation and Maintenance</td>
</tr>
<tr>
<td>PAGASA</td>
<td>Philippine Atmospheric Geophysical Astronomical Services Administration</td>
</tr>
<tr>
<td>PHRC</td>
<td>Potential Hazard &amp; Risk Classification</td>
</tr>
<tr>
<td>PNCOLD</td>
<td>Philippine National Commission on Large Dams</td>
</tr>
<tr>
<td>PMF</td>
<td>Probable Maximum Flood</td>
</tr>
<tr>
<td>PMP</td>
<td>Probable Maximum Precipitation</td>
</tr>
<tr>
<td>PRS'92</td>
<td>Philippine Reference Survey of Year 1992</td>
</tr>
<tr>
<td>RCC</td>
<td>Roller Compacted Concrete</td>
</tr>
<tr>
<td>RIO</td>
<td>Regional Irrigation Office</td>
</tr>
<tr>
<td>SEE</td>
<td>Safety Evaluation Earthquake</td>
</tr>
<tr>
<td>SMD</td>
<td>System Management Division</td>
</tr>
<tr>
<td>USBR</td>
<td>United States Bureau of Reclamation</td>
</tr>
<tr>
<td>USACE</td>
<td>United States Army Corps of Engineers</td>
</tr>
<tr>
<td>US FEMA</td>
<td>United States Federal Emergency Management Agency</td>
</tr>
</tbody>
</table>
2.3 ABBREVIATIONS

Cu.m  Cubic meter
CMS  Cubic meters per second
cm.  Centimeter
Has.  Hectares
Lps.  Liters per second
Lps/ha.  Liters per second per hectare
MCM  Million Cubic Meter
Mm.  Millimeter
Mts.  Meters
SECTION 3.0  DAM CLASSIFICATION SYSTEMS, TYPES OF DAM, DAM AND RESERVOIR SITE SELECTION GUIDELINES AND CRITERIA

3.1.0  DAM CLASSIFICATION SYSTEMS

3.1.0.1  This Guideline introduces and prescribes two (2) Reservoir /Storage Dams Classifications Systems which NIA shall adopt. These Classifications shall serve as one of the basis for establishing (of appropriate Flood & Earthquake loading magnitude and loading conditions, sizing of hydraulics & structural appurtenances elements based on the result of the conduct of Hazard and Risk Assessment) and prescription of Design Criteria for Inflow Design Flood (IDF) and Maximum Design Earthquake (MDE) or Safety Evaluation Earthquakes (SEE) and any other applicable loading conditions for the (Proposed/New and Existing) Dam and Reservoir Structures which the Agency, dam engineers, designers, owners/operators intends to design, build, operate and maintain.

3.1.0.2  The following Reservoir Dam Classification Systems shall be adopted and to be applied under this Guideline:

1. SIZE CLASSIFICATION, (SC) and
2. POTENTIAL HAZARD & RISK CLASSIFICATIONS (PHRC)

3.1.1.0  DAM SIZE CLASSIFICATION SYSTEM

All Dams currently under the Planning or Detailed Design Stages and/or (New & Existing) constructed, owned and under operational control (operated) by NIA shall be classified according to SIZE (Dam Height and/or Reservoir/Storage Capacity) as basis for proper identification, description and prescription of design and safety evaluation loading criteria and conditions.

3.1.1.1  GENERAL DEFINITION

Dam and Reservoir Size Classification shall be the description and condition of the structure according to its height at foundation level and/or Reservoir Storage Volume at maximum design capacity condition which ever shall govern.
3.1.1.2 DAM SIZE CLASSIFICATION DESIGNATION.

The Size Classifications (SC) and corresponding descriptions and qualifications (according to Height and Storage Volume) being introduced for adoption in this guideline shall be based on the definition specified under NIA-MC No.91 s.2017 (Ref.#7) and/or as defined below:

**SMALL DAMS**- Dams having height of 15.0 meters and below or with reservoir storage capacity of 3.00 Million Cubic Meters (MCM) and below.

**MEDIUM OR INTERMEDIATE SIZE DAMS**- Dams having height above 15 meters up to 75.0 meters or with reservoir storage capacity above 3.0 MCM up to 60.0 MCM.

**LARGE DAMS**- Dams having height above 75.00 meters or with reservoir storage capacity above 60.0 MCM.

3.1.2 POTENTIAL HAZARD & RISK CLASSIFICATIONS (PHRC) SYSTEM

3.1.2.0.1 All existing, newly constructed and proposed NIA Dams and Reservoirs shall be identified and assigned with Potential Hazard & Risk Classification (PHRC). This process and task shall be a joint undertaking and responsibility of the qualified dam engineering experts and/or experienced Dam Designers and the Agency Dam Safety Engineers or hired/commissioned Consultants.

3.1.2.0.2 The Dam Design Engineers or Dam Safety Professionals comprising of composite discipline/experts (Engineering Geologist, Seismologist, Geotechnical Engineer, Geophysicist, Engineering Hydrologists, Civil, Hydraulics, Structural, Electrical, Electronics, Mechanical Engineers and Environmental Engineer/Scientist) shall prepare an Assessment and Evaluation Report of the description of conditions and judgment of the degree and classification level of the Potential (Downstream) Hazard of the Dam and Reservoir Structure brought about by flood, geologic, seismic/earthquake, structural, Electro-mechanical and human induced (Sabotage) hazards and risk including the corresponding effect upon human life, properties, infrastructures (residences, buildings, roads and highways, utilities and other facilities), economic Activities and Environmental consequences if the dam fail.
3.1.2.1 DAM & RESERVOIR POTENTIAL HAZARD & RISK CLASSIFICATIONS (PHRC) DESIGNATION SYSTEM

3.1.2.1.1 NIA dam design engineers and consultants shall be required to establish and properly assess, categorize and shall ultimately specify the Potential (Downstream) Hazard & Risk and Size Classifications of the proposed Reservoir/Storage Dam structure they are about to developed during the planning stage and during the conduct of the detailed engineering studies/design.

3.1.2.1.2 All NIA existing Storage/Reservoir Dams shall undergo similar assessment and evaluation processes for the purpose of Dam Safety Assurance and shall at same period and time be also assigned/prescribed with an Updated Hazard Classification after each and every conduct of Formal Dam Integrity and Safety Assessment and Evaluation as prescribed under SECTIONS 21 and 23 respectively.

3.1.2.1.3 The Dam and Reservoir Potential Hazard & Risk Classification Designation (PHRCD) shall be presented in an Alpha-Numerical form of designation with the corresponding potential damages and risk rating. For Initial Assessment and Rating Methods and Procedure, the prescribed and acceptable method and procedure shall be by Rule of Thumb or by Engineering Judgment Method. When a more detailed (qualitative and quantitative) method of assessment is being done or required, the procedures and provisions prescribed in SECTION 21.0 or as presented and reflected in Table 3.1.2 and/or as defined and described (under this section) below shall apply:

**PHRC-1** - (LOWHAZARD)-Dam failure will cause minimal damages to inundated areas, affected properties, isolated rice lands and crops, farm lots and farm structures, undeveloped lands, trails, barangay roads and crossing structures and has no risk to human life and cause only minimal damages to environment.

**PHRC-2** - (SIGNIFICANT/MODERATE HAZARD)-Dam failure can cause major damages to local village/s or barangays, can cause loss of homes, properties, live stocks &large cattle/animals, can cause significant damages to municipal and provincial roads or highways, minor railroads and bridges or interrupt use or service of important local public utilities, will cause risk of loss of
human life, significant damage to environment and will cause significant economic and social disruption.

**PHRC-3** (HIGH/EXTREME HAZARD) - Dam failure has great potential or can cause loss of Human lives, homes and properties, can cause serious economic and social disruption and extensive damages to industrial and commercial areas and buildings, important public utilities, national or major highways, railroads and bridges, can cause paralysis to domestic operation and activities of public/local government units and private entities and entail extreme environmental damages.

### Table 3.1.2 - DAM AND RESERVOIR POTENTIAL HAZARD & RISK CLASSIFICATIONS (PHRC) DESIGNATION SYSTEM

<table>
<thead>
<tr>
<th>RISK</th>
<th>PHRC DESIGNATION &amp; RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PHRC-1 (Low)</td>
</tr>
<tr>
<td>1.*($H^2\cdot V^{1/2}$)</td>
<td>($H^2\cdot V^{1/2}$)&lt; 25.0</td>
</tr>
<tr>
<td>2. Life Safety (Lives in Jeopardy) Risk/Loss of Life</td>
<td>None/Loss of human life is unlikely and not expected</td>
</tr>
<tr>
<td>3. Economic Risk</td>
<td>Low</td>
</tr>
<tr>
<td>4. Environmental risk</td>
<td>Low</td>
</tr>
<tr>
<td>5. Social disruption risk</td>
<td>Low (local /Rural Area)</td>
</tr>
</tbody>
</table>

*($H^2\cdot V^{1/2}$) – Shall be one of the Criterion for Potential Hazard & RISK Classifications (Ref. # 22)

**Note:** The parameter ($H^2\cdot V^{1/2}$) is an indicator of potential Risk downstream of the dam and correlates with the Peak Downstream Flood Wave in the event of complete...
Dam Breach. Where: H=Height of dam above reservoir bed in Meters, and V=Reservoir Storage volume in Million Cubic Meters

3.1.2.2 PHRC GENERAL ASSESSMENT CONSIDERATIONS

3.1.2.2.1 NIA or any of its duly authorized Dam Design Engineers, Agency Dam Safety Officer, Commissioned Dam Safety Entities or Consultants shall undertake assessment and shall consider Dam height, Reservoir storage capacity, geological condition, site seismicity, proximity to active faults, proximity to densely populated or settlement areas, food production areas and environmental consequences in prescribing the PHRC level of all existing Dams and Reservoirs including those under the Planning Stage/Feasibility Study and those subject to/ongoing DES/DED or whose DES/DED has been completed but construction has not yet implemented.

3.1.2.2 There shall be future or projected assessment of population density, land use and zoning of the downstream of the damsite location. These are vital information in identifying the potential future hazards that the structure shall impose if dam break occurs.

3.1.2.3 As a requirement in undertaking a more detailed or quantitative Potential Hazard and Risk Assessment, a Dam Break Simulation Studies shall be done mandatorily to establish the effect of Flood Wave and delineate the possible inundated areas (Inundation Map) affected downstream and to properly evaluate and establish the Potential Hazard Classification of the Dam and Reservoir structure and finally be made as the basis in the preparation and establishment of the Design Criteria for Rehabilitation/Modification/ Decommissioning of the New/Existing dams and the Formulation and Updating of an Emergency Action Plans (EAPs)/Emergency Preparedness Plan (EPP) and Impact Mitigation Plan (IMP) for Existing Dams with processes as prescribed under Sections 21.0 and 22.0, respectively.

3.1.2.4 Dam Break Simulation Studies shall not be required and shall not be needed for NIA reservoir dams with Low Potential Hazard & Risk Classification (PHRC-I) Rating and having height lower than 6.0 meters or less than 0.50 MCM reservoir capacity provided that the downstream river reach within the first to 5.0km from dam axis has no established or shall not be allowed to establish future community or settlement area, commercial
and industrial complexes and home sites or there will be no risk for potential loss of human life and major properties if ever the dam will breach.

3.2.0 TYPES OF RESERVOIR DAMS (ACCORDING TO MATERIALS AND CONSTRUCTION METHOD) COVERED UNDER THIS GUIDELINES

3.2.0.1 This Guideline shall cover Three (3) types of reservoir/storage dams which are currently of practical application locally, site specific adoptability and world-wide acceptance.

These types of Reservoir /Storage Dams (according to kind of materials and method of construction) shall cover and be limited to the following:

1) Embankment (Earthfill & Rockfill) Dams
2) Conventional Mass Concrete or Masonry (CMC/CMM) (Gravity, Buttress, Arch and/or Combination) Dams
3) Roller Compacted Concrete (RCC) Dams (Gravity and Arch) and Concrete Faced Roller Compacted Soil-Cement (RCSC) Dams or Hardfill Dams.

Hardfill Dams shall be limited to Gravity type and with structural height limit of 30.0meters unless proven that higher height limit can be made safe and economically constructed in the Philippines.

3.2.0.2 These dams specified under Section 3.2.0.1 shall be subjected for classification assignment under the two (2) Dam Classifications System (Dam height or Storage Volume and Potential Hazard & Risk Classification) that had been introduced and specified in Sections 3.1.1, and 3.1.2 and as further defined under each corresponding Sub-Sections for adoption under these guidelines.

3.2.0.3 The types of Reservoir Dams under these guidelines shall be further subject to the limitations specified and enumerated in SECTIONS 3.2.1.0, 3.2.2.0 and 3.2.3.0 respectively.

3.2.0.4 Other types of dams to be constructed (with different materials and subject to special and unconventional method of construction) other than those specified under these guidelines shall be subject for NIA approval prior to adoption and implementation.
3.2.0.5 Due to the latest advancements and new development in dam engineering, other types which are of similar characteristics, similar design and construction principle involved and had been developed and constructed in other countries shall be considered. Provided, that it shall be substantiated and had proof that the type of structure application had already gained satisfactory performance records and may be replicated in this country and can be proven that it will perform satisfactorily and can be operated safely during the entire design service or economic life of the structure.

3.2.0.6 Types of Dams and its appurtenances having special or innovative design features or under experimental stage of development shall also be allowed in a case to case basis to be constructed by NIA provided, the structure shall be for limited use only or for experimental purposes and for the advancement of the Dam Engineering Design and Construction Technology. Dams classified under the above-mentioned categories shall be subject to Mandatory Numerical and Physical (Hydraulics and Structural) Modeling Studies.

3.2.0.7 The Dam Engineer and commissioned/hired Consultants responsible for the design, construction and operation of these Experimental Structures shall ensure that defensive design features had been incorporated and the availability of safety measures and the provisions of warning facilities are fully established as contingency measures during emergency situations and in case of critical dam incidences.

3.2.1.0 APPLICATION LIMITATIONS GUIDELINES FOR RESERVOIR DAMS

3.2.1.1.0 EMBANKMENT DAMS

Embankment Dams covered under this guideline shall be limited to the following:

1. EARTHFILL DAMS, and
2. ROCKFILL DAMS

3.2.1.1.1 EARTHFILL DAMS (EFD’s)

Basic Sections of Earthfill Type of Embankment Dams are shown on Figures 14.1.1A, 14.1.1B &14.1.1C for basic configuration reference purposes only.
Earthfill dams considered under this guideline shall be subject to the following application limitations:

a. Homogeneous (H-type) and Modified Homogeneous (MH-type) Types- Shall be applicable to Small and medium size dams with maximum structural height limit of 15.0 meters (for H-types) and 30.0 meters (for MH-type) respectively. This type of embankment dams shall be discouraged and minimize its application or construction to regions/localities having the Type-II and Type-IV (Wet & Very Wet) Philippines Climatic condition.

b. Zoned type - Shall be applicable for dam structural heights up to or greater than 100.0 meters depending on the capacity and geological conditions of the foundation to sustain/carry the weight of the dam structure.

c. Diaphragm type - This type shall be applied even for dam structural heights greater than 100.0 meters depending on the capacity of the foundation.

In general, the adoption/application of Earthfill type of embankment dams shall be minimized to regions/localities having the Philippine type-II and type-IV climatic conditions due to probable prolonged construction duration and weather induced unfavorable/altered material (index) properties that needs to be treated first (which is an expensive/costly process) prior to placement as embankment materials. However, application of this type of dam for the specified climatic condition may still be considered and shall be decided on the basis of availability of acceptable construction materials, project duration and overall project/contract cost.
3.2.1.2 ROCKFILL DAMS (RFD’s)

For basic information, reference purposes, the basic Sections of Rockfill Type of Embankment Dams are shown on Figures 14.1.2A, 14.1.2B & 14.1.2 C.

Application of this type of embankment dam shall be decided on the basis where dam site topography, dam foundation and reservoir geology is ideally suitable and adequate quantity of suitable rock materials is available. This type of dam can be constructed to all regions/localities having even the worst/adverse type of climatic conditions. Height application of this type shall be in very wide range and covers both the Small, Intermediate and Large dams as classified under Section 3.1.1.0 of this guideline.

Rockfill Embankment Dams shall be designed to consist of the following major discrete/sectional parts:

1. **Impervious Core or Sectional Part**-composed of compacted soil or Impervious Upstream Surface Slope of facing materials consisting of other materials such as reinforced concrete or asphaltic concrete.

2. **Transition Zones**- provided usually on both sides of the core composed of relatively small sized rock particles or gravel and sand with a well graded composition.

3. **Filter Zones**–composed of clean but well graded sand.

4. **Internal Drain Zones**- composed (if required) of clean, pervious (processed) rock particles, and

5. **Rockfill Shells**- composed of coarse rock fragments or cobbles and gravels, ranging widely in particle gradation but commonly with a maximum size of about 460.00 mm. to 1220.00 mm. (18.0 inches to 48.00 inches), grading down to fines of 20% to 40% passing a (1.0 inch) 25.40mm sieve and 5% to 15% passing 4.75mm (No.4) sieve.

The Rockfill materials shall be placed in lifts with thickness commensurate with the maximum particle size and compacted by rolling and vibrating with mechanical equipment and shall be wetted but not often flushed with water.
6. **Coffer Dams** (Upstream/Downstream) shall be treated as either temporary or incorporated as permanent part of the embankment dam structure. Shall be composed of random fill/rock fill shell and impermeable to semi-permeable core capable of preventing seepage entry and diversion flood overflow during construction into the main working area. The main function is to confine and protect the working area during foundation excavation and early stages of embankment construction (filling & compaction) from being flooded.

Rockfill type dams that are covered and considered under this guideline are:

a. **Impermeable Faced Rockfill type dams** – The application of this type shall be limited to small up to intermediate size dams with height not to exceed 30.0 meters.
   1. Concrete Faced Rockfill Dam (CFRD)
   2. Asphaltic Concrete Faced Rockfill Dam (ACFRD)

b. **Imperm eable Earth Cored Rockfill type dams**- Height application shall always be governed and dependent on the sufficient quantity, type of core materials, soundness and suitability of the foundation.

   b.1. **Sloping Earthfill Core type RFD** - Applicable to any height range (wider application for dams greater than 100.0 meters) where foundation is suitable and construction materials are sufficiently available.
   b.1.1. Moderately Sloping Earthfill Core
   b.1.2. Extremely Sloping Earthfill Core

   b.2. **Central Earthfill Core type RFD**-
   Same application with item b.1
   b.2.1. Thin Central Earthfill Core (Diaphragm Type) RFD
   b.2.2. Thick Central Earthfill Core

c. **Rigid core type RFD**- Application shall be limited and restricted to Small Size Class (height less than 15.0 meters) dams.
3.2.2.0 CONVENTIONAL MASS CONCRETE (CMC) AND OR MASS MASONRY CONSTRUCTION (MMC) RESERVOIR/STORAGE DAMS

CMC and MMC Dams (Gravity, Buttress and Arch type dams) shall be designed and shall be traditionally constructed by conventional methods involving the use of Reinforced or Un-reinforced Mass Concrete or Mass Masonry Construction with or without admixtures. (MCC or MMC)

3.2.2.1 CMC AND MMC GRAVITY DAMS

Gravity Dams of this kind shall be designed and constructed preferably with locally available construction materials and admixtures that shall be mixed to form a strong dam body. These materials shall be limited to Conventional Mass Concrete, Rubble Masonry with Concrete Binder, Plain Concrete, Reinforced Concrete and/or Composite Section with Rubble Masonry and Reinforced Concrete Materials.

Adoption of other materials for dam body other than that specified in this guideline shall not be allowed. Except, where metal parts of the appurtenances like the Outlet Works and Spillway Gates and Lifting /control mechanism are so required and specified.

Applicability of this type of Dams shall be governed under the provision of Section 3.3.1.0- (Factors Governing Selection), Section 3.1.1.0 – (Size Classification) and Section 3.1.2.0- (Hazard Classification) of these guidelines.

3.2.2.2 CMC /MMC ARCH AND BUTTRESS DAMS

Arch and Buttress Dams covered by this guideline shall be designed and constructed with materials limited to (plain and/or reinforced) Conventional Mass Concrete (CMC), Mass Masonry Materials and required Admixtures. Except, where metal parts of the appurtenances like the Outlet Works control and regulating gates/valves /stoplogs/bulkheads and Spillway Gates and Lifting or hoisting mechanism are so required and specified.
3.2.3.0 ROLLER COMPACTED CONCRETE (RCC) DAMS AND CONCRETE FACED ROLLER COMPACTED SOIL - CEMENT (RCSC) OR HARDFILL DAMS

Application of RCC Dams shall cover the gravity and arch or any of the combinations of the types of Roller Compacted Concrete regardless of size/height classifications and as to the foundation condition and capacity shall allow.

Concrete Faced Roller Compacted Soil-Cement (RCSC) or Hardfill type dam’s application shall be limited to Gravity type only. The herein specified type of dams shall be constructed of site available and suitable soils with cement based binding materials constructed through Roller Compaction Equipment.

Hardfill Dams shall be limited to Gravity type and with structural height limit of 30.0meters unless proven that higher height limit and foundation can be made safe and economically viable.

Application of Hardfill type of dam in the Philippines for now shall be limited to Gravity Type with a maximum structural height of 30.0 meters. The restriction imposed is due to very limited performance data observation on the NIA existing Hardfill dam which to date is not yet conclusive and the present knowledge of application being experienced is likewise still limited.

Higher height application shall be considered and maybe allowed (on special application case/s) for Hardfill dam if the Design Engineer can provide enough justification/s (duly supported by Numerical and Physical Modeling Studies and subjected to VE/VA analysis and assessment) acceptable to NIA-CO-DSD and to the Agency’s Central Dam Safety Office (CDSO) and shall substantiate that this type of dam shall have adequate margin of Factor of Safety available and cost shall be more economical than the other type of dams covered and specified under these Guidelines.
SECTION 3.3.0   DAM & RESERVOIR SITE SELECTION GUIDELINES & CRITERIA

3.3.1.0   DAMS AND RESERVOIRS: GENERAL SITES SELECTION CRITERIA

Dams and reservoir sites shall be selected on the basis of the criteria and conditions stated and specified under this section and subject to the provisions and requirements stipulated in Section 6.0 and Section 9.0 respectively.

3.3.1.1.0   FACTORS GOVERNING SELECTION OF DAM TYPE AND DAM AND RESERVOIR SITE

The selection of dam and reservoir site and the type of dam to be adopted shall be governed by, but not limited to the following general factors enumerated below:

1. Topography
2. Geology and Foundation Conditions
3. Availability of Materials
4. Vital appurtenances (Spillways, Outlet works, Tunnels, Galleries & Adits) Size & Location
5. Climatic condition, Legal, Esthetic, Social, Environmental, Economic & Cost Considerations

Items 1-5 as enumerated above shall be governed and subject to the provisions and prescribed conditions of the related items under Sections 5.0 and 6.0 of these guidelines.

The following Site Specific/ Special Conditions and Criteria in addition to the above general factors (items 1-5) shall be considered for the selection and prioritization of Reservoir Area Sites.

1. Shall not be covered nor within the Protected Area Management Bureau (PAMB) jurisdiction of the DENR.

2. Shall not submerge or encroach permanent settlement site in large coverage (Barangay/Municipality), important heritage sites, major infrastructure of provincial regional/national impact, value,
interest and holy grounds, burial sites, settlement sites of Indigenous People.

3. No known presence of existing subterranean channel, volcanic vents, sink holes, concentrated leak (highly pervious strata/layer) of reservoir rim/banks and other unfavorable geologic features.

4. The reservoir area shall not be identified(mapped traversed or crossed by an Active or Potentially Active Seismic Fault Line/s.

5. The reservoir area and adjacent or surrounding vicinity of the site has no identified potential peace and order issues or not susceptible to human induced (sabotage) hazard and risk.

3.3.1.1 RESERVOIR AND DAM SITES TOPOGRAPHY

The site topography shall dictate the axis selection for any type of dam to be erected. Accessibility to dam site, Reservoir area configuration & size, height and thickness of abutments, confining rims, planks and storage capacity are the major factors that shall be considered in the site selection process.

Topographic map shall have full features with contours lines and reflected corresponding elevations (preferably at 0.25m/0.5m/1.0m or at any convenient and acceptable contour interval) that exactly illustrates land form and shall show the true distance and elevation between points. The topography being illustrated shall be true and exactly similar with the actual dam and reservoir site being represented.

The site topography shall have or possesses appropriate and desirable location for the dam axis, foundation, abutment, spillway and diversion or irrigation outlet works and other dam appurtenant structures.

The determination of storage volume of the reservoir and permissible height of the dam shall be based on the topography limitation of the proposed reservoir rim or planks.
3.3.1.2 SITE GEOLOGY

Dam and Reservoir Sites shall be free of any of the following adverse geologic qualities:

1. Badly fractured rock foundations and abutments
2. Potential/Impending landslides or rock slides area, uncontrolled/unregulated and intensive human (agricultural) activities along the reservoir rim or planks and close to the site of intake structure of the outlet work.
3. Very high differential depth of soft materials from stream or channel bed to bedrock foundation level.
4. High Seismicity and Existence of Active and wide faults lines.
   For dams to be designed at dam sites having very high seismicity and having potentially Active FAULTS in the foundation; Refer to SECTION -8 .3 (General Seismic Loading Criteria) and SECTION - 6 .3 (Guidelines for Dams on Active Faults).
5. Very high /prohibitive cost of foundation treatment to limit leakage and improve stability condition.

3.3.1.3 SELECTION OF TYPE OF DAM FOR IMPLEMENTATION

For a given dam and reservoir site conditions, dam design engineers/designers shall prepare design for (minimum of 3 – schemes) alternative type of dams as described and specified under Section 3.1 and shall be subjected to SELECTION (Value Engineering / Value Assessment) or OPTIONEERING Process with the most suitable and with the most economical (taking into consideration the initial investment and the long term O&M cost) be presented for consideration and approval.

3.3.1.4 AVAILABILITY OF CONSTRUCTION MATERIALS

Adequacy and suitability of available construction materials and the proximity of the possible or explored sources shall be one of the major factors to be considered in the dam type and damsite/reservoir site selection process.
Availability and sufficiency and the identification of the borrow area and quarry sites of the following construction materials shall qualify the proposed/prospective dam & reservoir sites:

1. Soils for Embankment (Earthfill) dams
2. Rock for Embankment and Riprap (Rockfill dams)
3. Concrete aggregates (Sand, gravel, crushed stones) and Cementing/Binding Materials and Admixtures for (CMC or RCC designed) Concrete and Masonry Dams and concrete appurtenances (Spillways & Outlet works structures)

TABLE 3.3.1 and APPENDIX-2 “NIA-STANDARD/SAMPLE TABULATION OF EXTRACTIBLE/AVAILABLE TYPES OF MATERIALS AT IDENTIFIED AND DESIGNATED SOURCES (BORROW/QUARRY AREAS) FOR EMBANKMENT DAMS” shall be adopted & used and shall be required mandatorily in addition and complimentary to (Field and Laboratory) Test Results conducted for the determination of INDEX AND ENGINEERING PROPERTIES of the Dam body materials and foundation. These items shall be reflected on the Feasibility Studies (FS), DED Drawings & Design Report for uniformity and completeness of design data presentation.

TABLE 3.3.1- NIA-STANDARD/TABULATION OF EXTRACTIBLE/AVAILABLE TYPES OF MATERIALS AT IDENTIFIED AND DESIGNATED SOURCES (BORROW/QUARRY AREAS) FOR ZONED EMBANKMENT (EARTHFILL OR ROCKFILL) DAMS. (SAMPLE ENTRY ONLY: refer to SECTION 14.1.1.5.0 –Figures of Basic Embankment Dam Sections)

<table>
<thead>
<tr>
<th>DAM ZONE Designation</th>
<th>ZONE DESCRIPTION</th>
<th>MATERIALS CLASSIFICATION</th>
<th>SOURCE DESIGNATION</th>
<th>MATERIALS DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core</td>
<td>Silty Sand, Sandy silt, Clayey Sand &amp; Sandy Clay</td>
<td>Borrow Area No.1(BA#1) &amp; BA#2</td>
<td>6” (152.4mm) max; 20% to 80% passing #200(0.074mm) sieve, Min.PI=20.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>1A</td>
<td>Core at Cutoff trench &amp; base</td>
<td>Clayey sand and sandy clay</td>
<td>BA#1 &amp; BA#2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Blanket Drain</td>
<td>Quartzite</td>
<td>BA#3</td>
<td></td>
</tr>
<tr>
<td>2A</td>
<td>Coarse Filter</td>
<td>Quartzite</td>
<td>BA#2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Outer Shell</td>
<td>Quartzite &amp; Phyllite</td>
<td>BA#2, BA#3 &amp; Inlet/Outlet Spillway &amp; Tunnel Channels</td>
<td></td>
</tr>
<tr>
<td>3A</td>
<td>Inner Strip shell</td>
<td>Weathered Quartzite &amp; Phyllite</td>
<td>BA#2, BA## &amp; Inlet/Outlet Spillway &amp; Tunnel Channels</td>
<td></td>
</tr>
<tr>
<td>3B</td>
<td>Filter</td>
<td>Weathered Quartzite &amp; Phyllite</td>
<td>BA#2, BA## &amp; Inlet/Outlet Spillway &amp; Tunnel Channels</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Upstream Slope Protection</td>
<td>Quartzite &amp; Phyllite</td>
<td>BA#2, BA#3 &amp; Inlet/Outlet Spillway &amp; Tunnel Channels</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Upstream Filter</td>
<td>Gravelly sand</td>
<td>BA#2</td>
<td></td>
</tr>
</tbody>
</table>

### 3.3.1.1.5 REGIONAL & LOCAL CLIMATIC CONDITIONS, ENVIRONMENTAL AND SOCIAL CONCERNS & OTHER FACTORS

1. Climatic Condition is also a major factor in the selection of the type of dam for application on a specific damsite or vice-versa. For regions/locality having the Philippines Type-II & Type-IV (All Wet & Very wet season) climatic condition the adoption of Homogeneous Earthfill type of embankment dam is being restricted and discouraged due to unavoidable prolonged construction duration and unfavorable/ altered material index properties that needs (costly treatment) to be treated first prior to placement as embankment materials.

2. The identification and determination of both the favorable and unfavorable climate, Environmental & Social impact effects of constructing dams shall be made part of the damsite and reservoir sites selection process.

3. Negative or unfavorable project impacts should not outweigh the favorable or positive side of the project location to qualify in the selection process.

---

**Note:** The Tabulation of information, Dam Zone Designation and entry presentation may vary depending on the available materials, type and design configuration of the Embankment Dam.

- BA # - Borrow Area Number
- P.I. – Plasticity Index

<table>
<thead>
<tr>
<th></th>
<th>Downstream Filter</th>
<th>Sand</th>
<th>BA#2</th>
<th>3/8” (9.50mm) max; ≤2% passing #100 (0.15mm) sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Drain</td>
<td>Gravel</td>
<td>BA#2</td>
<td>2” (50.8mm) max; ≤2% passing #8 (2.36mm) sieve</td>
</tr>
<tr>
<td>8</td>
<td>Random Fill</td>
<td>Earth &amp;/or Rock</td>
<td>Rock borrow, Overburden, Req’d. Excavation</td>
<td>9” (228.60mm) max.</td>
</tr>
</tbody>
</table>
4. Environmental issues particularly (health and sanitation) project waste disposal and mitigating measures shall be identified and the cost shall be determined and compared to possible alternatives.

5. Any social issues that may arise shall be within tolerable level that will not cause dissatisfaction and unrest to affected persons or entities that shall lead to outright project rejection.

6. Issues regarding ROW’s/LARP/NCIP’s /FPIC & IP’s/PAF’s / PAMB & other possible project related issues and requirements at reservoir and dam sites shall be considered in the site selection process.

3.3.1.1.6 DAM & RESERVOIR SITE COST (PROJECT COST)

The governing and deciding factor in the final selection of the dam and reservoir sites shall be the one that renders the over-all project cost the most economical after considering the following:

1. Right of Way (ROW), FPIC & IP’s requirements, Land acquisition, resettlement and clearing cost.

2. Cost of relocating existing public facilities and utilities

3. Replacement cost of private and public properties

4. Disturbance Compensation for affected persons for cost and losses of moving to another location.

5. Physical cost of the dam structure as designed and to be constructed on the selected site.

6. Environmental and social cost due to adverse impact and mitigation measures formulated including watershed protection, improvement & development to compensate for the implications brought about by the project.
**SECTION 4.0** ENGINEER’S QUALIFICATIONS, DETAILED ENGINEERING/DESIGN STUDIES AND REPORTS, GOOD FOR CONSTRUCTION (GFC) PLANS AND DRAWINGS & DAM CONSTRUCTION REQUIREMENTS, RECORDS, KEEPING & ARCHIVING GUIDELINES.

**4.1 QUALIFICATIONS OF THE ENGINEER**

4.1.1 Engineers who shall undertake the design, supervise construction and manage the operation of the dam and reservoir must be a competent licensed Civil Engineer (Ref.# 35) and/or Professionals/Experts who has adequate and sufficiently undergone trainings and possess extensive experience on dam engineering (planning, design, construction, operation & maintenance and dam safety evaluation) discipline.

**4.2.0 DETAILED ENGINEERING STUDIES OR DETAILED ENGINEERING DESIGN (DES/DED) REPORTS**

4.2.1 A complete DES/DED Report shall be prepared and submitted to NIA covering all aspect of the dam and reservoir design and construction. The engineering features, classification (PHRC & Size), specific design parameters adopted, result of Numerical and Physical modeling studies, environmental and social considerations, construction methodologies, techniques and strategies shall be incorporated and reflected on the report. It shall also contain general description of design, including various construction factors (Right-Of-Way, Social and Environmental Issues) that maybe encountered and involved, location maps, drawings showing the general plan and sections, tables and/or figures showing hydraulic and structural capacities of the appurtenances.

4.2.2 The report shall include evaluation of Potential Hazard Classification (PHC) Category, Dam Size Classification, the foundation seismicity and geological conditions, the hydrologic and hydraulic design and a structural stability analysis of the dam and reservoir. It shall also include calculations sufficiently detailed to accurately define the final design and proposed work as represented on the construction plans and drawings.

4.2.3 To ensure a complete description and record of all essential data, calculations and conclusions entering into the Detailed Engineering Design/Study...
(DED/DES) Report, a uniform format and procedure is desirable as stipulated and provided under Section 4.2.4

4.2.4 For uniformity of design report presentation, and as a general guide, an outline of the items which the report shall cover are prescribed under NIA- MC No.36 s.2016 with its amendments stated under MC No. 59 s. 2016 and supplemented by MC No.91 s. 2017 (Ref.# 2, 3, & 7). Sample and recommended/suggested Outline is presented in Appendix-3 and Appendix-4 respectively.

Any deviation from this general guide or format (Appendix-3 & 4) shall be allowed provided the items included/excluded will support the design or not part and unnecessary. Any items included and supplemented shall support the design and be fully explained.

4.3.0 GOOD FOR CONSTRUCTION (GFC) PLANS & DRAWINGS

4.3.1 Prior to project implementation a duly verified, confirmed and approved “Good for Construction (GFC) Drawings” shall be prepared and be made available and issued to the implementing unit/project office and or Contractor if works will be implemented through contract or if by Force account shall be issued to the Agency’s authorized construction implementing Office or Entity (i.e. RIO, PMO or IMO)

4.3.2 All drawing sheets to be used for construction references should bear the marking of “Good for Construction” with the signature of the Duly Authorized NIA-Official affixed on it.

4.3.3 The NIA-Central Office Design and Specifications Division (NIA-CO-DSD), and or RIO’s and IMO’s concerned shall ensure that the Plans are in proper form and in accordance with the current standards, sound and acceptable dam engineering design principles and acceptable practice and construction procedures as required under MC 36 s.2016, MC 59 s.2016 and MC 91 s.2017 (Ref.# 2, 3 &7).

4.3.4 NIA-DSD-CO shall not be made responsible for projects where the detailed design and construction drawings are prepared by the Non-NIA Engineers, Consultants and/or other independent design and construction entities and the project is not to be funded, owned and operated by NIA.
4.3.5 The concerned Design (Consulting firm, Individual Consultant) Entity shall be held responsible for the plans and drawings prepared by them as mandated under the specific and applicable provisions of Republic Act for the procurement infrastructure projects (RA-9184) and also under the Design-Build-Operate (DBO) scheme of implementation.

4.3.6 NIA Dam Construction projects shall not be implemented without the duly marked/Approved GFC Plans and Drawings.

4.3.7 All NIA Approved (With or Without” Good For Construction” GFC- Marked) Detailed Engineering Studies/Detailed Engineering Design (DES/DED) Plans and Drawings of Irrigation, Drainage and related Infrastructures (River Training Works/Facilities, Roads including the Dam and respective appurtenances) for Reservoir or Storage Type Irrigation Projects/Systems NOT IMPLEMENTED within THREE (3) years reckoned from the date of APPROVAL thereof shall be subjected same by the Duly Authorized/Delegated Authority (Ref.#1) for REVIEW/EVALUATION and or UPDATING of Survey/Topography, geologic, meteorological, Hydrologic, Hydraulics, and Structural/Stability Design Data, Analysis Calculations and Technical Specifications prior to adoption as reference and supporting documents for Contract Works Procurement and Construction/Implementation.

4.3.8 All Duly Approved Plans and Drawings of Reservoir Type Infrastructure Projects and Appurtenances as mentioned, enumerated, identified and described under Sub-Section 4.3.7 NOT IMPLEMENTED Within FIVE (5) Years reckoned from the date of APPROVAL thereof shall be RE-SUBMITTED and/or shall be subjected for Detailed Re-Study/Re-Design prior to adoption as reference and supporting documents for Contract Works Procurement and Construction/Implementation.

4.4 PLANNING INVESTIGATION, PROJECT VALIDATION INSPECTION AND CONSTRUCTION SUPERVISION REPORTS AND DAM CONSTRUCTION RECORDS.

4.4.1 Site reconnaissance, inspection and investigation during the planning and design stage shall always be supported with reports stating all facts and important information, on site geology, topography, availability of construction materials, accessibility by any mode of transportation and other
related data and potential issues and problems that may be encountered during course of design and construction. The report should always be supported and accompanied by Pictorials with date of picture/s taken reflected.

4.4.2 During the construction stage, Periodic and Special Inspection shall be required if revisions of design or adjustment in designs shall be deemed necessary to cope with the actual site condition and situation different from those conditions during the conduct of detailed design. In these situations the construction/project Engineer/Manager shall immediately inform the NIA-DSD-Central Office or concerned RIO/IMO (for In-House Design) and/or the Consulting Firm’s concerned/liable Expert (for Out-sourced DED/DES Consulting Services) be requested for immediate conduct of inspection to verify and confirm the necessity of any design revision/s. NIA-MC no.82 s.2017(Ref.#36) provide guidance and policy on undertaking project inspection by NIA officials, Design Engineers and Consultants during project construction stages.

4.4.3 Prior to undertaking of design revisions, proper documentation of the original site condition should be taken through official reports fully supported by ground survey/surface mapping and pictures stating the condition necessitating changes. This condition has been provided for under the provisions of NIA-MC No.82 s. 2017

4.4.4 Copy of all reports pertaining to changes in design of all on-going construction including recommendations and actions taken shall be furnished to the Interim NIA Dam Safety Organization/Office (INDSO) under the direct technical and administrative supervision of the Deputy Administrator for Engineering and Operations (DA-EO) and the Managers of the Engineering and Operations Departments. The original and/or reproducible copy shall be kept at the DSD-Central Office (For depository & archiving) for future reference.

4.4.5 All recommended design revisions shall be properly documented and be reflected on the original Approved GFC drawings and should be concurred first by DSD-C.O. or by the RIO's /IMO's Design Chief concerned as maybe the case prior to approval by the duly authorized NIA official before the implementation.
4.5 RIGHT-OF-WAY, SOCIAL AND ENVIRONMENTAL REQUIREMENTS AS PRE-CONSTRUCTION AND CONSTRUCTION PRE-REQUISITES.

4.5.1 The Implementing Offices (PMO’s) shall ensure that Right-of-way (ROW’s), Social and Environmental requirements has been fully addressed prior to procurement by Contract or Force-Account Works and Implementation of Construction Activities of Reservoir Type Irrigation Projects.

4.5.2 NIA Shall observe strict compliance to Republic Act No.8974 (Ref.#37) which provides Policy-Guidelines on the acquisition of Right-of-way for National Government Infrastructure Projects.

SECTION 5.0 MAPS AND SURVEYS PREPARATION GUIDELINES AND CRITERIA

5.0.1 Maps and survey are one of the major and primary design data needed in the formulation, development of project scheme, Operation & Maintenance and Emergency Preparedness Plans. Maps and Surveys are vital in the scheme development and finalization of any site-specific reservoir dam design and construction.

Maps and survey data shall be made available as prerequisite in the design, construction and operation stages of any dam and reservoir projects and systems. These items are valuable tools in the early stage of planning, during the detailed design stage, during the construction stage and during the operation life of the structure.

5.0.2 Administrative Order No.16, Effectivity date, 05 July 2011- (REF.#44) Shall apply to NIA which requires and direct all Government Entities to Mandatorily Coordinate with NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY (NAMRIA) in the Acquisition of Data from Airborne and Space borned Platforms for use in their Respective Infrastructure Projects.
5.0.3 Executive Order No.45, Effectivity date, 05 January, 1993, (REF.#43) Requires the adoption of the Philippine Reference System of 1992 (PRS 92) as the STANDARD REFERENCE SYSTEM FOR SURVEYS IN THE PHILIPPINES shall be observed and shall be adopted under this guideline until such time that a new prescribed survey reference had been legally issued by the government and/or its Survey and Mapping regulating Agency, the NAMRIA.

5.0.4 It shall be mandatory and imperative that the pertinent maps and survey (Topographic Maps, Plan, Profile and Cross-Sections Surveys) data to be used (particularly during the detailed design stage) shall be the latest available or an updated one being prepared and duly signed by a licensed GEODETIC ENGINEER.

5.1. TOPOGRAPHIC MAPS

5.1.1 Updated topographic maps with scale convenient for design purposes and with ideally/preferred contour lines and elevation interval of 0.25m, or 0.50m for flat sloped terrain and a maximum interval of 1.00m shall be prepared for steep slopped terrain of reservoir area, damsite and appurtenant structures. Same shall prescribed to be produced by geodetic survey/consulting survey firms or be procured or availed from government (NAMRIA) and/or private geodetic survey firm/institutions that cater for same purpose.

5.2 GROUND TOPOGRAPHY

5.2.1 Ground topography shall be made available by actual conduct of topographic survey by NIA-IMO/RIO Survey group or by the consultants or any commissioned private Geodetic Engineering company and individuals.

5.2.2 Ground topography taken (from airborne or Space borne platforms) by Satellite Imagery or GIS are acceptable provided same will give results that would be acceptable, comparable or maybe better than that obtained from the government agency (NAMRIA) responsible for these aspects.

5.2.3 Topographic Surveys shall be supported with established Horizontal and Vertical control points and/or Benchmarks with corresponding Identification and Designation with the location to be identified by Grid Coordinates (Northing & Easting) and/or equivalent Geographic
Coordinate/location (Latitude & Longitude) including respective reference Elevations.

5.2.4 All Survey Control Points to be established for the project shall be tied or referred to the National Mapping and Resource Information Authority (NAMRIA) Duly Certified/Issued-Philippine Reference Survey of 1992 (NAMRIA Established – PRS’92) and/or Department of Environment and Natural Resources (DENR) established PRS’92 survey references.

5.3 SATELLITE IMAGERY

5.3.1 The use of new Information Technology through the satellite imagery or Global Information System (GIS) Technology mapping or the use of real time photographs of the target area or dam sites taken from airborne and/or space borne platforms (Ref. # 44) shall be an acceptable data and references in the planning and or detailed design stages provided same are referred and tied to (Ref. #43) Philippines Reference (Survey) System of 1992 (PRS’92) and complied with the provision and requirement of Sub-SECTION 5.0.2 of these guidelines.

5.4 GEOLOGIC AND GEO-HAZARD MAPS

5.4.1 Geologic (Regional and Local) map shall be made available reference for the specific use of the Engineering Geologist and Geo-technical Engineer and ultimately by the Dam Design Engineer during the reconnaissance and during the initial and final identification of potential reservoir and dam sites.

5.4.2 Site Specific or local Geo-hazard maps if available are very valuable reference for these purposes. The information and data derived from Regional Geo-hazard maps shall be verified and validated on site for confirmation of data previously obtained from the source map.

5.4.3 Philippines Seismic Map (Local and regional) shall be required as reference for the establishment and confirmation of seismicity of the project site and the generation/derivation of seismic design parameters and criteria.

5.5 OTHER MAPS

5.5.1 Other maps that shall provide valuable information like Climate Map, weather map, Typhoon belt map, Wind Zone map and the Land Resources Map (Land Use Map, Land Classification Map & Soil Map) Watershed Map where the
watershed surface cover or vegetation cover information from other government agency like the DENR are being taken. Regional and Local Geologic map, Seismicity Map and the Flood & Geo-Hazard Maps of the Philippines, Wind Zoning Map and many other maps as being required shall be included as part of the source of data and be integrated in the Design Report.

5.6 \textbf{PROFILE AND CROSS SECTION SURVEYS}

Profile and cross-sections survey results shall be made available prior to design of the dam structures and its appurtenances. Survey of dam axis including all appurtenances proposed and final alignments including the river channel or waterways where the structures shall be sited shall be a mandatory requirement and a design data prerequisite. These survey data and results shall be made part or be incorporated as part of the design drawings \textit{duly signed by the responsible Geodetic Engineer}.

5.7 \textbf{SURVEY RECORDS DEPOSITORY CENTER FOR ALL NIA ESTABLISHED PRS-’92 REFERENCE SURVEY CONTROL POINTS AND BECHMARKS.}

5.7.1 NIA Shall establish and form an Interim SURVEY RECORDS DEPOSITORY UNIT within the existing (IMO’s/RIO’s/PMO’s/UPRIIS/MRIIS) respective Organizations which shall have the responsibility to collect and prepare list, keep and update record, archive for future use, submit copy to higher NIA authorities and furnished same to requesting entities for reference.

5.7.2 All PRS-’92 reference survey control points, monuments and benchmarks established for (proposed/new/existing) Reservoir type Irrigation Schemes/Projects/Systems under the NIA (IMO’s/RIO’s/PMO’s) Field Offices jurisdiction and control shall be mandatorily required to prepare and keep \textit{initial and updated LIST} and regularly submit same to the SURVEY RECORDS DEPOSITORY CENTER (SRDC) located at NIA-Central Office and addressed to the \textbf{Deputy Administrator for Engineering and Operations}. Copy of the said LIST of established PRS-’92 Survey Control Points/Monuments & Benchmarks shall be furnished respectively to the Office of the Department Managers of Engineering (PPD/DSD/CMD) and Operations (IEC) and the \textbf{Agency Dam Safety Group/Office}.
SECTION 6.0  GEOLOGICAL AND GEOTECHNICAL INVESTIGATIONS GUIDELINES

6.1  GEOLOGICAL AND GEOTECHNICAL INVESTIGATION

The Engineering Geologist in collaboration with the Geotechnical Engineer/Expert and other related Specialist/Disciplines shall be responsible for the undertaking of surface and sub-surface mapping & investigations for the Dam and Reservoir Sites, potential sources of dam materials, the reservoir area/bed, reservoir rim or flanks and along the Dam Foundations and Abutments and at foundations of the Dam and its major appurtenances like the Spillway, Outlet Works and Power/Turbine House including appurtenances.

6.2  SCOPE OF INVESTIGATION

6.2.1  The scope, degree and extent of the investigation (Geological, Hydro-geological, Geo-hazards, site seismicity and geotechnical) shall be based and depends on the Stage of Project Development (Planning, Design, Construction and O&M) and the specific requirement and complexity of the project/system.

6.2.1.1  The investigation shall cover Surface and Sub-surface but shall not be limited to the following aspects:

1. Undertake surface and Subsurface Mapping of the damsite (Dam base/foundation and abutments) and adjacent vicinity, establish Regional and Local Geology and Seismicity and identify location of Lineaments, Fault line/s and to classify if Fault is Active or Inactive and provide descriptions. Specify the type (from the four (4) types of faulting mechanism as follows: (i). Underthrust (ii). Thrust, (iii). Extension, (iv). Strike-slip), width, depth, length & direction/orientation of fault), seams, joints, shear zones and establish other geological features, Reservoir Triggered Earthquake (RTE) and Tectonic Seismic induced Peak Ground Acceleration (PGA), velocity and displacement that are needed by the dam design engineer relative thereto. Determine the degree of water tightness of the reservoir area, along the rim or flanks and foundations and abutments along the dam axis, spillway and outlet works.
2. Formulate and recommend measure/s in collaboration with the other design team/experts to reduce leakages if there are any in the reservoir bed and rims/flanks and beneath and along the dam foundation.

3. Confirmation of the availability and sufficiency of construction materials, identification of the sources, estimate of the quantities, identify classifications and assist/observe/participate if necessary in the undertaking of the testing of the (Engineering and Index properties) said Construction and Foundation materials. (APPENDIX -2 provides TABLE 3.3.1. - NIA- Standard Tabulations of Materials for Embankment Dams)

4. Establish the engineering and index properties based on the result of In-situ and Laboratory test of the Foundation and Dam construction materials for the use of the dam design engineer

5. Determine the seismicity of the dam and reservoir site.

6. Identify the reservoir rims subject to potential land slide or where instability may incur in the future.

7. In collaboration with the Seismologist, Geotechnical Engineer, Dam/Civil works Design and Structural Engineer, Establish Seismic/Earthquake Design Criteria and Estimate and recommend the design seismic force value/coefficient or the design peak ground acceleration (PGA) that shall be used for the structure and elements or shall recommend the acceptable range of Seismic Design Magnitudes/Intensities that shall be used by the dam design engineer for adoption to the project.

8. Establish and recommend the Foundation Strength and capacities for the Dam and its appurtenant structures.

9. Undertake Boreholes/Drillholes for the assessment of foundation condition and the documentation during the course of foundation exploration the log of borehole and conduct site geologic mapping prior to or during project implementation and/or during the course of foundation excavations during construction.

10. Other Hydro-Geological related assessment such as water table location and level, surface soil erosion rate, Sedimentation rate and possibilities of soil or mud/debris avalanche within the reservoir rim, watershed and along main and tributary waterways.
6.2.2 REQUIRED DEGREE OF SUB-SURFACE EXPLORATION AND NUMBER OF BOREHOLES

6.2.2.1 Sufficient subsurface exploration (drill holes / boreholes, test pits or auger holes and if necessary, do exploratory adits) shall be undertaken to verify and establish the suitability of the foundation material. The number of drill holes and required depth shall be specified and decided upon by the Design Team (Engineering geologist/Geotechnical, Civil Works, Dam design & Structural Engineer) on and along the centerline of the dam and its major appurtenances but should not be less than that specified hereunder:

6.2.2.1.1 DAM AXIS

6.2.2.1.1.1 For Small, low hazard dams a minimum of three (3) exploration/ drill/bore holes shall be made along the dam axis.

6.2.2.1.1.2 One drill hole be done on or at location nearest to the deepest section and one on each abutment side. Borings/drill holes should be extending to a minimum depth equal to the height of the proposed dam.

6.2.2.2 SPILLWAY ALIGNMENT CENTER LINE

6.2.2.2.1 A minimum of three (3) boreholes shall be required (for small, low hazard dams) which shall be done one on the upstream end or approach channel section, one at location nearest to the middle part or if possible exactly at the intersection of the spillway centerline with dam axis and one at the downstream end of the spillway or at the spillway energy dissipator/stilling basin location. A minimum depth of six (6) meters shall be required unless hard and water tight rock foundation is already encountered above this level.

6.2.2.3 OUTLET WORKS ALIGNMENT CENTER LINE

6.2.2.3.1 A minimum of three (3) boreholes shall be required (for small, low hazard dams) which shall be done one on the upstream end or at the inlet channel section, one at location nearest to the middle part or if possible exactly at the intersection of the outlet works centerline with dam axis and one at the downstream end of the energy dissipator/stilling basin location.
**Depth of boreholes** shall be dictated by the required level of competency of foundation material. However, a minimum depth equal to the **height of the Dam** shall be required on Outlet (Conduit or Tunnel) Structure crossing under/over the dam base unless hard and water tight rock or desired foundation is already encountered above this level.

### 6.2.2.4. For Intermediate/medium (size) height and large/high dams, regardless of hazard classification, the number of exploration/bore or drill holes shall be prescribed based on the requirement to properly establish the sufficiency of the information needed for the design of the structure and shall also be dictated by the complexity of the dam and its appurtenant structures but **shall be more than what is prescribed for small and low hazard dams.**

### 6.3 GUIDELINES FOR RESERVOIRS/STORAGE DAMS ON FAULTS OR WITH POTENTIALLY ACTIVE FAULTS IN THE FOUNDATION.

#### 6.3.1 When a major active fault is crossing the dam foundation, the site shall be abandoned and a more appropriate site shall be selected and explored. **SECTION 9.2** provides supplemental Guidelines and Criteria in the Investigation and Selection of Dams and Reservoirs Sites with high Seismic Hazard and Risk implications.

#### 6.3.2 In highly seismic areas it may not be possible to find any site without FAULT Slip hazard. In such cases, concrete dams shall be avoided and preference be given to conservatively designed embankment dam designed with thicker filter and transition zones on both sides of a wide core, having ductile properties. Such structure can accommodate significant fault offsets without failure.

#### 6.3.3 If the seismo-tectonic condition of a damsite are not clear, then the Design Engineer shall avoid adopting Concrete Dam as structure but rather **select a conservatively designed Embankment Dam.**
SECTION 7.0  METEOROLOGIC AND HYDROLOGIC GUIDELINES & CRITERIA

7.0.1  METEOROLOGICAL AND HYDROLOGICAL INVESTIGATIONS

7.0.1.1  Meteorological and Hydrological Investigations shall be the responsibility of the Meteorologist and Engineering Hydrologist. The coverage of the investigation shall include the assessment of the watershed condition, hydro-meteorological parameters needed for the estimation of Irrigation Diversion Requirement (IDR), Stream flow observation/assessment and gathering or generation and ultimately to be able to estimate water demand to be used as parameter for the conduct of Reservoir Operation Simulation Study. The study shall be made as the basis for the reservoir storage sizing to fully support the estimated demand plus losses and the determination of initial dam height requirement.

7.0.1.2  Additional reference in the processes and methods of estimation of Hydrological parameters for the design of NIA-Storage Dam Projects, (REF.#64) the "Supplemental Guidelines/Manual on Planning, Design, Construction and Operation & Maintenance Of Irrigation Projects/Systems"; Volume -1: “HYDROLOGIC DESIGN MANUAL WITH CLIMATE CHANGE CONSIDERATION” formulated under the “Philippines Climate Change Adaptation Project-Phase-1” shall be considered and use as reference for estimation purposes or where it is applicable.

7.0.1.3  The Engineering Hydrologist shall verify and confirm watershed or the catchment area surface cover condition, the proposed reservoir area configuration, riverbed or waterway conditions. There shall be an estimation preferably site specific of catchment yield in terms of Runoff and Sedimentation. The assessment of the river and tributaries historical Stream Flow Records and peak discharges, sedimentation rate and transport if available are part of the activities which is needed for the determination of hydrological and hydraulics design parameters. The establishment of the Design Flood Criteria and the assessment and determination of the Design Flood Magnitudes as basis for the Dam Design Engineer and estimation of the corresponding maximum or peak flood discharge.
7.0.1.4 The **Watershed or Catchment Area** shall be classified according to size and shall be defined as follows:

1. **SMALL**- shall be defined as catchment and tributaries having a total area of less than **150.0** square kilometers (Sq.km.)

2. **INTERMEDIATE/MEDIUM**- shall be defined as catchment and tributaries having a total area greater than **150.0 sq.km** but less than **500.0 sq.km**

3. **LARGE**- Shall be defined as catchment and tributaries having a total area greater than **500.0 sq.km**

7.1 **Hydrologic Guidelines & Criteria**

7.1.1 All rivers, creeks and waterways proposed as source for Reservoir/Storage Dams development with Domestic Water Supply Component shall be properly investigated for the availability and adoptability or suitability (Substantiated with Laboratory Chemical and Microbial Analysis) of surface and subsurface water resources and other relevant hydrologic information.

7.1.2 **Stream Flow Gauging Stations** shall be established and a mandatory requirement for all rivers/waterways to be explored or having potential as source for storage dam’s development projects. Stream flow gauging station sites shall be properly selected and shall be established for the collection of actual records of mean daily and/or mean monthly dependable flow, Peak Flood Flow and corresponding water levels and other parameters needed for the design of Reservoir/Storage Dam projects.

7.1.3 No Reservoir Dams shall be subjected to Detailed Engineering Study (DES) and shall not be prioritized for construction unless substantiated with actual Stream flow records or observed mean daily, monthly dependable flow and mean annual flow. Minimum Stream Flow records prescribed shall be as indicated on Table 7.1.1.
### TABLE 7.1.1-Minimum Prescribed (Actual/Observed) Site Stream Flow Records/Data for Reservoir Type Irrigation Projects.

<table>
<thead>
<tr>
<th>DAM SIZE Classification</th>
<th>Potential Hazard &amp; Risk Classification and Prescribed Minimum Number of Years of Stream Flow Records</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PHRC-1 (Low)                                      PHRC-2 (Moderate/Significant)                  PHRC-3 (High)</td>
</tr>
<tr>
<td>SMALL</td>
<td>1-year                                            2-yrs                                       3-years</td>
</tr>
<tr>
<td>MEDIUM</td>
<td>2-yrs                                            3-yrs                                       5-yrs</td>
</tr>
<tr>
<td>LARGE</td>
<td>3-yrs                                            5-yrs                                       10-yrs</td>
</tr>
</tbody>
</table>

Note: Records shall be taken from Stream Gauging Station/s established on the same River/s or near the Damsite.

7.1.1.4 Correlated Stream flow values shall be allowed to be used only to fill incomplete records.

7.1.2 **Reservoir Operation Study Criteria**

7.1.2.1 Reservoir Operation Simulation Study shall be undertaken for the sizing of the reservoir and to establish the required reservoir operating levels and height of the dam that will satisfy the demand requirements with the maximum and minimum Storage capacities of the reservoir being established.

7.1.2.2 The following Reservoir Operations Study Criteria shall be adopted for (Irrigation related) NIA reservoir /storage dams:

i. Maximum annual shortage shall be less than 25% of average demand.

ii. Maximum cumulative shortage for ten (10) consecutive years shall be less than 50% of the annual demand.

iii. Reservoir reliability shall not be less than 95%.

iv. Shortage shall not be exhibited in three (3) successive years.

v. Allowable carryover storage shall not be higher than 24 months.
7.1.2.3 For other type of storage/reservoir dams including Multi-purpose Projects, the Operation Study Criteria to be used shall be set based on the specific requirements, objectives and purpose of the infrastructure.

7.1.3 Meteorological & Hydrological Studies, Determination of Irrigation Diversion Requirement (IDR), Demand & Losses

7.1.3.0 Hydro-Meteorological Studies shall be undertaken and shall be prepared and updated every three (3) years or if there occurred extreme events necessitating adjustment/revisions /changes /of parameters in the design of new or safety evaluation & assessment of existing dams. The updating of said studies shall be done by and shall be the responsibility of a competent Engineering Hydrologist.

7.1.3.1 Hydro-meteorological data generated shall be subject for review, confirmation and acceptance by the NIA Engineering Department (NIA-CO -PPD & DSD) prior to adoption or application in the derivation and estimation of the required Irrigation Diversion Requirement (IDR), Reservoir Demand and Losses.

7.1.3.2 Reservoir demand shall be specified as either for Domestic, Irrigation, Hydro Power and Other Uses or the combination of two or more of the prior mentioned utilization.

7.1.3.3 Reservoir Losses (evaporation, seepages & leakages when appreciable) shall be specifically identified and estimated/quantified and be the basis in undertaking the Operation Simulation Study for the sizing and optimization of the reservoir.

7.1.3.4 When reservoir has been designed to release the required irrigation diversion requirement through the irrigation outlet works to a natural water course/waterway/creek or same river as conveyance having a length of more than 1.0 kilometer and having water surface width more than 10.0 meters, and the released discharge is being catch or regulated by a downstream Afterbay/Catch Diversion Dam or re-regulation storage dam, the losses (seepage/leakage and evaporation) incurred through the said waterway or natural conveyance facilities shall be accounted and added as part of the demand in the reservoir operation simulation studies or reservoir sizing and capacity estimation.
7.1.4 Flood Studies

7.1.4.0 Selection and prescribing the appropriate Design Floods Criteria/Magnitude/Specific Frequency Flood (SFF) or Return Period of Inflow Design Flood (IDF) Loading for the reservoir, Service Spillway, Auxiliary and/or Emergency Spillways, Outlet Works/ or Diversion Outlets shall be the responsibility of the Dam Design Engineer. However, the estimation of the corresponding values and the development of the HYDROGRAPH of the prescribed Inflow Design Flood (IDF)/ Flood Magnitudes/Return Periods as set and prescribed by the Dam Design Engineer shall be the responsibility of the Engineering Hydrologist.

7.1.4.1 Prescription of the Flood Hydrologic Design Parameters & Flood Loading Criteria (Inflow Design Flood) shall consider and shall be based on assessed Potential Hazard & Risk Classification and Size Classification of the Dam Structure and Reservoir Project as specified in SECTION 3.0 of these Guidelines.

7.1.4.2 Values prescribed in Table-7.4.1- “MINIMUM INFLOW DESIGN FLOOD CRITERIA FOR NEW & EXISTING STORAGE DAMS” shall be used as reference/guide in determining the minimum prescribed design flood magnitudes for new and existing dam and its major appurtenances.

7.2 Inflow Design Flood (IDF) Estimation Procedure for Storage/Reservoir Dams

7.2.1 Procedures for estimating Runoff and Peak Flood Discharges can be found on various Hydrology Technical Bulletin, reference textbooks and Publications. However, the Engineering Hydrologist remains to be the sole responsible person in estimating and recommending the acceptable values corresponding to the prescribed Specific Frequency Flood (SFF) or Probable Maximum Flood (PMF) and in developing the IDF Hydrograph as set forth under Table-7.4.1.

7.2.2 Simplified procedure/s for estimating IDF and developing its corresponding hydrograph shall be considered and acceptable for micro-catchment or very small watershed less than 10.0Sq.km. where the Small Dam to be designed shall not be higher than 6.0 meters and reservoir storage capacity not higher than 0.25MCM.
7.2.3 Frequency based storm/rainfall and Probable Maximum Precipitation or Rainfall events are primary and very valuable parameters in estimating Peak discharges for various SFF magnitudes/Return Period (ie.100 years, 200yrs. Flood) and in estimating the Probable Maximum Flood (PMF) value. These parameters should be carefully evaluated by the NIA-Engineering Hydrologist or by the hired Consulting firm or individual Consultant prior to its adoption.

7.2.4 **As additional reference in the Processes and Methods of Estimation of Hydrological Parameters, including in particular the estimation of Stream Flows and Specific Frequency Floods (SFF)/Peak Floods or Inflow Design Flood corresponding to the prescribed Return Period for NIA-Storage Dam Projects, (REF.#64) the “Supplemental Guidelines/Manual on Planning, Design, Construction and Operation & Maintenance Of Irrigation Projects/Systems”; Volume1: “HYDROLOGIC DESIGN MANUAL WITH CLIMATE CHANGE CONSIDERATION” formulated under the “Philippines Climate Change Adaptation Project-Phase-1“ shall be considered and maybe use for Specific Frequency Flood (SFF) estimation purposes only or where it is applicable.

7.2.5 Minimum recommended and prescribed Inflow Design Flood Magnitudes to be applied on reservoir/storage dam projects and related appurtenances are prescribed on Table-7.4.1 as mentioned under **Sub-Section 7.1** of these Guidelines.

7.3 **Design Flood Application for Existing Dams**

7.3.1 **Existing reservoir dams that are being subjected to Dam Safety Evaluation and/or to be rehabilitated or to be modified** shall be investigated for the capacity and adequacy of its freeboard to be able to absorb and contain the updated or re-assessed Hydrological parameters particularly the Reservoir Inflow Design Flood (IDF) and for its Spillway to pass the routed design flood without overtopping.

7.3.2 IDF to be used for safety evaluation of existing dams shall be updated at every **three to five (3-5) years** or if there occurred an extreme flood event/s in between or within the prescribed period exceeding the original IDF previously adopted in the recent Dam Safety assessment and evaluation.
7.3.3 The Minimum Inflow Design Flood (IDF) Frequency (Return Period/magnitude prescribed/specified) to be used for the rehabilitation, modification, analysis and evaluation of hydraulics and structural performance, integrity assessment of existing Dams & Reservoirs and the related appurtenances thereof shall be of IDF frequency/return periods higher than or the same with the original IDF frequency used during the Detailed Engineering Design/Study (DED/DES) Stage of the Infrastructure but with updated higher discharge value.

7.3.4 IDF criteria for the Safety Evaluation of existing dams shall be based on updated or presently evaluated Potential Downstream Hazard Classifications and the same shall be applicable for new dams as shown on Table 7.4.1

7.4 Persons Authorized to Prescribe the Inflow Design Flood with the corresponding Magnitudes/Return Period and Estimation of Peak Discharges.

7.4.1 The Dam Design Engineer (DDE) in consultation with the Engineering Hydrologist and other members of the design team shall be responsible for prescribing the minimum required Inflow Design Flood (IDF) Magnitudes or Design Flood Frequency or Design Flood Return Period which may be in the order of 2, 5, 10, 15, 25, 50 yrs. floods, 100 yrs. Flood, for diversion works during construction and 200 yrs to 10,000 yrs. Flood or the Probable Maximum Flood (PMF) whichever is being prescribed for the hydraulic design of the reservoir and dam appurtenances subject to limitations prescribed in SECTION-7.4 and Table 7.4.1

7.4.2 The Engineering Hydrologist shall be responsible for the derivation, estimation, determination and development of the HYDROGRAPH for the Peak Inflow Discharge (PID) or the Inflow Design Flood (IDF) by either Deterministic or Probabilistic Methods which shall correspond with the Dam Design Engineer’s prescribed IDF Magnitudes/Return Period for the Dam and appurtenances.

7.4.3 Various procedures for estimating Peak Runoff and Peak Discharges that had been previously published by different researchers and institutions applicable to the Philippines setting with the popular currently being used by Engineers/Hydrologist with wide acceptance in the various government offices like the NIA, DPWH, MWSS, NWRB, DENR, MMDA, PAGASA, other private
firm, individuals and consultants shall be considered and be allowed for use provided the same shall be subject to review and approval by the NIA-CO Engineering Hydrologist.

7.4.4 Methodologies and procedures currently being used/applied and acceptable for the estimating of peak flows for the dam design requirement are enumerated and identified in various references, codes and guidelines. However, the evaluation, selection and recommendation of appropriate values and the decision regarding the correctness and precision of the method and dependability and acceptability of the results of the method and procedure applied remains the sole responsibility of the Expert Hydrologist Engineer.

7.4.5 Consultant/ Hydrologist derived and developed HYDROGRAPH with the corresponding estimated hydrological values or results that shall be used or adopted for the project shall be subject to NIA's review and approval.

7.4.6 Applicable Empirical Formulas and Other Current and latest developed Methods and procedures that shall be introduced by the Consultant/Engineering HYDROLOGIST maybe used and considered for determining & estimating Peak Flood Flows and for establishing Inflow Design Flood based on Standard Frequency Flood (SFF) or the estimation of Probable Maximum Flood (PMF) and in the development of corresponding Hydrograph shall be subject to NIA’s Approval.
### TABLE 7.4.1-MINIMUM INFLOW DESIGN FLOOD (IDF) REQUIREMENT AND CRITERIA (FOR NEW AND EXISTING RESERVOIR DAMS)

<table>
<thead>
<tr>
<th>Potential Hazard &amp; Risk Classifications (PHRC)</th>
<th>Size Classifications</th>
<th>Minimum Inflow Design Flood (IDF) for Reservoirs</th>
<th>Minimum IDF for sizing Service Spillway</th>
<th>Minimum IDF for Auxiliary and Emergency Spillway /Low Level Outlet/ Emergency Conduit</th>
<th>Minimum IDF for Diversion Conduit/Tunnel Outlet Works and cofferdams (temporary or permanent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHRC-1</td>
<td>Small</td>
<td>200yrs</td>
<td>200yrs</td>
<td>25 yrs</td>
<td>Season peak Q or 5 yrs Flood</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>500yrs</td>
<td>500 yrs</td>
<td>50 yrs</td>
<td>10yrs</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>1000yrs</td>
<td>1000yrs</td>
<td>100 yrs</td>
<td>15yrs</td>
</tr>
<tr>
<td>PHRC-2</td>
<td>Small</td>
<td>500 yrs</td>
<td>500 yrs</td>
<td>50 yrs</td>
<td>10yrs Flood</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>1000yrs or PMF</td>
<td>1000 yrs or PMF</td>
<td>100yrs</td>
<td>15yrs</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>5000yrs or PMF</td>
<td>5000yrs or PMF</td>
<td>100 yrs</td>
<td>25yrs</td>
</tr>
<tr>
<td>PHRC-3</td>
<td>Small</td>
<td>1000yrs</td>
<td>1000yrs</td>
<td>100 yrs</td>
<td>15yrs Flood</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>5000yrs or PMF</td>
<td>5000yrs or PMF</td>
<td>200 yrs</td>
<td>50yrs</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>10,000yrs or*PMF</td>
<td>10,000yrs or PMF</td>
<td>500 yrs</td>
<td>100yrs</td>
</tr>
</tbody>
</table>

**NOTE:**
- *PMF- Probable Maximum Flood
- Size Classification shall be set as defined in Section 3.1.2 and shall be determined by either Storage or height, whichever category shall govern.
- Hazard & Risk Classification shall be as defined under Section 3.2.2
SECTION 8.0 EARTHQUAKE MAGNITUDE AND INTENSITY SCALES AND DESIGN SEISMIC LOAD GUIDELINES & CRITERIA

8.0.1 Seismic Magnitude and Intensity Scales

The Modified Mercalli Intensity (MMI) Scale and the Richter Magnitude (RM) scales shall be used as the main reference in defining or rating the effects of an earthquake. These Seismic Scales shall be defined as follows:

a. Mercalli Intensity Scale is a semi-quantitative linear scale of Seismic Intensity which is a measure or rating of the effects of an earthquake at different sites. Intensity ratings are expressed as Roman numerals (I to XII) with the Numeral - I, as the lowest and Numeral-XII as the highest Earthquake Intensity rating.

b. Richter Magnitude Scale is a quantitative logarithmic scale to measure the effect of any earthquake from place to place.

c. Other seismic Intensity scales (Rossi-Forrell (RF)/Japan Meteorological Agency (JMA)/Mercalli-Cancani-Sieberg (MCS)/Medvedev-Sponeuer-Karnik (MSK) may be used for comparative analysis on the effect of the generated earthquake intensity or magnitude and the corresponding Peak Ground Acceleration (PGA) and Velocity of an earthquake in the structure.

Table -8.0.1A provides correlative Instrumental Earthquake Magnitude and Intensity Scales with the corresponding/approximate range of Seismic induced Peak Ground Acceleration (PGA) and Velocity. The table shall be used as reference in prescribing the initial design seismic load and for defining the seismic performance/capacities of the particular type of dam structures and appurtenances.
### TABLE 8.0.1A - Comparison of Seismic Magnitude Scale (Richter) and Intensity Scale (Modified Mercalli) with Corresponding Approximate Range of Peak Ground Acceleration and Velocity.

<table>
<thead>
<tr>
<th>Richter Magnitude Scale</th>
<th>Modified Mercali Intensity Scale (MMI)</th>
<th>Approx. Peak Ground Acceleration Range</th>
<th>Velocity Cm/Sec</th>
<th>Perceived Shaking</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 -4.30</td>
<td>I</td>
<td>&lt; 1.667 &lt; 0.0017g &lt; 0.10</td>
<td></td>
<td>Not Felt</td>
</tr>
<tr>
<td></td>
<td>II - III</td>
<td>1.667 - 13.734 0.0017g - 0.014g</td>
<td>0.10 - 1.10</td>
<td>Weak</td>
</tr>
<tr>
<td>4.30-4.80</td>
<td>IV</td>
<td>13.734 - 38.259 0.014g - 0.039g</td>
<td>1.10 - 3.40</td>
<td>Light</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>38.259 - 90.252 0.039g - 0.092g</td>
<td>3.40 - 8.10</td>
<td>Moderate</td>
</tr>
<tr>
<td>4.80-6.20</td>
<td>VI</td>
<td>90.252 - 176.58 0.092g - 0.180g</td>
<td>8.10 - 16.00</td>
<td>Strong</td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>176.58 - 333.54 0.180g - 0.340g</td>
<td>16.00 - 31.00</td>
<td>Very Strong</td>
</tr>
<tr>
<td>6.20-7.30</td>
<td>VIII</td>
<td>333.54 - 637.65 0.340g - 0.650g</td>
<td>31.00 - 60.00</td>
<td>Severe</td>
</tr>
<tr>
<td></td>
<td>IX</td>
<td>637.65 - 1,216.44 0.650g - 1.240g</td>
<td>60.00 - 116.00</td>
<td>Violent</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>&gt; 1,216.44 &gt; 1.240g &gt;116.00</td>
<td></td>
<td>Extreme</td>
</tr>
<tr>
<td>7.30-8.90</td>
<td>XI</td>
<td>&lt; 1568.00 &lt; 1.600g</td>
<td></td>
<td>Total destruction. Almost everything damaged. Objects Thrown into the air.</td>
</tr>
<tr>
<td></td>
<td>XII</td>
<td>&gt; 1568.00 &gt; 1.60g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**
1. 1g = 9.81 M/Sec²
2. 1g = 981.00 Gal
3. 1Gal = 0.01 M/Sec²
**TABLE 8.0.1B -** Comparison of Different Seismic Intensity Scales with Corresponding Approximate Range of Peak Ground Acceleration (PGA) expressed in terms of Earth’s Gravitational Acceleration (g) in meters per second square (m/sec.²)

<table>
<thead>
<tr>
<th>Modified Mercalli (MMI)</th>
<th>Rossi-Forrel (RF)</th>
<th>Japan Meteorological Agency (JMA)</th>
<th>Mercalli-Cancani-Sieberg (MCS)</th>
<th>Medvedev-Sponheuer-Karnik (MSK)</th>
<th>Peak Ground Acceleration g= (m/sec.²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>I</td>
<td>II</td>
<td>I</td>
<td>I</td>
<td>&lt; 0.0017g</td>
</tr>
<tr>
<td>II</td>
<td>II</td>
<td>I</td>
<td>III</td>
<td>II</td>
<td>0.0017g-0.0140g</td>
</tr>
<tr>
<td>III</td>
<td>III</td>
<td>IV</td>
<td>III</td>
<td>III</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>IV</td>
<td>II</td>
<td>V</td>
<td>IV</td>
<td>0.014g-0.039g</td>
</tr>
<tr>
<td>(V/*)</td>
<td>V</td>
<td>III</td>
<td>VI</td>
<td>V</td>
<td>0.010g-0.025g</td>
</tr>
<tr>
<td></td>
<td>(VI/*)</td>
<td>IV</td>
<td>VII</td>
<td>VI</td>
<td>0.025g-0.050g</td>
</tr>
<tr>
<td></td>
<td>(VII/*)</td>
<td>VIII</td>
<td>V</td>
<td>VIII</td>
<td>0.050g-0.100g</td>
</tr>
</tbody>
</table>

8.1.0 **Dam Components Affected During Earthquake**

8.1.1 Design shall consider Earthquakes effect on all dam components at the same time. This situation and condition requires careful planning of the dam components configuration and selection of materials to be adopted as element parts capable of resisting seismic induced forces.

8.1.2 The following are the general dam components that are subject to and simultaneously affected during an earthquake:

- Dam body
- Foundation
- Safety devices
8.2.0 General Design Seismic Load Criteria

8.2.1 In Table -8.2.1A and Table 8.2.1B provides the ranges of design seismic loading specified in these guidelines which shall be one of the basis and criteria for undertaking the design of NIA-Dams and appurtenant structures. The Potential Hazard and Size Classification/ category of the dams shall be considered in the application of the said criteria for Structural Design and Seismic Safety Evaluation consideration.

### TABLE 8.2.1A- GENERAL SEISMIC LOADING CRITERIA (For Design, Construction, Operation & Safety Evaluation) OF NEW & EXISTING DAMS

<table>
<thead>
<tr>
<th>Hazard &amp; Risk Classification (PHRC)</th>
<th>Size Classification</th>
<th>Seismic Load Category</th>
<th>EMBANKMENT DAMS</th>
<th>CONCRETE DAMS (Conventional Mass Conc. -CMC) &amp; (Roller Compacted Conc.-RCC)</th>
<th>HARDFILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHRC-1</td>
<td>Small</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EARTH-FILL</td>
<td>ROCK-FILL</td>
<td>GRAVITY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25yrs</td>
<td>25yrs</td>
<td>25yrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100 yrs</td>
<td>100 yrs</td>
<td>100 yrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>250yrs</td>
<td>250yrs</td>
<td>250yrs</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;250yrs</td>
<td>&gt;250yrs</td>
<td>&gt;250yrs</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td></td>
<td>50yrs</td>
<td>50yrs</td>
<td>50yrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>150 yrs</td>
<td>150 yrs</td>
<td>150 yrs</td>
</tr>
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<td></td>
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<td></td>
<td>500yrs</td>
<td>500yrs</td>
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<td></td>
<td>&gt;500yrs</td>
<td>&gt;500yrs</td>
<td>&gt;500yrs</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td></td>
<td>50yrs</td>
<td>50yrs</td>
<td>50yrs</td>
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<td></td>
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<td>500yrs</td>
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<td>&gt;1000 yrs</td>
<td>&gt;1000 yrs</td>
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<td>&gt;1000 yrs</td>
<td>&gt;1000 yrs</td>
<td>&gt;1000 yrs</td>
</tr>
<tr>
<td></td>
<td>Small</td>
<td></td>
<td>25yrs</td>
<td>25yrs</td>
<td>25yrs</td>
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<tr>
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<td></td>
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<td>250yrs</td>
<td>250yrs</td>
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<td>2500yrs</td>
<td>2500yrs</td>
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<td></td>
<td></td>
<td>25000yrs</td>
<td>25000yrs</td>
<td>25000yrs</td>
</tr>
</tbody>
</table>

### PHRC-2

<table>
<thead>
<tr>
<th>Size</th>
<th>MDE-SEE-500yrs</th>
<th>MDE-SEE-500yrs</th>
<th>MDE-SEE-500yrs</th>
<th>MDE-SEE-500yrs</th>
<th>MDE-SEE-500yrs</th>
<th>MDE-SEE-500yrs</th>
<th>MDE-SEE-500yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>50yrs &gt;500yrs</td>
<td>50yrs &gt;500yrs</td>
<td>50yrs &gt;500yrs</td>
<td>50yrs &gt;500yrs</td>
<td>50yrs &gt;500yrs</td>
<td>50yrs &gt;500yrs</td>
<td>50yrs &gt;500yrs</td>
</tr>
<tr>
<td>Large</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
</tr>
<tr>
<td>Small</td>
<td>50yrs-250yrs</td>
<td>50yrs-250yrs</td>
<td>50yrs-250yrs</td>
<td>50yrs-250yrs</td>
<td>50yrs-250yrs</td>
<td>50yrs-250yrs</td>
<td>50yrs-250yrs</td>
</tr>
<tr>
<td>Medium</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
</tr>
<tr>
<td>Large</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
<td>100yrs MCE</td>
</tr>
</tbody>
</table>

**NOTE:**
- **CE**-Construction Earthquake ($\geq 25$yrs to $\leq 100$yrs return period)
- **OBE**- Operating Basis Earthquake ($\geq 100$ to $\leq 1000$ yrs return period)
- MDE/SEE-Maximum Design Earthquake/Safety Evaluation Earthquake ($\geq 250$ to $\leq 10,000$ yrs return period or MCE=Maximum Credible Earthquake)
- The Terms MDE or SEE are sometimes used as substitute for MCE
- Size Classification shall be set as defined in Section 3.1.2 and shall be determined by either Storage capacity or Height, whichever results to larger size category.
- Hazard & Risk Classification shall be as defined under Section 3.2.2
- The Dam Design Engineer may opt to adopt less than the herein minimum prescribed earthquake loading provided the said adopted seismic loading has been duly substantiated and supported (by Geologist/Seismologist/Geophysicist/Geotechnical Engineer) with site specific studies and justification/s acceptable to NIA.
TABLE 8.2.1B- General Seismic Load Criteria for Design, Construction, Operation, Safety Evaluation and Assessment of Major Appurtenances and Critical Elements of New and Existing Dams

<table>
<thead>
<tr>
<th>PARTICULARS</th>
<th>APPURTENANCES</th>
<th>DESIGN EARTHQUAKE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CE (≧25-≦100 yrs)</td>
</tr>
<tr>
<td>Dam &amp; Safety Relevant Elements</td>
<td>Spillway</td>
<td>(500yrs)</td>
</tr>
<tr>
<td>Outlet Works</td>
<td>(500yrs)</td>
<td>(500yrs)</td>
</tr>
<tr>
<td>Appurtenant Structures</td>
<td>Powerhouse</td>
<td>(250yrs)</td>
</tr>
<tr>
<td>Essential Building Facilities</td>
<td>Office buildings, Staff house, Control house, access &amp; others</td>
<td>(25 yrs)</td>
</tr>
</tbody>
</table>

NOTE:
- CE-Construction Earthquake (≧25yrs to ≦100yrs return period)
- OBE- Operating Basis Earthquake (≧100 to ≦1000 yrs return period)
- MDE/SEE/MCE-Maximum Design Earthquake/Safety Evaluation Earthquake /Maximum Credible Earthquake (≧250 to ≦10,000 yrs return period)
- The Terms MDE or SEE are used as substitute for MCE

8.3.0 Design Seismic Loading Magnitudes/Return Period for Specific Load Combinations

The typical load combinations when Earthquake Magnitude is being considered shall be as follows:

i. **Usual Load Combination**: CE Magnitude/ Return Period (≧25yrs-≦100 yrs)

ii. **Unusual Load Combination**: OBE Magnitude/ Return Period (≧100yrs-≦500yrs)
iii. **Extreme Load Combination**: MDE/SEE Magnitude/ Return Period (10,000Yrs or MCE)

*Table 8.3.0-* provides the Seismic Design Loading Magnitudes and corresponding Return period to be applied for the particular dam components or elements. The Hazard and Size Classification shall be made as basis and considered in the application of the specified **seismic loading magnitudes**.

**TABLE 8.3.0** - DESIGN SEISMIC LOADING CRITERIA FOR SPECIFIC DAM ELEMENTS OR COMPONENTS

<table>
<thead>
<tr>
<th>DESCRIPTION OF FACILITIES</th>
<th>ELEMENTS OR COMPONENTS</th>
<th>DESIGN EARTHQUAKE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(≧ 25yrs - ≦ 100yrs)</td>
</tr>
<tr>
<td><strong>DIVERSION FACILITIES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Civil Works</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intake (Outlet Structure)</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Tunnel, Tunnel liner</td>
<td>X</td>
</tr>
<tr>
<td><strong>GEOTECHNICAL</strong></td>
<td>Rock Slope</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Underground Facilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cofferdams</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Temporary Cofferdams</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Permanent Cofferdams</td>
<td></td>
</tr>
<tr>
<td><strong>ELECTRICAL/MECHANICAL</strong></td>
<td>Gate Equipment</td>
<td>X</td>
</tr>
<tr>
<td><strong>DAM</strong></td>
<td>Dam Body</td>
<td>X</td>
</tr>
<tr>
<td>• Dam Body</td>
<td>Individual Block</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Crest Bridge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crest, Spillway, Cantilevers</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Bottom Outlet, Cantilevers</td>
<td>X</td>
</tr>
</tbody>
</table>
### Table 8.4.1

<table>
<thead>
<tr>
<th>FOUNDATION and ABUTMENTS</th>
<th>Abutment Wedges</th>
<th>X</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BOTTOM OUTLET</strong></td>
<td>Main Gates, Valves</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Guard Gate</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Operating Equipment</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DAM ELECTRICAL &amp; MECHANICAL</td>
<td>Essential Parts</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**NOTE:** Marked (X) - denotes applicability

- **CE**-Construction Earthquake (≥25yrs to ≤100yrs return period)
- **OBE**- Operating Basis Earthquake (≥100 to ≤1000 yrs return period)
- **MDE/SEE/MCE**- Maximum Design Earthquake/Safety Evaluation Earthquake/ Maximum Credible Earthquake (≤10,000 yrs return period)
- The Terms MDE or SEE are used as substitute for MCE

### 8.4 Seismic Performance Criteria

Existing dams performance shall be evaluated based on the seismic loading magnitude or Return Period specified under Table 8.4.0 of these Guidelines.
### Table 8.4.0 - Seismic Performance Criteria for Dams and Safety Relevant Elements/Components

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Dam Component</th>
<th>Earthquake Loading</th>
<th>Functionality Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. DAM</strong></td>
<td>Dam Body</td>
<td>OBE (100-1,000 yrs)</td>
<td>Fully functional. Minor non-structural damage accepted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MDE/SEE/MCE (1,000-10,000 yrs)</td>
<td>Reservoir can be stored safely, Structural damage (cracks, deformations) accepted. Stability of the dam must be ensured</td>
</tr>
<tr>
<td><strong>2. SAFETY RELEVANT ELEMENTS</strong></td>
<td>SPILLWAY, LOW LEVEL/BOTTOM OUTLETS</td>
<td>OBE (100-1,000 yrs)</td>
<td>Fully functional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MDE/SEE/MCE (1,000-10,000 yrs)</td>
<td>Functional so that reservoir can be operated/controlled safely and moderately. Flood of 200 yrs return period could be released after.</td>
</tr>
</tbody>
</table>

#### 8.5 Estimation of Earthquake Induced Peak Ground Acceleration

**8.5.1** Seismic induced Peak Ground Acceleration (PGA) corresponding to CE, OBE, MDE/SEE/MCE magnitudes for use in the design and Safety Assessment and Evaluation of New and Existing Dams including all the related Appurtenances and Structural Elements shall be estimated using either the Probabilistic Method (Statistical Analysis of Strong -Motion Acceleration Records and other recently developed/introduced and internationally accepted Statistical Methods) or the Deterministic Methods (i.e. Site Specific Acceleration Response Spectrum and or Acceleration Time History Determination Method)
8.6. **SEISMIC/EAUHQUAKE INDUCED LOADS/FORCES ANALYSIS PROCEDURES**

8.6.1 **Dynamic Loading/Forces Procedure**

Dynamic Loading Procedure shall be a mandatory requirement to be applied and to be used in the stability and structural response and integrity analysis of all Reservoir Dams including the primary & important safety appurtenant structures categorized under the High Potential Hazard & Risk Classification (PHRC-3) irrespective of Dam Size (Height and Storage Volume) Classifications with Site estimated earthquake induced Peak Ground Acceleration (PGA) \( \geq 0.20g \) \( (1.962 \text{ m/s}^2) \)

8.6.2 **Pseudo-Static Loading/Forces Procedure**

Pseudo-Static Loading Procedure shall be applicable and acceptable in the preliminary setting of dam section /configuration, stability and structural analysis of Class PHRC-1 and PHRC-2, Small and Intermediate/Medium Size Reservoir Dams only. However, the application of the dynamic loading procedure shall also be used to provide information on the dynamic response and behavior of the dam structure and to verify the result of the analysis. The use or application of purely Pseudo Static loading/force procedure to any type of dam and its structural elements shall be subject to the approval of NIA-DSD-CO and shall be allowed only if justified sufficient for the analysis and that the responsibility shall be borne solely by the dam design engineer/s (team) and Consulting Firm who rendered the design activities.

8.7 **In lieu of the estimated design earthquake forces based on statistically or probabilistically estimated Peak Ground Accelerations (PGA) and site specific determined and established PGA’s by the methods specified under Sub-Section 8.5 and either of the procedures specified under Sub-Sections 8.6.1 and 8.6.2, the design Seismic Force Factor or Seismic Force Coefficients provided under Table 8.7.0 may be used and assumed (REF.#25 & #26). However, the result of the analysis using the selected value derived or taken from these Tables shall be subject to review, confirmation and approval by the NIA, DSD-Central Office or by a competent or NIA duly authorized/commissioned/practicing and/or 3rd party Geotechnical consultant/firm/Engineer.**
**TABLE 8.7.0** Provides the Minimum Design Horizontal Seismic Load Factor/Coefficients (K_h) to be applied for the (Pseudo-Static) calculation for different type of dams for the following aspect:
A. Seismic Induced Wave Height and Run-up.
B. Hydrodynamic pressure
C. Recommended Range of Horizontal Seismic (Pseudo-Static) Inertial Force Factor on Reservoir Dams (Reservoir & Dam body) and Related Appurtenant Facilities Structural and Stability Analysis.

**TABLE 8.7.0**– RANGE OF DESIGN HORIZONTAL SEISMIC LOAD FACTOR / COEFFICIENTS (kh)

<table>
<thead>
<tr>
<th>PHILIPPINES SEISMIC ZONE/REGION</th>
<th>TYPE OF FOUNDATION</th>
<th>RESERVOIR AREA</th>
<th>CONC. (CMC &amp; RCC) GRAVITY DAMS</th>
<th>CONC. (CMC &amp; RCC) ARCH &amp; BUTTRESS DAMS</th>
<th>ZONED EMBMNT DAMS</th>
<th>HOMOGENEOUS EMBAMNT DAM</th>
<th>RCC/CONC.FACED HARDFILL DAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>III-Strong Seismic Zone/Region</td>
<td>Ordinary Rock Foundation</td>
<td>0.12-0.25</td>
<td>0.12-0.15</td>
<td>0.24-0.30</td>
<td>0.10-0.15</td>
<td>0.15-0.18</td>
<td>0.12-0.15</td>
</tr>
<tr>
<td></td>
<td>Soil Foundation</td>
<td>0.15-0.30</td>
<td>-</td>
<td>-</td>
<td>0.18-0.30</td>
<td>0.20-0.30</td>
<td>-</td>
</tr>
<tr>
<td>II-Moderate Seismic Zone</td>
<td>Ordinary Rock Foundation</td>
<td>0.12-0.20</td>
<td>0.12</td>
<td>0.24</td>
<td>0.12-0.15</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>Soil Foundation</td>
<td>0.15-0.25</td>
<td>-</td>
<td>-</td>
<td>0.15-0.18</td>
<td>0.18-0.20</td>
<td>-</td>
</tr>
<tr>
<td>I-Weak Seismic Zone(Palawan Area)</td>
<td>Ordinary Rock Foundation</td>
<td>0.10-0.15</td>
<td>0.10-0.12</td>
<td>0.20-0.24</td>
<td>0.10-0.12</td>
<td>0.12</td>
<td>0.10-0.12</td>
</tr>
<tr>
<td></td>
<td>Soil Foundation</td>
<td>0.10-0.20</td>
<td>-</td>
<td>-</td>
<td>0.15</td>
<td>0.18</td>
<td>-</td>
</tr>
</tbody>
</table>

Note:
1. **Seismic Zones** are as prescribed under (REF.#87) the 1990 or the latest edition of Structural Code of the Philippines.
2. The Dam Design Engineer may opt to adopt less or more than the herein minimum prescribed Earthquake loading Factor/Coefficient provided the said adopted seismic loading factor has been duly substantiated and supported by a duly recognized/competent practicing Geotechnical Engineer/Seismologist with site specific geotechnical/seismic studies and justification/s acceptable to NIA.
SECTION 9.0  RESERVOIR SITES AND AREA INVESTIGATIONS AND DESIGN GUIDELINES & CRITERIA

9.1 Leakage Investigation and Identification

9.1.1 Reservoir area which shall cover and includes the reservoir/bed, the rims or flanks up to the Maximum Design Reservoir Water Surface Level shall be thoroughly investigated for any potential leakages and signs or presence of highly pervious or high permeability and fissured rock condition of underlying bed materials.

9.1.2 Identified sites of high leakage yield rate shall be corrected by introducing appropriate engineering interventions.

9.2 Seismicity and Stability of Reservoir Bed and Rim /Flanks

9.2.1 Due consideration of the effect of seismicity of the reservoir area should be made prior to the final selection and finalization of the location of the Reservoir. Stability of reservoir bed and surrounding rims and flanks against ground movement has to be established and confirmed by the geologist and the geotechnical engineer/expert.

9.2.2 The potential occurrences of Reservoir Triggered Seismic (RTS) activity shall be included in the investigation and consideration during the site identification, selection and during the design stage.

9.2.3 Any indication of presence of seismic fault that may have potential to be active and open upon the occurrence of earthquake that may cause high reservoir leakage shall be evaluated. Such condition shall be enough reason to justify relocation of site or reformulation and/or redesign of the project unless an economical and reliable engineering intervention can be formulated or available.

9.2.4 Under SECTION 6.3 provides Guidelines and Restrictions on the adoption of Dam Foundations and Reservoir Sites with high seismicity and with Active Seismic Faults.

9.3 Leakage Corrective Measures

9.3.1 The Dam Design Engineer in collaboration with the Geologist, the Geotechnical Engineer, Geophysicist and other Technical Specialist shall be
responsible in formulating and devising the required engineering intervention to minimize or totally eliminate leakage by considering cost, efficiency and affectivity of the proposed measure.

9.3.2 In improving the water tightness of the reservoir, the adoption of local materials or latest devised or improved proven effective and efficient technology should be considered and prioritized. In lieu of conventional interventions, the design engineer may opt to utilize viable and practical new technologies available subject to economic limitation (Economic Internal Rate of Return-EIRR) of the project.

9.3.3 A comparative cost and performance efficiency analysis (VALUE ENG’G/VALUE ANALYSIS PROCESS) of the different engineering interventions available shall always be rendered to establish the viability of the final development scheme and to support the approval for the adoption of same by the NIA approving authority.

9.4 Borrow Sources for Dam Materials and Extraction of Earth/Rock Materials in the Reservoir Area.

9.4.1 Surface and Subsurface explorations to locate, identify borrow areas and to verify the suitability and adequacy of supply of materials and extraction of the needed materials inside the reservoir area shall be allowed for economic consideration. Provided, exposure of pervious soils foundation and fissured rock surfaces below Normal Water Surface Level of the proposed reservoir borrow areas (or any borrow areas whose sites/locations are connected to the reservoir area) shall be avoided, (and/or treated/corrected.)

9.4.2 If highly pervious soil or fissured rocks conditions are encountered during borrow operations, these exposed areas shall be sealed with sufficient thickness of compacted impervious earth or clay material or any other method or material available to rectify the situation.

9.4.3 In no case shall the impervious earth or clay material seal stated under Section 9.4.2 be less than 60.0 cm thick and consideration should be given to utilizing a greater thickness where site conditions and Dam and Reservoir Potential Risk & Hazard mitigation requirement dictates.
9.4.4 Borrow areas for construction materials shall be located with due consideration to future safety of the dam and shall be shown and delineated on the plan.

9.4.5 No borrow area shall be allowed in the reservoir and downstream of the dam area within a distance measured from upstream (Su) or downstream (Sd) toe of the dam, equal to twice the height of the dam (2xH) or at minimum distance as specified and stipulated in the DENR-Administrative Order No-2010-21, Section-79. a (REF.# 100) or (for Dam Size Classification) below whichever is higher:

\[ \text{Su} = 50.0 \text{ meters; } \text{Sd} = 1.0 \text{ km, minimum for Small Dams}, \]

\[ \text{Su} = 250.0 \text{ meters; } \text{Sd} = 1.0 \text{ km, minimum for Medium height} \]

\[ \text{Su} = 500.0 \text{ meters; } \text{Sd} = 1.0 \text{ km, minimum for large & high dams}. \]

9.4.6 A Borrow Area Sealing Plan with sufficient details shall be prepared and submitted to the NIA-CO-DSD (Copy furnished the Agency Dam Safety Organization for reference) for approval together with supporting geotechnical analysis and calculations and materials test results assuring the water tightness and adequate imperviousness of the borrow sites sealing materials prior to Initial Reservoir Filling.

9.5 Initial and Final Reservoir Filling

9.5.1 Requirements and conditions for the conduct of initial and final or full reservoir filling are stipulated and specified under the provisions of SECTION 17.0 of these Guidelines.

9.6 OTHER CONSIDERATIONS AND CRITERIA IN THE DEVELOPMENT, DESIGN AND USE OF RESERVOIRS

The following CRITERIA shall be considered and observed in the planning, development, design and utilization of reservoirs:

9.6.1 Reservoir Development Restrictions and Design Criteria

9.6.1.1 Option to limit or limited utilization to about 10% of the reservoir area for freshwater fish culture. Prohibit the use of synthetic/high chemical level pollutants fish meals /feeds that contaminates reservoir water with dangerous chemicals.
9.6.1.2 Prohibit the direct discharge of domestic waste/dangerous chemicals and other pollutants into the reservoir.

9.6.1.3 Prohibit the direct crop cultivation or any agricultural cropping activities within the water receded area of the reservoir to avoid or eliminate pesticide pollutants contamination of the reservoir water and the accelerated erosion and sedimentation processes within the reservoir.

9.6.1.4 Establish and strictly implement policies with NIA-LGU’s-Stakeholders joint participation in the provision of safety barriers and notices to prohibit encroachment of illegal occupants/tillers/ informal settlers within the reservoir area.

9.6.1.5 Identification and provision of access facilities into and exit or escape facilities from the reservoir area of astray animals and wild life.
SECTION 10.0  SPILLWAYS DESIGN GUIDELINES & CRITERIA

**Spillways** as Controlled (Gated) or Uncontrolled (Un-gated) primary outlet Structures shall be designed and to be constructed (as a primary and critical appurtenance) for dam protection from overtopping and for regulation of flood outflow from the reservoir.

10.1.0  Type of Spillways

All reservoir dams regardless of Hazard and Size Classifications shall be provided with appropriate type or a combination but not limited to the following Spillways:

I.  Service Spillway-
The structure alone must have the sufficient capacity to pass and handle the routed extreme reservoir Inflow Design Flood.

II.  Auxiliary Spillway-
The structure shall be designed to function and have sufficient capacity to pass certain percentage or excess portion of the routed prescribed maximum reservoir inflow design flood.

III.  Emergency Spillway-
The structure shall be designed to function only during extreme flood situations exceeding the maximum perceived or prescribed reservoir inflow design flood. The structure shall be sited and constructed on locations where ideally an earth or grass-lined spillway, fuse dike and saddle dike can be safely established.

10.1.1  Spillway sizing and Design Flood Capacity

10.1.1.0  Size of Spillway shall be based on the result of the comparative study of the different configuration and Type adoptable due to site condition and width required that will give optimum and economical dam embankment/freeboard height by Routing the prescribed reservoir Inflow Design Flood (IDF) magnitude/return period/frequency as prescribed in Section 7.4, Table 7.4.1 or as specified and recommended by the Dam Design Engineer or Engineering Hydrologist for the project.
10.1.1.1 Spillway Design Flood Capacity shall be based and subject to the provisions of Section 7.0 and that as prescribed in Table 7.4.1 under Sub-Section -7.4 of these guidelines.

10.1.1.2 Preference shall be given for the use and adoption of Reservoir Flood Routing Procedure by "Level Pool Technique" for the NIA Reservoir dam Projects and in the undertaking of assessment of Existing Dams Spillway Capacity during the conduct of Dam Safety Evaluation subjected to the Latest or Updated Flood Magnitude and or corresponding Inflow Design Flood.

10.1.2 HYDRAULICS & STRUCTURAL DESIGN PERFORMANCE CRITERIA FOR SPILLWAYS

10.1.2.1. Approach or Inlet channel sections shall be designed to convey flow capacity 25% higher than the flow capacity of the Inlet control weir of the spillway structure (Q inlet channel=1.25xQ control weir) particularly where the inlet channel is located and positioned in a deep excavation of erodible earth materials and or fractured rock formations having potential for slope degradation, instability/slide or rockfall that may cause blockage of the channel.

10.1.2.2. Spillway Chute/Sections having hydraulic flow velocity exceeding 15 meters/second shall be investigated for Cavitations potential and for flow velocity exceeding 30 meters/second shall be provided with anti-cavitations measures preferably Aerator structure.

10.1.2.3. Spillway Chute floor slabs shall be designed to resist the anticipated hydrostatic and dynamic Uplift pressures. Provision of anchorage to foundation shall be considered to ensure structure stability.

10.1.1.4. Terminal Structure or Hydraulics Energy Dissipator most appropriate and fitting for the spillway type and site condition shall be designed and provided to ensure that non-erosive and scouring flow condition and behavior will occur that will endanger the foundation of the spillway outlet structure.

10.1.1.4. All type of spillways designed for having complex features, gated or un-gated control, unconventional and with special features of appurtenances and elements, special and unique unsymmetrical alignment, configuration/geometrics and settings shall be subjected to mandatory
10.1.1.5. Exit or Outlet Channel shall be designed with adequate capacity to convey the exiting flow and the channel provided with appropriate scour protection to prevent channel rapid deterioration.

10.1.1.6. Spillway being a major and critical reservoir dam appurtenance shall be provided with appropriate instrumentations to monitor its Hydraulics and structural performance and to detect any unsafe condition of the structure.

10.1.1.7. Spillway Inlet Control Structure when designed to be fitted or provided with Steel Gates and or stoplogs with lifting or hoisting mechanism shall have a redundant operation control system of either combinations of an automatic/telemetric or electrically, electronically, engine driven and or manually operated system. The Type and classification, location and positioning of gates and its hoisting mechanism shall be dictated by the Hydraulics and Structural design requirements and the applicable provisions under SECTION- 13.0 of these Guidelines.

10.1.2.8. NIA-MC#91 s.2017, Section 3.2.4/Sub-sections 3.2.4.1 to 3.2.4.10 provides supplementary and further guidance in the design of Spillways.
SECTION 11.0  OUTLET WORKS (DIVERSION, IRRIGATION & OR HYDRO POWER/DOMESTIC WATER SUPPLY AND EMERGENCY/LOW LEVEL OUTLETS) CONDUITS, CHANNELS & PERMANENT & TEMPORARY COFFERDAMS.

11.0.1. All reservoir dams irrespective of hazard and size classification shall be designed and fitted with the appropriate type of Outlet Works. Provision of these appurtenant hydraulic structures and the construction of the related facilities particularly the Diversion Tunnel or Conduit, Diversion (Inlet or Outlet) Channels, Temporary or Permanent Cofferdams as the case maybe are necessary and required for the satisfactory completion of the project and for efficient operation and easy maintenance of the completed dam and reservoir facilities.

11.0.2. Irrigation, Hydro Power and Domestic Water Supply Outlet Works shall be designed and constructed primarily for the function to regulate or release water impounded by the dam in a reservoir for the aforesaid respective purposes. It shall be designed with capability to release Inflow at regulated or retarded rate, divert Incoming flows into an open channel or pipeline/closed conduit or released stored water at a rate dictated by demand or downstream need. The same structure/appurtenance shall also be designed for secondary function as an auxiliary or supplemental outlet for the release of excess flood flow during emergency situation and diversion of ordinary flood flow during construction stages or the combinations of the above-mentioned functions and usages.

11.0.3. As special design consideration, Intake Tower Inlet of Outlet Works shall not be allowed or be avoided to be established, set, positioned and be located closely parallel or alongside or crossed under or within the Spillway inflow path direction and range. This is to minimize the Intake Inlet suction of suspended debris and sediment particles during the Spillway flood spilling condition operation.

11.0.4. Provision of Emergency or Low Level Outlet shall be required and shall be incorporated as a mandatory appurtenant structure facility in all High Hazard (PHRC-3) Classification Reservoir Dams irrespective of Size Classifications specified under these Guidelines. The facility shall have the capability to lower the reservoir at safer water level at specified (minimum of 24 hrs.) time during emergency situations. Small/Low and medium
/Intermediate size under PHRC-1 & 2 reservoir Dams with Hydraulic height less than 30.0 meters, or having micro-catchment area less than 150.0 sq.km., or having estimated high sediment yield, shall be provided with Emergency or Low Level Outlet. The said Low Level Outlet Structure shall also be designed to have the function and capability to extrude/eject sediments, drain the reservoir if so, required for Dam Safety Inspection and Maintenance and Repair of any sustained damages as the case may dictate.

11.0.5. Outlet Works when provided for in the design shall be fitted with appropriate manually and or automatically operated Hydro-Mechanical and Hydro-Electrical & Electronics Control facilities for regulation and control of flow. High level or advance/automated electronic or telemetry control technology shall be allowed for installation and fitting to the appurtenances provided the installations will cause substantial benefits and facilitate, faster, easier and safer operation.

11.0.6. All mechanical and electrical/electronic control system installation and fittings to be applied for the outlet works specified under this Section shall also be subject to the provisions of Section 13 and conditions stated in Sub-Section 11.0.4 of these guidelines.

11.0.7. All type of Outlet Works designed for having complex features, with gated or un-gated control, unconventional and with special features of appurtenances and elements, special and unique unsymmetrical alignment, configuration/geometrics and settings shall be subjected to mandatory Numerical (2-D or 3-D) and Physical hydraulics and structural modeling test/studies or any other studies as required by NIA.

11.0.8. NIA-MC#91 s.2017, Section 3.2.5/Sub-sections 3.2.5.1 to 3.2.5.7 provides supplementary and further guidance in the design of Outlet works.

11.1.0. CLASSIFICATION OF OUTLET WORKS

11.1.1. Outlet Works to be integrated as appurtenant structure of the reservoir /storage dam shall be classified according to purpose, physical and structural arrangement or hydraulic operation.

11.1.2. The incorporation of either one or more or combinations of the following outlet works classification specified in Sections 11.1.2.1 to 11.1.2.5 shall be
allowed when so required or applicable based on project needs and subject to
the dam designer's discretion or judgment for application to the
particular/specific NIA Dam project/s:

11.1.2.1. River Outlet- When the outlet works structure empties or exit directly
into the river (i.e. Diversion Outlet Works during construction stage,
Emergency or Low Level /Sediment Extruder Outlet Structures)

11.1.2.2. Canal Outlet- When the outlet works structure discharges into a canal
(i.e. Irrigation Outlet Works)

11.1.2.3. Pressure Pipe Outlet- When the outlet structure delivers water into a
closed conduit or pipe system. (i.e. Outlet Works connected to pipeline
for Domestic water supply and Penstock of Hydropower Plant)

11.1.2.4. Application of Tunnel or Cut and Cover Section Outlet shall be as
prescribed (under sub-sections 11.1.2.4.1 and 11.1.2.4.2) below
respectively.

11.1.2.4.1 Tunnel Section Outlets shall be used and adopted to reservoir dams sited at
narrow rivers with steep abutments. Tunnels outlets shall be planned and
designed to be bored and pass through at the Dam abutments.

11.1.2.4.2 Cut and Cover Section Outlets shall be used and adopted to unfavorable
foundation geology and usually constructed to pass through the abutments
and/or under the dam base.

11.1.2.5. Gated or Un-Gated Outlet

Outlet Works (for small dams) shall generally be constructed near river
bed level. They shall be provided with Gates/valves to regulate and
control the release of the temporary stored water or shall be designed
Un-gated in order to retard the outflow while the reservoir temporarily
stores part of the Inflow design flood discharge or flood runoff.

11.2.0. DIVERSION OUTLET AND EMERGENCY OR LOW-LEVEL OUTLET WORKS
SIZING AND DESIGN OUTFLOW CAPACITY

11.2.1. Diversion outlet conduit irrespective of sectional shape in combination
with cofferdam shall be sized accordingly based on anticipated or
prescribed IDF magnitude during the entire duration of the construction period.

11.2.2. Specified or required IDF magnitude for the diversion outlet works shall be based on and governed by the provision of SECTION 7.0 and Table 7.4.1 of these guidelines.

11.2.3. Flood routing procedure shall be applied in the estimation of the size and outflow capacity of the diversion conduit or diversion channels during construction in conjunction with the height required for the temporary or permanent cofferdam to be integrated with the Dam appurtenances.

11.2.4. Emergency and/or Low Level Outlet Works shall be designed with a capacity to lower the reservoir water during emergency situations at a safe Level (24 hrs. minimum) without inducing a sudden reservoir drawdown rate of about 2.50cm per minute for Small Dams and 5.0cm per minute for Medium and Large Dams (1.50m/hr for Small Dams to 3.0m/hr for medium and Large dams drawdown rate) which may impair or jeopardize the embankment dam slope stability.

11.3 OUTLET WORKS SETTING, LAYOUT AND ARRANGEMENT GUIDELINES & CRITERIA

11.3.1 Setting and positioning of Outlet Works shall be carefully studied, site condition thoroughly assessed and construction provision and operational requirement shall be observed. As special design consideration, Intake Inlet of Outlet Works shall not be allowed to be established, set, positioned and located closely along or crossed under or within the Spillway Inflow direction and range. This is to minimize the suction of suspended debris and sediment particles during the flood spilling condition operation.

11.3.2 The final outlet works layout, configuration, geometrics of its elements or appurtenant parts arrangement, position and set-up shall be based and governed /controlled by the site topography, geology and structure function/s duly supported by Numerical (2-Dimensional or 3-Dimensional) and Physical Hydraulics and or Structural Modeling Studies when required by NIA.
11.3.3 Crossing of the outlet work conduits above or below main waterways shall be avoided to ensure non-obstruction of flood flow during the temporary diversion.

11.3.4 There shall be a surface and subsurface investigation undertaking for the selection and prescription of Outlet works competent foundation level to adequately sustain the design loads.

11.3.5 The reservoir storage level or operation requirement and hydraulic and structural design prerequisites for outlet works shall be observed and mandatorily enforced.

11.3.6 The outlet works structure (For small dams) shall preferably be placed at dam abutment and the invert set sufficiently below minimum reservoir operating level to provide assured head for effective outlet flow and to attain the required maximum discharge capacity.

11.3.7 Cut and cover outlet conduit shall be applied and adoptable to unfavorable foundation geology such as deep over burden or inferior rock foundation and wide rivers/channels/waterways Section. Sub-Section 11.1.4.1 provides supplemental guidance and criteria on the application of this type of outlet structure.

11.3.8 Tunnel outlet shall be applied and adoptable to sites in narrow river sections with steep abutments. A minimum size of 1.80 meters diameter shall be used for construction convenience and for practical application. Sub-Section 11.1.4.2 provides supplemental guidance and criteria on the application of this type of outlet structure.

11.3.9 The outlet works for small or low to medium size/height (Dam height; $H \leq 30.0$ meters) embankment/earth fill dams shall be carried through, under or around the dam as cut and cover box culverts or conduits and for some medium to large and high (Dam height; $H > 30.0$ meters) embankment dams shall be carried through the abutment as a Tunnel.

11.3.10 For concrete dams the outlet works for economic consideration shall be installed or curved through the dam body as formed conduit or as a pipe section embedded in the concrete mass.
11.4 OUTLET WORKS CONTROL LOCATION

11.4.1 Outlet works control shall be generally located and placed at the \textit{upstream end of the conduit}, at an \textit{intermediate point along its length} and or in other situations at the \textit{lower end of the structure}.

11.4.2 Outlet works control located at the \textit{upstream end} of the conduit shall be applicable for small/low (and or with low hydro static & dynamic pressure head) dams.

11.4.3 Outlet works control located at the \textit{intermediate point} along the conduit /tunnel length shall be applicable for large size and high hydro static & dynamic pressure head dams.

11.4.4 Outlet works control located at the \textit{lower end} of the structure shall be applicable for small to medium size and/or low to intermediate hydro static &\& dynamic pressure head (Hp≤30.0 meters) dams. Provided, the outlet works concrete conduit \textit{shall be fitted with steel liner} to ensure that potential bursting pressure failure and leakage shall be contained.

11.5 PERMANENT & TEMPORARY COFFERDAMS

11.5.1 Provision of cofferdams shall be a mandatory requirement being a vital dam construction appurtenance. It shall be provided and constructed in combination with diversion outlet structure necessary (and required) for the satisfactory completion of the project.

11.5.2 Cofferdams either permanent or temporary shall be designed based on or subject to the loading conditions as prescribed under \textit{SECTION -7.0 and SECTION -8.0 of these Guidelines}. 
SECTION 12.0 GALLERIES DESIGN CONSTRUCTION, O&M GUIDELINES & CRITERIA

Galleries are dam appurtenances which shall be provided when so required and designed as structurally formed or provided openings inside the dam body, Foundation, and Abutments for construction, operation & maintenance and inspection access.

12.1 GENERAL REQUIREMENT

12.1.1 When required by design for construction and operational considerations, formed openings or galleries of practical and economical shape shall be provided in a dam irrespective of size/height and hazard classification.

12.1.2 Galleries when provided in a dam shall serve for purposes of grouting the foundation and concrete construction joints for, drilling/re-drilling drainage holes/outlets and conveyance, operation & maintenance of gates, access to housing and control of equipment, hoisting, pumping and for inspection/monitoring of instrumentations equipment and for observations/reading of measurement of structural behavior of dam.

12.1.3 Size of gallery shall be dependent on the prescribed function and purpose it shall serve and shall have a minimum rectangular dimension (Width x Height) of about 1.50mx2.20m (For inspection/monitoring of instrumentation equipment/observations/readings of measurement of structural behavior of dams) and 1.80mx 2.40m. (For purposes of foundation grouting, seepage/drainage pumping, access to housing and control of gates, operation and maintenance of gates & hoisting)

12.2 KIND OF GALLERIES & ALIGNMENT CONSIDERATIONS

The dam galleries when so required and provided shall be the following kind:

a. Parallel to Dam Axis Galleries
b. Normal to Dam Axis Galleries
c. Vertical and Indented Shaft
12.2.1 **Parallel to Dam Axis Galleries** shall be applied and provided to but not limited to intermediate and large dams as classified under these guidelines.

Parallel to Dam Axis Galleries that shall be provided when required shall be the following:

i. **Foundation Gallery**
   Foundation Gallery shall be provided usually for drilling holes for main grout curtain and also for drilling drain holes. It is generally extends through the length of the dam near the rock surface. In plan it may be located near or parallel with the axis.

ii. **Drainage Gallery**
   Drainage Gallery shall be provided for the purpose of drilling and draining the downstream portion of the dam foundation. It may be located further downstream, about 2/3 of the base width from the upstream face. The gallery usually extends only through the deepest portion of the dam.

iii. **Gate Chamber Gallery**
   The gallery is usually designed and provided to connect hoisting chambers just over the control gates. The location and size shall depend on the need and size of the equipment to be housed. (e.g. Sluice operating gallery, & Penstock operating gallery)

iv. **Construction (Joints) Grouting Gallery**
   This gallery shall be provided for grouting concrete construction joints that are difficult to grout on the surface of the dam. It shall be placed usually near the top of each 15.0 meters lift of concrete. The gallery may also be provided and utilized for artificial cooling of the poured-in-place concrete blocks.

v. **Inspection Gallery**
   Inspection Gallery when so required by design shall be provided for dam safety inspection and monitoring purposes.
12.2.2 Normal to Dam Axis Gallery

Normal to Dam Axis gallery shall be provided when necessary and as required in the design as access adits which serve as approaches or entrance to different galleries. These galleries/adits sometimes are used as location for measuring boards of the different equipment (in recessed chambers) such as pumps.

12.2.3 Vertical and Inclined Shafts

**Vertical Shaft** shall be provided for air ventilation, housing elevator, ladder rungs access and access to vertical instrumentation read out stations.

**Inclined Shaft** shall be provided to connect two galleries or one gallery at two different elevations.
SECTION 13.0 HYDRO-ELECTRICAL AND HYDRO-MECHANICAL FACILITIES (CONTROL GATES, GUARD GATES, VALVES, BULKHEADS, STOPLOGS AND HOISTING/LIFTING MECHANISMS & EMBEDDED PARTS)

13.1 Hydro-Electrical, Hydro-mechanical and respective operation control system/facilities when so required by design shall be provided and integrated as major components of Dam (Spillway and Outlet Works) Appurtenances.

13.2 GATES AND VALVES FOR SPILLWAYS AND OUTLET WORKS

Gates and valves for Spillways and Outlet Works shall be defined based on Classification according to Pressure Head Rating and based on Category according to their functional use in the structure.

13.2.1 PRESSURE HEAD RATING CLASSIFICATION SYSTEM FOR GATES AND VALVES

Pressure head rating classification (REF.#134 & #135) shall be defined and reckoned from the bottom sill to maximum operating water surface level of the gates and valves and shall be classified as follows:

1. LOW PRESSURE HEAD - Pressure head below 15.0 meters
2. INTERMEDIATE PRESSURE HEAD - Pressure head above 15.0 meters and below 30.0 meters
3. HIGH PRESSURE HEAD – Pressure head greater than 30.0 meters

13.2.2 GATES AND VALVES FUNCTIONAL USE CATEGORY

Operating Gates and Regulating Valves shall be used to control and regulate the outlet works flow and shall be designed to operate in any position from closed to fully open position.

Guard or Emergency Gates- shall be designed to be utilized only to effect closure in the event of maintenance or failure of the operating gates or where de-watering is desired either to inspect the conduit below the guard gate or to inspect and repair the operating gates.
Stop Logs / Bulk Head- shall be designed to be installed and provided at the Intake Tower Inlets for Intermediate and high dams, High pressure conduits and/or Tunnel entrances so that the conduit/tunnel can be temporarily closed off during an emergency period or during the construction of closure structure or concrete plug of diversion tunnel.

Bypass Valves- shall be required to be designed and installed for balancing pressure between Guard and Regulating gates or valves. It shall also be designed having a capacity to release, reduce water level or empty/drain the water trapped in the space between the gates or valves at specified duration.

13.2.3 LOCATION OF CONTROL GATES/VALVES AND STOPLOGS/BULKHEADS

Locations of steel gates and operation control system/facilities for OUTLET WORKS shall be governed by the provisions of SECTION 11.4.0-OUTLET WORKS CONTROL LOCATIONS.

For Gated/Controlled SPILLWAYS, the location of control Gates and Stoplogs shall be dictated by the Hydraulic requirements, Structural considerations, Configurations, and setting of the Structure.

13.3 ELECTRICAL AND ELECTRONICS SYSTEMS/FACILITIES

Electric power and Electronics Systems requirements for operating and monitoring of the conditions and performances of the gates, valves, Operations and Maintenance of equipment, lighting, communications, controls and monitoring systems for dam and reservoir complexes/appurtenances shall be properly planed, designed, provided, operated and maintained.
SECTION 14.0  DAM SECTIONS, CONFIGURATIONS/GEOMETRIC DESIGN, LOADING CONDITIONS AND STRUCTURAL STABILITY & SAFETY CRITERIA

Dams regardless of type of material, size and classification shall be properly and safely designed with capability to withstand and resist the possible severest or extreme loading conditions or combination of loads being applied to any of the dam parts acting as discrete elements integrated to form a single, stable and safe structure.

14.1.0.  DAM SECTION DESIGN GUIDELINES & CRITERIA

Preliminary and initial Dams Section and configuration shall be governed by the requirements and specific provisions of SECTION-3 and of this Section. However, the final section being adopted shall be governed by the results of the requirements and provisions of Sub-Sections 14.1, 14.2. and 14.3 respectively of these Guidelines.

14.1.1  EMBANKMENT (EARTHFILL & ROCKFILL) DAM DESIGN

Earthfill or Rockfill Embankment dam shall be designed to have a composition of the following discrete parts or elements (Zone) and appurtenances that are applicable or required and shall be sized, proportioned and dimensioned based on the guidelines and criteria stipulated under this section and related sub-sections:

a. Embankment Dams Foundations and Abutments
b. Cutoffs/cutoff trench
c. Embankment (Pervious Fill/Random fill/Transition Fill, Impervious Dam Body/Clay Core and Permanent Coffer Dam) Section
d. Embankment Slopes and Protection
e. Embankment Crest
f. Freeboard
g. Permanent and/or Temporary Cofferdams
h. Seepage Drains and Filters
i. Stability Berms
j. Rock Toe
k. Instrumentations
l. Operation & Maintenance, Inspection Facilities, Miscellaneous Parts and Requirements
m. Spillway, and its Hydro- mechanical, Electrical and Electronics Control and monitoring Facilities /appurtenances.

n. Outlet Works (Diversion & Irrigation Outlets) and its Hydro- mechanical, Electrical and Electronics Control and monitoring Facilities /appurtenances.

14.1.1.1 EMBANKMENT (Earthfill & Rockfill) DAMS, FOUNDATIONS AND ABUTMENTS DESIGN CRITERIA

The following Criteria must be complied to provide and ensure a safe Embankment Dam Structure:

1. The Foundation, Abutments and Embankment must be stable for all Loading Conditions especially during construction and Operation. Very steep, high abutments shall be cut to a flatter slope in the Impervious/Core and Transition Zones. Steepest Cut slope for hard massive rock abutments shall not exceed 2 vertical on 1 horizontal. For soil/earth abutments, Steepest cut slopes shall not be steeper than 1 vertical on 3 horizontal.

2. Seepage through the Embankment, Foundation and Abutments must not exert excessive forces on the structure nor must piping of materials be permitted.

3. Core materials must be impermeable/possess water tightness and capable of retaining stored water with minimal seepage losses and resistant to concentrated leaks.

4. The Embankment slopes must be stable under varying conditions. The Upstream Slope must be protected against wave action and the Downstream Slope must be protected against erosion.

5. The top of the dam (Dam Crest) must be high enough to provide allowance for settlement of the dam and foundation and also to provide sufficient freeboard to prevent (wind and seismic) waves generated during normal and maximum reservoir water surface level from overtopping the dam.

6. The Spillway and Outlet Structures must have adequate capacity to prevent overtopping of the dam. It is a primary importance that the spillway alone be capable of releasing the prescribed Inflow Design Flood.
7. The Spillway and the Outlet works must be structurally safe and stable under all operational conditions. Slopes of the inlet channels must be stable so as not to cause slope slide and clogging of channels.

14.1.1.2 EMBANKMENT, DAM FOUNDATIONS, ABUTMENTS AND MATERIAL EXPLORATIONS AND TESTING.

Foundations, Abutments and Materials for Embankment Dams shall be subject to and must undergo mandatory surface and sub-surface explorations and (Site and Laboratory) Testing as specified in Section 6.2 of these Guidelines.

Special laboratory and in-situ/field test must be required to determine the physical and engineering properties of the foundation, abutments and embankment materials. Other test shall be undertaken as may be required (Dynamic Properties Test) to determine the most appropriate foundation, abutment and embankment materials.

The following Embankment, Dam Foundations and Abutments Materials major index and engineering properties shall be explored, tested and analyzed in order to design a safe structures that are suitable and appropriate for the selected site and conditions:

I. EARTH/SOIL EMBANKMENT AND FOUNDATION MATERIALS PROPERTIES

i. Permeability
ii. Specific Gravity
iii. Density
iv. Gradation
v. Plasticity Index
vi. Atterberg limit
vii. Consolidation
viii. Shear Strength
    (Cohesion, C & Internal Friction Angle, φ) Tri-axial Test
    (UU, CU & CD) and
ix. Bearing Capacity
II. ROCK MASS FOUNDATION MATERIAL PROPERTIES

i. Deformation Modulus

ii. Static Strength Properties
   1. Compressive Strength
   2. Shear Strength (Cohesion-C, Internal Friction, φ)
   3. Allowable Bearing Capacity

iii. Dynamic Strength Properties
   1. Elastic Moduli
   2. Rock Densities
   3. Poisson's Ratio

iv. Rock Mass Foundation Ratings/Rock Quality Designation (RQD)
   1. Weathering Number (Wn)
   2. Joint Number (Jn)
   3. Hardness Number (Hn)
   4. Lugeon Value (Lv)

The Rock Mass Foundation Material Properties specified for Embankment Dams under this Section shall also be applicable for Concrete, Masonry and Hardfill Dams.

14.1.1.3 EMBANKMENT DAMS FOUNDATIONS AND ABUTMENT CLASSIFICATIONS

14.1.1.3.1 In general, an embankment dam should never be located on or near an active fault. However, certain or other type of embankment dams maybe constructed on seismically active areas or sites provided special defensive design measures shall be formulated and incorporated and undertaken to avoid catastrophic events or dam failure.

14.1.1.3.2. Embankment Dams shall be allowed to be constructed only on the following four (4) main classes of foundations herein specified, subject to the conditions and limitations under these guidelines:

1. ROCK FOUNDATIONS & ABUTMENTS
2. PERVIOUS FOUNDATIONS & ABUTMENTS
3. IMPERVIOUS SOIL FOUNDATIONS & ABUTMENTS
4. NON-UNIFORM/ NON-HOMOGENEOUS FOUNDATIONS & ABUTMENTS
14.1.1.3.2.1 ROCK FOUNDATIONS & ABUTMENTS

14.1.1.3.2.1.1 **Solid Rock Foundations** are adoptable and suitable to any type of dams including and specifically for Embankment (Earthfill and Rockfill) Dams due to the relatively high bearing capacity and resistance to erosion and percolation.

14.1.1.3.2.1.2 Removal of disintegrated rock shall be required together with the sealing of seams and fractures will be mandatory for this kind of foundations.

14.1.1.3.2.1.3 Primary considerations in the design of rock foundations and abutments shall be the formulation of treatment requirement to contain the erosive leakage, excess loss of water through joints, fissures, crevices, seams in permeable strata and fault planes.

14.1.1.3.2.1.4 **Grouting** shall be one of the main options for foundation and abutments treatment measure that shall be considered and be incorporated in the design if warranted.

14.1.1.3.2.1.5 **Shale or other type of soft rock foundations** having joints, faults and seams that are filled with soft materials and weak layers shall be given special foundation treatment to improve the strength.

14.1.1.3.2.1.6 **Rock Abutments** should be prepared same manner as the rock surface of the foundation. It shall be mandatory to remove or trim rock overhangs and should be applied particularly at the impervious and transition zones. Trimming should be done prior to abutment grouting.

14.1.1.3.2.1.7 Maximum vertical rock face of the abutments when so required and adopted in the design to support the impervious core and transition zones shall not exceed 1.50 meters. This is to avoid impervious core cracking at the location of the core-abutment interface.

14.1.1.3.2.1.8 High and very steep rock abutments generally should be cut back to flatter slope in the impervious and transition zones. Slope with Hor.=1.0 and Vert.= 2.0 or flatter slope is desirable and preferable.
14.1.1.3.2.2 PERVIOUS FOUNDATIONS AND ABUTMENTS

14.1.1.3.2.1 Foundations consist of alluvial deposits composed of highly pervious materials like sand and gravels overlying impervious geological formations like rock or clay shall be qualified as foundation for earthfill and rockfill dams, subject to the limitations and provisions under these Guidelines.

14.1.1.3.2.2 Gravel foundations are suitable for Earthfill, Rockfill and low gravity dams if the foundation is well compacted. However, gravel foundations are highly susceptible to high seepage flow rates, high percolation rates and special treatment shall be required or to be undertaken to provide effective water cutoffs or seals.

14.1.1.3.2.3 Silt and Fine sands foundations can be used to support low gravity dams and Earthfill type of Embankment dams if properly designed but they are not suitable for Rockfill type of embankment dams. Main problem associated with this type of foundations are settlement, piping prevention, excessive seepage flow rates, percolation losses and protection of foundation at the downstream toe due to erosion or piping.

14.1.1.3.2.4 Loose Fine Sands or Coarse Silt Deposits in a foundation reduces its strength having high compressibility and highly susceptible to liquefaction when subjected to earthquake forces or vibrations.

14.1.1.3.2.5 Treatment to be provided to control the above-mentioned foundation problems in sub-section 2.1.4 shall be governed by the thickness of the pervious foundation strata.

14.1.1.3.2.6 Field and Laboratory investigations and testing of the above-mentioned foundation materials shall be mandatory.

14.1.1.3.2.7 Abutments composed of soil with steep slopes shall be flattened to minimize transverse cracking of the dam embankment.

14.1.1.3.2.8 Pervious Foundations and Abutments composed of loose fine sands or silts CROSSED BY ACTIVE FAULT are NOT SUITABLE for use or shall not be allowed nor to be adopted as foundation for Embankment or other type of dams.
14.1.1.3.2.3 IMPERVIOUS SOILS FOUNDATIONS & ABUTMENTS

14.1.1.3.2.3.1 Foundations consisting of SILT and CLAY extending to large depth are considered highly impermeable and do not require providing treatment for under seepage control and piping.

14.1.1.3.2.3.2 Foundations of this type are highly prone to excessive pore water pressure and excessive deformations or settlement once subjected to loading.

14.1.1.3.2.3.3 Stability and safety analysis check of foundation materials against shear stress shall be required and dam section design shall be adjusted in such a way that the slopes of the embankment are made flatter to develop wider base and shall be provided with stability berms on either side when dictated or as required by design.

14.1.1.3.2.3.4 Clay Foundations can be used for earthfill dams but shall require special treatment and elaborately conservative dam section design.

14.1.1.3.2.3.5 Unconsolidated and high moisture content clay foundations are highly susceptible for large settlement and are considered not suitable for the construction of gravity dams and should not be used for Rockfill dams.

14.1.1.3.2.4 NON-UNIFORM OR NON-HOMOGENEOUS FOUNDATIONS AND ABUTMENTS.

14.1.1.3.2.4.1 This type of foundation and abutments are generally the combinations of foundations as previously specified and enumerated.

14.1.1.3.2.4.2 Foundations and Abutments of this type can be made suitable to specific type of dams by introducing special design features of the dam section and providing appropriate foundation treatment.

14.1.1.4 EMBANKMENT DAM FOUNDATION AND ABUTMENTS SEEPAGE CONTROL APPURTENANCES AND ELEMENTS

14.1.1.4.1 Control of seepage through the foundations and abutments shall be required and shall be provided with thorough and careful design study.
14.1.1.4.2 Seepage control measures that maybe applied and considered in Embankment Dam design are the following:

1. Cutoffs
   1.1. Cutoff Trench
   1.2. Slurry Trench cutoffs
   1.3. Concrete cutoffs
   1.4. Steel Sheet Piles cutoffs (for Small gravity and buttress dams)
2. Upstream Impervious blanket
3. Foundation Grouting
4. Downstream Pervious (sand and gravel) Inclined or vertical Chimney and blanket Filter/Drains
5. Pipe Drains (where practically applicable)
6. Relief wells and
7. Drainage Adits into the abutments

14.1.1.4.2.1. CUTOFFS PURPOSE, FUNCTION AND DESIGN

Cutoffs are (Embarkment) dam base element or parts that are in contact with the foundation and abutment surfaces. Cutoffs are provided and shall be designed for the purpose of controlling seepage and percolation through pervious foundations and abutments. They are also use for reducing the amount of seepage (seepage flow rate) and seepage forces that may induce potential damage to the structure by rendering soil particles unstable resulting to piping.

14.1.1.4.2.2. TYPE OF CUTOFF TRENCHES (COTs)

General Type of Cutoff trenches (COTs) that shall be considered for adoption are:

1. Sloping Side Trench- for adoption and application on granular or pervious foundation materials
2. Vertical Side Trench-for adoption and application on Rock foundations or hard and impervious cohesive and consolidated foundation materials.
14.1.1.4.2.3 LOCATION OF CUTOFF TRENCHES (COTs)

Trench center line should preferably located upstream from the centerline of the dam crest but not beyond a point where cover of impervious embankment above the trench will no longer provide resistance to percolation of at least equal to that provided by the trench.

The trench center line should be kept parallel to the dam axis or dam center line across the deepest portion of the river bed and river flood plains section or where the maximum dam section location occurs but should converge towards the centerline of the dam as it merged or join towards or upward the abutment in order to maintain and provide adequate embankment cover.

For Small or Low Dams (height, \(H \leq 15.0\) meters defined per MC#91 s.2017), and for construction convenience, trench center line may be laid parallel with and exactly along the dam crest or dam axis center line provided the required percolation resistance at the foundation level are satisfied to avoid piping failure.

For Medium Size/height (height, \(H>15.0\) to \(H<75.0\) meters defined per MC.# 91 s.2017) and for Large or High dams (height, \(H>75.0\) meters defined per MC.#91s.2017), the Upstream Offset of about \(0.20xH\) to \(0.50xH\) from the dam crest or dam axis centerlines maybe use for approximation purposes. Such offset when adopted for the alignment of the cutoff trench centerline at the maximum dam section should satisfy and ensure the provision of the required and adequate percolation resistance.

For other type of Embankment Dams where the water retaining barrier or impervious part/element (Diaphragm Type) were located at or near the upstream slope surface, the cut off trench shall be located at or near the upstream toe of the dam.
14.1.1.4.2.4 DEPTH OF CUTOFF TRENCHES (COTS)

Depth of cutoff trench shall be determined based on the soundness, shear strength, bearing capacity and impermeability of the foundation material where it will be resting.

For Small or Low dams, where \( H \leq 15.00 \) meters the depth of cutoff trench as a rule and for economic consideration shall not be excavated deeper or greater than the depth of the exposed height of the Dam Embankment.

Expressed in the equation: \( d \leq H \)

Where: \( d = \) depth of Cutoff trench

\[ H = \text{height of dam embankment above ground.} \]

For best practice, the cutoff trench shall be embedded or extended down to bedrock or other impervious and competent foundation stratum.

14.1.1.4.2.5 BOTTOM WIDTH OF CUTOFF TRENCHES

Cutoff trench bottom width (Wbcot) generally should increase with an increase in reservoir head and will decrease as the depth of the trench increases due to loss of head as the seepage force at the foundation contact travels vertically through or along the foundation contact.
a. For Small Embankment Dams, the bottom width may be estimated by the USBR formula:

\[ W_{bcot} = H - d \]

Where: \( W_{bcot} \) = bottom width of cutoff trench

\( H \) = Reservoir head above ground surface,

\( d \) = Depth of cutoff trench excavation below ground surface

c. For Construction convenience (accessibility and maneuverability of construction equipment and by practical placement and spacing of grout holes for Foundation curtain/blanket grouting) the required approximate Minimum Cutoff Trench bottom width (\( W_{bmin.} \)) shall be as follows:

i. For Small/Low Dams; \( W_{bmin.} = 4.0 \) meters

ii. For Medium Size/Height; \( W_{bmin.} = 6.0 \) meters

iii. For Large/High Dams; \( W_{bmin.} = 8.0 \) meters

14.1.1.4.2.6 SLURRY TRENCH CUTOFFS

Slurry Trench shall be adopted when the depth of excavation is greater than 15.00 meters up to 25.00 meters and or where control of ground water will be difficult to achieve using other type of trench.
Width of Slurry Trench shall be dependent on the type of excavating equipment. (Backhoe and Draglines cranes)

Sides of the trench shall be made stable by supporting by means of Bentonite Slurry or any alternative and feasible measures.

Base of the trench shall be ensured to be resting upon bedrock or other impervious and competent foundation stratum and not on large boulders.

Location of the Trench shall be based upon the judgment of the Dam design engineer. However, it shall be advisable and best practice that the location for the trench should be beyond the upstream toe of the dam when combined with upstream impervious core or blanket so that repair can be done when necessary or required.

14.1.4.2.7 CONCRETE (PRE-CAST & CAST-IN-PLACE) CUTOFFS
Concrete cutoffs shall be applicable for used where the depth of cutoff ranges from 1.50 meters up to 6.00 meters. Deeper concrete cutoffs shall be considered or allowed depending on the hydraulic requirement and structural capacity of the element.

Thickness shall be dependent on structural requirement and perceived loading capacity. (Usually from 0.25 m to 0.50m)

Excavations for deeper cutoffs are done by drilling with special equipment and the excavation walls or sides are supported by Bentonite slurry

Concrete cutoffs shall be constructed or poured in place by tremies.

Location shall preferably be beyond the upstream toe of the dam or at an ideal site where cracking of the concrete cutoffs will be avoided or minimized due to overstressing as the result of the influence of stresses induced by the embankment loading and weight.
14.1.1.4.2 Steel Sheet Piles Cutoffs
Steel sheet piles cutoffs shall be used where it is suitable and applicable as alternative to Concrete cutoffs. This type of cutoffs are suited for application to concrete or masonry small size/low height gravity and buttress dams on non-rock or earth foundations.

14.1.1.4.3 Upstream Impervious Blanket
Upstream Impervious Blanket when used or applied in the design to control and reduce the amount of seepage passing through the foundation shall be ensured to be connected to the impervious (core) section of the dam.

The Length and Thickness of the Upstream Impervious Blanket can be estimated by various formulas and equations given on different references and from experiences. However, it shall be subject to the limitations as prescribed below:

The blanket shall have at least minimum length of about 10 times depth of the reservoir or hydraulic head. In case of fine sand or silty foundations, the blanket length shall be kept to about 15 times the reservoir depth or hydraulic head.

The thickness of the upstream impervious blanket shall be kept between 1.5 meters (minimum) to 3.0 meters (maximum) and shall depend and be determined based on the length, permeability of the blanket material to be used and permeability and depth of pervious stratum of the foundation.

14.1.1.4.4 Foundation Grouting
Control of seepage under permeable (Earth or Rock) foundations shall be undertaken and can be attained through curtain grouting below a well prepared cut-off-trench or core trench.

For average foundation condition, depth of grout zone of Grout Curtain shall be provided to about 2/3 to 3/4 of the reservoir water depth.
Depth of Grouting for jointed rock foundations may be estimated by any recently developed, applicable and acceptable Empirical Formulas and or by Simond's Formula:

\[ D = \frac{1}{3} \times H + C \]

Where: 
- \( D \) = depth of grout
- \( H \) = hydrostatic head above core trench
- \( C \) = constant (5.0 meters)

14.1.1.4.5 DOWNSTREAM CHIMNEY AND BLANKET DRAINS

Downstream (Vertical or Inclined) Chimney Drains shall be provided to intercept seepage water before it reaches the downstream slope.

The Horizontal drainage blanket shall be designed and provided to intercept and serve as discharge point or exit conveyance for the chimney drain and provided or laid over the portion of foundation downstream from the impervious zone or cut-off trench of the dam and extended to combine with a rock toe.

The top of chimney drains shall be placed above the estimated maximum reservoir water surface level to prevent the occurrence of phreatic siphoning.

Length of the horizontal blanket drains shall be properly established and shall be generally estimated to about 2.5 to 3.0 times the height of the dam.

14.1.1.4.6 PIPE OR TOE DRAINS (WHERE PRACTICALLY APPLICABLE)

Pipe drains shall be designed and applied to collect the seepage from the horizontal blanket which discharges into the spillway stilling basin or into the river channel below the dam.

14.1.1.4.7 PRESSURE RELIEF WELLS

Pressure Relief Wells shall be provided when so required based on foundation condition where artesian pressures exist and need to be reduced to avoid formation of sand boils and piping.
Relief wells shall be designed to penetrate at least 50% into the pervious strata or thick aquifer where the foundation is stratified.

Depth of wells shall be based on geological information available during the investigation and can be estimated about equal to the height of dam as adequate and satisfactory.

Wells shall be spaced such that pressure gradients between them shall not exceed 0.5 to 0.7.

As a general rule wells shall be spaced sufficiently close together to about 15.0 meters on center.

14.1.1.4.8 DRAINAGE ADITS INTO THE ABUTMENTS

Drainage adits into the abutments shall be required and designed to adequately convey the intercepted and accumulated seepages within the dam body and the foundation.

14.1.1.5 EMBANKMENT DAM GEOMETRICS AND SECTION

14.1.1.5.1 The type and classification of the Embankment dam to be adopted should meet the requirement and shall be subject to the provisions and limitations prescribed under Section 3.0 of this guidelines.

14.1.1.5.2 The selection of the type of Embankment Dams (Earthfill or Rockfill) and the setting of configuration and geometrics of the Dam Section shall be dictated and governed primarily by the availability of materials near the site, the climatic Condition, adoptability, adequacy & applicability and suitability of the foundation. Figure 14.1.1A, Fig 14.1.1B & Fig 14.1.1C and Figure 14.1.2A, Fig 14.1.2B & Fig 14.1.2C may be use as guide for the Setting, placement of Basic Dam Section for Earthfill and Rockfill Dams respectively.
FIGURES OF THE BASIC DAM SECTIONS OF THE (EARTHFILL AND ROCKFILL TYPE) EMBANKMENT DAMS

I. EARTHFILL TYPE EMBANKMENT DAMS
   (BASIC SECTIONS)

   Reservoir Water Surface Level

   Upstream Face/slope

   Impervious Earthfill Materials

   Downstream Face/slope

   Grout Curtain

FIGURE 14.1.1A- HOMOGENEOUS EARTHFILL DAM SECTION
FIGURE 14.1.1B- MODIFIED HOMOGENEOUS EARTHFILL DAM SECTION
Reservoir Water Surface Level

Upstream Slope/Face

Pervious/Rand Earthfill

NG

Downstream Slope/Face

Pervious/Rand Earthfill

Impervious Earthfill Materials

Rocktoe

Filter/Drain

Grout Curtain

FIGURE 14.1.1C-ZONED EARTHFILL DAM SECTION
II. ROCKFILL TYPE EMBANKMENT DAMS
   (BASIC SECTIONS)

![Diagram of Central Core Rockfill Dam Section]

**FIGURE 14.1.2A - CENTRAL CORE ROCKFILL DAM SECTION**
Reservoir Water Surface Level

Upstream Slope/Face

Impervious Sloping Core Materials

Downstream Slope/Face

Rock Riprap

Rockfill Shell

H
V

Filters & Drains

Grout Curtain

Rocktoe

FIGURE 14.1.2B - SLOPING IMPERVIOUS CORE ROCKFILL DAM SECTION
Reservoir Water Surface Level

Upstream Slope/Face

Impervious Material

Foundation Gallery

Grout Curtain

Downstream Slope/Face

Rockfill Materials

Blanket Filters & Drains

FIGURE 14.1.2C- DIAPHRAGM TYPE ROCKFILL DAM SECTION
14.1.1.6.0 EMBANKMENT DAM SECTIONS AND SLOPES

14.1.1.6.1 For initial or tentative (Feasibility Study Level Design) setting of upstream and downstream dam slopes and dam section configuration, Table -14.1.1A, Table-14.1.1B & Table-14.1.1C (REF. nos. 11,12,13 &14) shall be used. Other methods and standards from other countries that are of internationally accepted practice may be introduced for application under this guideline but shall be subject to approval by NIA.

14.1.1.6.2 The final dam embankment slopes or dam section configuration shall be governed by the result of the dam slopes or embankment and foundations stability analyses and other redundant Safety features and measures integrated thereat and considering all applicable loading conditions specified in the appropriate Sub-section of these guidelines.

Table-14.1.1A – Recommended Dam Slopes (by Terzagi)
(Extract from REF.#147)

<table>
<thead>
<tr>
<th>Type of Materials</th>
<th>UPSTREAM SLOPE (H:V)</th>
<th>DOWNSTREAM SLOPE (H:V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Homogeneous well graded materials</td>
<td>2.5 : 1</td>
<td>2 : 1</td>
</tr>
<tr>
<td>2. Homogeneous coarse silt</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3. Homogeneous Silt Clay or Clay</td>
<td>3 : 1</td>
<td>2.5 : 1</td>
</tr>
<tr>
<td>3.1 Height less than 15.0 meters</td>
<td>2.5 : 1</td>
<td>2.0 : 1</td>
</tr>
<tr>
<td>3.2 Height more than 15.0 meters</td>
<td>3 : 1</td>
<td>2.5 : 1</td>
</tr>
<tr>
<td>4. Sand or Sand &amp; Gravel with Clay Core</td>
<td>3 : 1</td>
<td>2.5 : 1.</td>
</tr>
<tr>
<td>5. With Reinforced Concrete Core Wall</td>
<td>2.5 : 1</td>
<td>2 : 1</td>
</tr>
</tbody>
</table>
Table-14.1.1B - Recommended Slopes for Small Homogeneous Earthfill Dams On Stable Foundations
(Extract from REF.# 141)

<table>
<thead>
<tr>
<th>Case</th>
<th>Type</th>
<th>Purpose</th>
<th>Subject to Rapid Drawdown</th>
<th>Soil Classification</th>
<th>U/S Slope (H:V)</th>
<th>D/S Slope (H:V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Homo geneous or modified-Homo geneous</td>
<td>Detention or Storage</td>
<td>NO</td>
<td>GW,GP,SW, SP</td>
<td>Pervious, Unsuitable</td>
<td>Pervious, Unsuitable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GC,GM,SC, SM</td>
<td>2.5 : 1</td>
<td>2 : 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CL,ML</td>
<td>3 : 1</td>
<td>2.5 : 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CH, MH</td>
<td>3.5 : 1</td>
<td>2.5 : 1</td>
</tr>
<tr>
<td>B</td>
<td>Modifi ed-Homo geneous</td>
<td>Storage</td>
<td>YES</td>
<td>GW,GP,SW, SP</td>
<td>Pervious, Unsuitable</td>
<td>Pervious, Unsuitable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GC,GM, SC, SM</td>
<td>3 : 1</td>
<td>2 : 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CL,ML</td>
<td>3.5 : 1</td>
<td>2.5 : 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CH,MH</td>
<td>4 : 1</td>
<td>2.5 : 1</td>
</tr>
</tbody>
</table>
### Table-14.1.1C – Recommended Slopes for Small Zoned Earthfill Dams on Stable Foundations
(Extract from REF.#141)

<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose</th>
<th>Subject to Rapid drawdown</th>
<th>Shell Material Classification</th>
<th>Core Material Classification</th>
<th>U/S Slope (H:V)</th>
<th>D/S Slope (H:V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoned with Min. Core-A</td>
<td>Any</td>
<td>Not Critical</td>
<td>Rockfill, GW, GP, SW (gravelly), or SP (gravelly)</td>
<td>GC, GM, SC, SM, CL, ML, CH, or MH</td>
<td>2 : 1</td>
<td>2 : 1</td>
</tr>
<tr>
<td>Zoned with Max. Core.</td>
<td>Detention or Storage</td>
<td>NO</td>
<td>Rockfill, GW, GP, SW (gravelly), or SP (gravelly)</td>
<td>GC, GM</td>
<td>2 : 1</td>
<td>2 : 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SC, SM</td>
<td>2.25:1</td>
<td>2.25:1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CL, ML</td>
<td>2.5:1</td>
<td>2.5:1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CH, MH</td>
<td>3 : 1</td>
<td>3 : 1</td>
</tr>
<tr>
<td>Zoned with Max. Core</td>
<td>Storage</td>
<td>YES</td>
<td>Rockfill, GW, GP, SW (gravelly), or SP (gravelly)</td>
<td>GC, GM</td>
<td>2.5:1</td>
<td>2 : 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SC, SM</td>
<td>2.5:1</td>
<td>2.25:1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CL, ML</td>
<td>3:1</td>
<td>2.5:1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CH, MH</td>
<td>3.5:1</td>
<td>3:1</td>
</tr>
</tbody>
</table>
14.1.1.6.3 CLASSIFICATION CRITERIA OF CORE MATERIALS FOR EMBANKMENT DAM.

Core materials for Embankment Dams shall be selected on the basis of its resistance to concentrated leaks (based on Sherard, 1967 Study/REF.#148 & REF.#161) and shall be described and classified as to quality as follows:

1. **Very Good Materials:**
   1.1. Very well-graded coarse mixtures of sand, gravel and fines materials.

2. **Good Materials:**
   2.1. Well-graded mixture of sand, gravel and clayey fines
   2.2. Highly plastic tough clay (CH) with Plasticity Index (PI) greater than 20.0

3. **Fair Materials:**
   3.1. Fairly well-graded gravelly, medium to coarse sand with cohesionless fines.
   3.2. Clay of medium plasticity (CL) with Plasticity Index (PI) greater than 12.0
   3.3. Coarse mixture of sand, gravel and fine materials

4. **Very Poor Materials:**
   4.1. Fine, uniform, cohesionless silty sand
   4.2. Silt from medium plasticity to cohesionless (ML), Plasticity Index (PI) less than 10.0. These materials are highly erodible
   4.3. Dispersive Clays (Clay soils having appreciable Sodium/Salt Contents)
14.1.1.7.0 EMBANKMENT DAM CREST DESIGN & CRITERIA

The following features shall be considered for the design of the Crest of an Embankment Dams:

1. Width
2. Drainage
3. Surfacing
4. Camber
5. Safety provisions & measures
6. Zoning
7. Other Features (For convenience of Visitors & O&M Staff)
   7.1. Parking area/bay
   7.2. Turn around bay
   7.3. Viewing bay or deck
   7.4. Inspection pathways/access/bridge

14.1.1.7.1 EMBANKMENT DAM CREST WIDTH (WC)

The crest width (Wc) shall be established, determined and estimated on the basis of the following conditions and considerations which ever shall govern:

1. Crest width requirement based on the minimum percolation distance through the embankment at reservoir level being considered.

   The crest width must be dimensioned such as not to result in high seepage gradient on dam sections below the crest. The seepage hydraulic gradient (H/L) should not be greater than the buoyant weight of the impervious embankment soil particle (G-1/1+e) on the dam body or should not developed within or near the upper level of the embankment which can result to piping. The condition is shown on Figure 14.1.1.5 and expressed in the equation below.
\[ \frac{H}{L} \leq \frac{(G-1)}{1+e} \]

Where:

- \( H \) = difference in elevation between the reservoir water surface level and the exit point/emergence point of the seepage
- \( L \) = Length of shortest path of percolation
- \( G \) = Specific Gravity of the soil particles
- \( e \) = Void ratio of the formation through which the potential leakage or seepage emergence point occurs.

Referring on Figure 14.1.1.5 as shown below, the Minimum Crest Width shall be established based on the above principle, using the equation below;

\[ (W_c)_{\text{min.}} = L - (Lu + Ld) \]

Where:

- \( (W_c)_{\text{min.}} \) = Minimum Crest Width in meters
- \( Lu = \left( \frac{h_u}{v_u} \right) \times fb \); and
- \( Ld = \left( \frac{h_d}{v_d} \right) \times Hw \)
2. Crest Width by Size / height and or Hazard classification of Dam Structure

a. For Small Dams by USBR

1. \( W_c = \frac{H}{5} + 10 \) ------- In English Unit
   Where:
   \( W_c = \) width of crest in Feet
   \( H = \) height of dam above riverbed in Feet

2. \( W_c = (\frac{H}{5} + 3.0) \) ------- In Metric Unit
   Where:
   \( W_c = \) width of crest in meters
   \( H = \) height of dam above riverbed in meters

b. For Dams Regardless of Size and Hazard Classification (by Varshney & Gupta, Theory and Design of Irrigation Structures; Vol.2)
\[ Wc = \frac{5}{3} \times H^{1/2} \]

Where:

- \( Wc \) = Crest width in meters
- \( H \) = height of dam in meters

c. For Small Dams Regardless of Hazard Category (by Lewis, 2002.) Extracted from ICOLD bulletin No.157 authored by the AD HOC Committee on small dams (2005-2011), Small Dams Design, Surveillance and Rehabilitation. (Reference #162)

The (LEWIS, 2002) Formula is expressed as:

\[ Wc = H^{0.5} + 1.0 \]

Where:

- \( Wc \) = Crest Width in meters
- \( H \) = height of dam from stream bed to crest level in meters

3. Crest Width Requirement by Construction Convenience

3.1. For Small Earthfill Dams, \( Wc = 4.0 \) meters min.
3.2. For Intermediate/Medium Height, \( Wc = 6.0 \) meters min.
3.3. For High Embankment Dams, \( Wc = 9.0 \) meters min.

4. Minimum Crest Width by Roadway Requirement in the Philippines:

4.1. For use as NIA Service/O&M Road, \( Wc = 4.0 \) m. (1-lane) \( Wc = 6.0 \) m (2-lanes)
4.2. For use/ connecting Barangay Road; \( Wc = 8.0 \) m
4.3. For use /Connecting Municipal Road; \( Wc = 12.00 \) M
4.4. For use /Connecting Provincial Road; \( Wc = 18.0 \) M
4.5. For use as &Connecting National Highway; \( Wc = 24.00 \) meters & above
14.1.1.7.2 DAM CREST SURFACE DRAINAGE, SURFACE PROTECTION AND SAFETY REQUIREMENTS.

14.1.1.7.2.1 CREST SURFACE DRAINAGE REQUIREMENT

Embankment Dams regardless of size and height shall be provided with Crest Surface Drainage.

A minimum crest crown of about 80.0mm thick be provided and the crest surface be made sloping towards the upstream and downstream slopes.

14.1.1.7.2.2 CREST SURFACE PROTECTION

Ensure that Dam Crest surfaces are protected against any identified and expected type and causes of erosion.

Dam crest surface shall be protected against the damaging effect of wave splash, rainfall, surface runoff, wind erosion and traffic wear when used as roadway as specified under sub-section 14.1.1.5.1 Item Nos.4.1 to 4.5

The following kinds of Crest Surface protections maybe adopted depending on the availability of the materials and cost considerations:

i. Gravel Surfacing- Provide 100 mm minimum thickness inclusive of the binding materials

ii. Asphalt (Bituminous) Pavement- Thickness shall depend on the specified traffic load.

iii. Concrete Pavement- Thickness shall depend on the specified minimum design traffic load and concrete strength. A minimum truck load using HS-20 is recommended. However higher loading maybe specified to satisfy both design, construction and O&M requirements.
14.1.1.7.2.3 DAM CREST SAFETY REQUIREMENTS.

Dam crest used as roadway for vehicular traffic shall be provided with appropriate safety measures as specified below or as applicable to the site condition:

i. Cable or Beam (concrete or steel) type guardrail along both sides of the crest shoulder

ii. Barrier (concrete or rubble masonry) wall

iii. Concrete Post at about 6.0 meters minimum interval or as required in the design

iv. Concrete Curb sill spaced at 1.0-meter center to center.

14.1.1.7.3 ZONING OF DAM CREST MATERIALS

Proper placement and Zoning of crest materials shall be required and observed at all times particularly during the design stage to avoid failure of dam crest.

Correct Placement and Zoning shall be achieved by observing the following:

i. Ensure that the top of impervious core to be set always above the estimated/computed Maximum Reservoir Water Surface Level. This is to prevent or avoid percolation through the embankment or Capillary Siphoning over the top of the core materials when reservoir is at full level.

ii. Steepen the Upstream and Downstream slopes of the embankment to:

a. Reduce the thickness of the slope protection at crest level

b. Allow easy construction of the impervious zones near the crest, and
c. Facilitate installation of guard post and rails or other type of safety barriers and devices.

14.1.1.7.4 Other Features (Operation & Maintenance, Visitors Facilities)

The following miscellaneous features and other facilities of an Embankment Dam Crest shall be provided when so required by design and for operations and maintenance considerations.

The facilities may include but not limited to the following:

i. Parking bay

ii. Turn around bay

iii. Viewing deck/area

iv. Inspection access or pathways, vehicle/foot bridge from dam crest to down slopes, abutments, other dam vital parts, control & monitoring facilities and appurtenances.

14.1.1.7.5 EMBANKMENT DAM CREST CAMBER REQUIREMENT ESTIMATION

Camber shall be provided along the crest to ensure that the estimated dam embankment Freeboard will not be diminished or reduced by Foundation settlement or Embankment Consolidation.

14.1.1.7.5.1 Camber requirement shall be estimated based on the following conditions and considerations:

1.0 DUE TO FOUNDATION SETTLEMENT AND EMBANKMENT CONSOLIDATION

1.1 Due To Embankment Consolidation Alone (ΔHec)

ΔHec = 0.01xH -----(1)

Application of Equation no. (1) shall be for the initial estimation of approximate value for Embankment Dams on relatively non-Compressible foundation (ie. Hard rock)
1.2 Due To Combined Foundation Settlement & Embankment Consolidation = ΔH (fs+ec)

\[ \Delta H (fs+ec) = 0.02xH \text{ to } 0.03xH \] (2)

Application of the Equation no. (2) shall be for the initial estimation of approximate value for Embankment dams on Foundations expected to settle and for Embankment dams with heights of 15 meters and below. For Embankment dams (H) higher than 15.0 meters, Static and dynamic analysis procedure using applicable and internationally accepted Finite Element software shall be used to confirm the initial approximation of deformation using the estimated values derived by the percentage of dam height method.

1.3 Earthquake Induced Embankment Settlement = \( \Delta H_{eq} \)

\[ \Delta H_{eq} = 0.010xH \] (3)

Application of Equation no. (3) shall be for initial estimation of approximate value for Embankment Settlement due to earthquake for Embankment Dams under Low Hazard and Risk Level Classification regardless of height Classification.

For dams under Medium to Large size with High Hazard and Risk Level Classification and with height H>15.00 meters, and with estimated site seismicity having Seismic Peak Ground Acceleration (PGA) \( \geq 0.20g \), a mandatory dynamic numerical modeling/analysis procedure using any internationally acceptable Finite Element Application Software shall be undertaken to determine and confirm the seismic induced settlement/deformations derived by other approximation methods.
2.0 TOTAL CAMBER REQUIREMENT = (∑Δc)

The total crest camber requirement shall be estimated by using either Equations (4) or (5) expressed below whichever is applicable:

\[ ∑Δc = ΔH_{ec} + ΔH_{eq} \] (4) For non-compressible foundations

\[ ∑Δc = ΔH (fs+ec) + ΔH_{eq} \] (5) For compressible Foundations

Where:

\[ ∑Δc = \text{Total Camber requirement in meters} \]

\[ H = \text{Structural Height of dam} / \text{Height above foundation level in meters}. \]

\[ ΔH_{ec}, ΔH (fs+ec) \text{ and } ΔH_{eq} \text{ are computed cambers due to settlement and consolidation of foundation & embankment induced by the Dam loadings, weight and earthquake as defined above.} \]

14.1.1.8.0 FREEBOARD REQUIREMENT DETERMINATION FOR EMBANKMENT DAMS

Wind Velocity and Earthquake generated or induced Wave height and Run-up in reservoir dams shall be (estimated/calculated by any means and principles including numerical and physical hydraulic modeling methods acceptable to the Agency’s dam engineering community) considered in the Design and analysis of Freeboard requirement for all types of dams covered by these Guidelines.

14.1.1.8.1 The following Terminologies and definition shall be applied for qualifying of the Freeboard requirement of Embankment Dams:

Total Freeboard Height shall be defined as the vertical distance between Crest/Top of the Dam (including Camber) and the Normal or Maximum Reservoir Water Surface Level.
Freeboard shall be defined as the vertical distance between Crest of the Embankment (without Camber) and the Reservoir Water Surface.

Normal Freeboard shall be defined as the difference in elevation between the Crest of the dam and the Normal Reservoir Water Surface requirement (as fixed by design requirement).

Minimum Freeboard Shall be defined as the difference in elevation between the crest of the dam (without camber) and the Maximum Reservoir Water Surface that would result should the Inflow Design Flood (IDF) occur and should the Outlet Works and Spillway functions as planned.

Surcharge Head shall be defined as the difference between the Normal and Minimum Freeboard.

Fetch shall be defined as the distance over which the wind can act on a body of water in a reservoir and generally the normal distance from the windward shore to the structure being designed.

14.1.1.8.2. METHODS OF ESTIMATION OF FREEBOARD FOR WAVE ACTION DUE TO WIND VELOCITY

14.1.1.8.2.1 Wind Velocity generated or induced Wave height and Run-up in reservoir dams shall be (estimated/calculated by any means and principles or technique including Empirical Formulas, numerical and physical hydraulic modeling methods acceptable to Agency’s dam engineering community) considered in the Design and analysis of Freeboard requirement for all types of dams covered by this Guidelines.

14.1.1.8.2.2 Free Board (FBw) for Wind induced Wave Action maybe estimated by any of the Methods best fitted/suited and applicable as prescribed in this Guideline by considering the generated Wave height and Wave Run-Up height (R) along the slopes expressed in the following equations/Formulas:
FBw= Hw/2 + R; ................Equation 14.1

Where:

FBw= Freeboard due to wave action (meters)

Hw= Wave height (meters) computed by any of the published and internationally acceptable derived or empirical Formulas.

R = Wave Run-up height along the embankment slope may be approximated as equal to 1.50xHw in meters, or shall be estimated using any derived or empirical formulas.

Wave height (Hw) and Wave Run-up (R) shall be estimated by using any of the internationally acceptable and applicable empirical formulas and methods developed and published by research entities, personalities and experts on the field and science of Tidal hydraulics.

The Figure 14.1.1.8.0 as shown below may be used as guide that defines the parameters in the estimation of the required Freeboard due wind generated wave height.

FIGURE 14.1.1.8.0 : Wind Generated Wave Setup (S) & Wave Run up (R).
Where:

\[ \Phi = \text{Slope surface inclination angle with the Horizontal.} \]

\[ C_d = \text{Camber depth} \]

\[ F_{bw} = \text{Computed Freeboard due to wind generated wave} = (S + R_d) \]

\[ L_W = \text{Wave Length} \]

\[ R_d = \text{Run-up depth} \]

\[ S = \frac{H_{sw}}{2} = \text{Wave Set-up} \]

\[ D = \text{Mean reservoir Depth} \]

\[ H_{sw} = \text{Significant Wave Height} \]

The required Freeboard for wind generated wave Setup (S) and wave Run up (R) shall be estimated based on the above Figure and the given Equations:

\[ F_{bw} = S + R \]

Where: \[ F_{bw} = \text{Estimated Wind wave induced Freeboard in meter.} \]

\[ S = \text{Computed Wind Wave Setup in meter.} \]

\[ R = \text{Computed Wave Runup in meters.} \]

Wind velocity Over Water (Vw) shall be derived based on Design Wind Velocity Over Land (V_L) recorded or be taken from the Wind Zone Map of the Philippines, as reflected in the Structural Code of the Philippines. (Ref. 163)

In the absence of locally developed relationship, Table 4.1.1.8A below shall be used in computing the Design Wind Velocity over Water (Vw).
Table 14.1.1.8A - Wind Velocity Relationship-Water to Land
(Extract from Reference 162)

<table>
<thead>
<tr>
<th>Effective Fetch (Fe) in Km</th>
<th>Wind Velocity Ratio Over Water/Over Land (Vw/Vl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.80</td>
<td>1.080</td>
</tr>
<tr>
<td>1.60</td>
<td>1.130</td>
</tr>
<tr>
<td>3.20</td>
<td>1.210</td>
</tr>
<tr>
<td>4.80</td>
<td>1.260</td>
</tr>
<tr>
<td>6.40</td>
<td>1.280</td>
</tr>
<tr>
<td>&gt;8.00</td>
<td>1.300</td>
</tr>
</tbody>
</table>

For Embankment Dams with smooth upstream faces, the computed Run-up (R) shall be increased by a factor of 1.5 or the design Run-up value shall be expressed in the Formula below:

\[ Rd = 1.5 \times R \]

\[ \text{----- in meter} \]

14.1.1.8.3 FREEBOARD REQUIREMENT FOR RESERVOIR WATER WAVE ACTION INDUCED BY EARTHQUAKE MOTION.

Earthquake generated or induced Wave height and Run-up in reservoir dams shall be (estimated/calculated by any means and principles or technique including numerical and physical hydraulic modeling methods acceptable to dam engineering community) considered in the Design and analysis of Freeboard requirement for all types of dams covered by this Guidelines.
14.1.1.8.4. FREEBOARD HEIGHT REQUIREMENT ESTIMATION BASED ON DAM & RESERVOIR LOADING CONDITIONS

Freeboard Height Requirement shall be estimated by considering the dam features, configuration, Load Criteria and Load Conditions& Combinations. Table 14.1.1.8A described and prescribed such conditions and shall use as basis and guide in the process of estimation.

TABLE 14.1.1.8B - FREEBOARD HEIGHT REQUIREMENT/ESTIMATION BASED ON DAM & RESERVOIR LOADING CONDITIONS

<table>
<thead>
<tr>
<th>DAM FEATURES &amp; LOAD CONDITIONS</th>
<th>LOAD CRITERIA /COMBINATIONS/CONDITIONS</th>
<th>CAMBER REQUIREMENT (Ct)</th>
<th>FREEBOARD HEIGHT (H) Above Spillway Crest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Spillway ungated/ Uncontrolled</td>
<td>IDF Criteria (Magnitude/Return Period) and Routed Flood Flow Depth over Spillway (h= meters)</td>
<td>Design Earthquake Criteria</td>
<td>Total Camber Ct=Meters (Ct=Ec+Fs+Se)</td>
</tr>
<tr>
<td>2. Sloped Upstream Dam Surface</td>
<td>Philippines Wind Zones (Zn) and Over Land Wind Velocity (Km/hr) Induced Wave Height (Hw=meter) &amp; Wave Runup (Rw=meter)</td>
<td></td>
<td>H=Meters</td>
</tr>
</tbody>
</table>

I (USUAL)

<table>
<thead>
<tr>
<th>Flood routed flow depth (h1)</th>
<th>Wind Zones: Z1=250kph Z2=200kph Z3=150Kph (Hw1 ;Rw1.)</th>
<th>MDE/SEE/ME (MMI≧VIII) Kh≧0.20g (He1;Re1) where: Re1=1.5He1</th>
<th>Ct1=Ec1+Fs1+Se1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:200yrs</td>
<td></td>
<td></td>
<td>H1=h1+1/2(Hw1)+Rw1+He1+Re1+Ct1</td>
</tr>
</tbody>
</table>

II (UNUSUAL)

<table>
<thead>
<tr>
<th>Flood , routed flow depth (h2)</th>
<th>Wind Zones: Z1=250 kph Z2=200kph Z3=150Kph (Hw2 ;Rw2.)</th>
<th>OBE (VI≦MMI≦VIII) Kh≦0.20g; Kh≧0.10g</th>
<th>Ct2=Ec2+Fs2+Se2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1,000yrs</td>
<td></td>
<td></td>
<td>H2=h2+1/2(Hw2)+Rw2+He2+Re2+Ct2</td>
</tr>
</tbody>
</table>
### 14.1.1.9.0 COFFERDAMS FOR EMBANKMENT AND CONCRETE DAMS

Cofferdams (Upstream/Downstream) are necessary appurtenant structures that shall be provided for the enclosure and protection of working area from flooding during construction stage of the Embankment or Concrete Dams, the outlet works and other similarly important dam appurtenances.

**Height of cofferdams** shall be dictated by the required level and degree of protection against overtopping/submergence of the working area and shall be estimated and established by routing the prescribed Construction Stage Inflow Design Flood (IDF) frequency *(as prescribed under Table 7.4.1 of Section 7)* for diversion works during construction.
For special conditions and economic consideration, Upstream and Downstream cofferdams may be designed to be integrated and become a permanent part of the (Embankment or Concrete) dam structures.

In ordinary or traditional Concrete Dams construction, cofferdams shall be designed and constructed as totally separated and independent and stand alone structures.

14.1.1.10.0 SEEPAGE DRAINS & FILTERS

Seepage drains and filters are vital embankment dam parts which are usually incorporated with the dam body to prevent the migration or movement of fine embankment materials either or both at the upstream (due to sudden drawdown of reservoir water level) and downstream face of the impermeable clay core between the interface with the transition/outer shell of the rockfill type embankment dam and or between the core and random fill material for the zoned embankment dams.

Filter / Drain Permeability Test shall be required if the following conditions exist:

1. Crushed Rock will be used for filter/drain material
2. Materials to be protected is dispersive
3. Materials to be protected contains cracks

Filters and drains shall be designed to have a minimum Permeability after placement and compaction at least equal to 20 times that of the theoretically calculated Permeability as expressed in the equation below:

\[ K_{d_{min}} = 20 \times K_t \]

Where: \( K_{d_{min}} \) = Minimum Design Permeability of Filter/Drain
\( K_t \) = Calculated theoretical Permeability of Filter/drain

FILTER/DRAINS DESIGN CRITERIA:
1. Filters/Drains shall be designed and are required and able to intercept seepage water coming from the upstream face and foundation which passes through the embankment impermeable clay core material to the downstream embankment face.

2. Filters shall be designed capable to retain fine embankment and foundation materials from freely moving out of the dam body and foundation which shall result to or will prevent the internal erosion process of fine materials or piping.

3. Drains shall be designed to have ample factor of safety and capacity to convey intercepted seepage flow rate and capability to retain in place and prevent migration or movement of the filter materials without inducing the build-up of hydraulic/pore pressure within or along the drain channel/section.

14.1.11.0 STABILITY BERMS

Stability berms are embankment dam body parts which are usually provided at the upstream and downstream lower level of the slope or at the toes of an embankment dam on poor/soft foundations to improve the dam embankment slope and foundation stability. This dam body part is also use to mitigate the effect of liquefaction (excessive embankment and foundation settlement) on loose saturated sands and gravel foundations due to seismic induced cyclic loading.

14.1.12.0 ROCKTOE

Provision of rocktoe for Embankment/Earthfill dams shall be governed by the following factors:

1. Minimum allowable cover on the phreatic line.

2. Downstream or Tail water level.

The top of rocktoe shall be set sufficiently higher than (1.0-1.50 meter above) the exit point of the phreatic line with the embankment downstream slope or higher than the design maximum tail water surface level.
For initial design the height of the rock toe shall be approximated/estimated to about 1/4 to 1/3 the height of the dam.

14.1.1.13.0 EMBANKMENT DAMS AND RESERVOIR INSTRUMENTATIONS

Instrumentations that shall be provided and be installed for Embankment Dams and its Reservoir shall depend on the prescribed Potential Hazard & Risk Classification (PHRC) and Size Classification (SC) defined under Section s 3.1.1.0 and 3.1.2.0, Complexity and degree of monitoring the safety performance of the dam structure, the nature of its foundation, abutments, storage area or reservoir and its major appurtenances particularly the spillway and outlet works.

Section 15.1 provides the minimum required Instrumentation to monitor the performance of Embankment Dams.

14.1.1.14.0 MISCELLANEOUS (O&M) APPURTENANCES AND SAFETY INSPECTION FACILITIES.

Miscellaneous (O&M) appurtenances and dam safety inspection facilities (Applicable to all type of Dams) shall be provided when so required by design but shall not be limited to the following:

1. Inspection pathways/access going to major appurtenances and critical sites.
3. Visual safety monitoring facilities (e.g. CCTV/observation towers)
4. Emergency provisions (power/lighting/transport/other logistics)
5. Air ventilations and Lighting provisions in adits/galleries/shaft/emergency access and pathways
14.1.2. CONCRETE (CONVENTIONAL MASS CONCRETE (CMC) & ROLLER COMPACTED CONCRETE (RCC) - (GRAVITY, BUTTRESS, ARCH & COMBINATIONS) DAMS DESIGN GUIDELINES AND CRITERIA

14.1.2.1 The primary considerations in the selection of CONCRETE/Conventional Mass Concrete (CMC) and Roller Compacted Concrete (RCC) as material for the Design of Dams shall be based on the following factors:

1. Availability, sufficiency, suitability or adequacy and acceptability of quality of component materials for Concrete.

2. Suitability/Competency/Bearing strength or capacity/soundness of the foundation Materials to carry and sustain all the applicable imposed loads

3. Availability/sufficiency of applicable Construction Equipment, Trained/experienced Manpower and favorable working site and weather conditions.

14.1.2.2 Materials for Concrete (CMC & RCC) Dams shall be subjected to proper selection process/quality assurance and (Field and Laboratory) TESTING prior to adoption for use. These materials shall include the following:

1. Aggregates
2. Cementitious materials
3. Mineral additives/admixtures
4. Chemical admixtures, and
5. Mixing water

14.1.2.3 The Specific Concrete Properties that shall be used in the design of CONCRETE (CMC & RCC) DAMS shall include but not limited to the following:

1. Unit Weight
2. Compressive Strength
3. Tensile strength
4. Shear Strength
5. Modulus of Elasticity
6. Creep
7. Poisson’s Ratio
8. Coefficient of Thermal Expansion/Contraction
9. Thermal Conductivity
10. Specific Heat, and
11. Diffusivity
14.1.3.  HARDFILL DAMS DESIGN GUIDELINES AND CRITERIA

The Guidelines specified under Sub-Sections 14.1.2.0.1 to 14.1.2.0.3 are the same considerations and material properties that are applicable and important in the design of SOIL-CEMENT or HARDFILL Dams.

14.1.3.1.  Concrete Faced Hardfill Dams shall be limited and designed as Gravity Dams

14.1.3.2.  Height Limit shall be 30.0 meters from foundation level

14.1.4.  CONCRETE DYNAMIC PROPERTIES AND CAPACITIES FOR CONVENTIONAL MASS CONCRETE (CMC) AND ROLLER COMPACTED CONCRETE (RCC) WITHOUT TEST DATA

In the absence of test data, the following relationship between Static and Dynamic properties of Concrete Hydraulic Structures (including Dams) maybe assumed (Bruhwiler, 1990/Reference #151, 153 &155) as follows:

1. Dynamic Elastic Modulus $= 1.15 \times$ Static Modulus of Elasticity ($E_c$)

2. Dynamic Poisson’s ratio $= 0.70 \times$ Static Poisson’s Ratio ($P$)

3. Dynamic Compressive Strength $= 1.15 \times$ Static Compressive Strength ($F_{c}^'$)

4. Dynamic Tensile Strength $= 1.50 \times$ Static Tensile Strength ($F_t$)

5. Dynamic Shear Strength $= 1.10 \times$ Static Shear Strength ($F_v$)

14.2.0.  DAM LOADING CONDITION CATEGORIES & CRITERIA

All reservoir dams shall be subjected to all applicable and perceived loading conditions. Sections 7 & 8 specifically provides Flood and Earthquake Loading Magnitudes and Frequencies which shall be adopted to generate the possible external and internal forces that will be applied as specific loadings to the Dam structure, Appurtenances including each integral elements. The said internal and external or combination of these forces shall also be used to investigate and checked for the dam body, all appurtenant structures, the foundations, abutments and reservoir rims & flanks stability conditions prescribed under this Section.
14.2.1. **Dam Loading Condition Categories** prescribed under this Guideline for Concrete and Masonry Dams shall be limited to and defined as follows:

I. **USUAL LOADS**— Loads and load conditions which are related to the primary function of the structure and can be expected to occur frequently during the service life of the structure.

II. **UNUSUAL LOADS**— Operating load and load conditions that are of infrequent occurrence.

III. **EXTREME LOADS**— Loads and load conditions which are highly improbable to occur and can be considered as loads which are induced by emergency conditions including sabotage, major accidents involving impact or explosions, calamitous events/natural disasters due to earthquakes or floods having or with frequency of occurrence exceeding the economic life of the structure.

*Table 14.2.1* provides the general loading conditions and combinations that shall be applied subject to the discretion of the Structural Designer/Engineer or as he may deemed applicable to the situation. The specified loadings shall serve only as guide in subjecting the structure to possible worst and severest loading situation that may be encountered during the service life of the structure.

Other loading conditions that the Design Engineer may deem appropriate to be applied to the structure shall be considered in addition to the prescribed loadings under this Section.
### Table 14.2.1 - LOADING COMBINATIONS TO BE APPLIED ON RESERVOIR DAMS

<table>
<thead>
<tr>
<th>Kind of Dams &amp; Reservoir Condition</th>
<th>Conc.(CMC/RCC) &amp; Masonry (MMC) Gravity Dams</th>
<th>Conc.(CMC/RCC) Arch &amp; Buttress Dams</th>
<th>Embankment Dams</th>
<th>Hard Fill Dams</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.Intermediate WS Level</td>
<td>X</td>
<td>X</td>
<td>-Self Weight -Hydrostatic Pressure -Seismic Force -Pore Pressure</td>
<td>X</td>
</tr>
<tr>
<td>5.Rapid WS Level Draw Down</td>
<td>X</td>
<td>X</td>
<td>-Self Weight -Hydrostatic Pressure -Seismic Force -Pore Pressure</td>
<td>X</td>
</tr>
</tbody>
</table>

**Note-1:** X = Not Applicable.

**Note-2:** Rapid Draw down as applied to Embankment Dams shall be defined as the drawdown of the reservoir by 1.50m-3.0meters per hour daily. (as defined by US Society on Dams based on USBR/USACE/FERC/NRCS/TVA description of loading conditions for embankment dams)
14.3.0. DAM STRUCTURAL STABILITY AND SAFETY CRITERIA

14.3.1. METHODS OF EMBANKMENT DAMS SLOPE STABILITY ANALYSIS AND INVESTIGATION

At present stage and development of science of the embankment dam stability analysis and investigation, NIA shall use and apply the following current two (2) well known methods to wit:

i. Limit Equilibrium Method (LEM)

ii. Finite Element Method (FEM)

1. The LIMIT EQUILIBRIUM METHOD (LEM)

The following Limit Equilibrium Methods with corresponding Application Software/Computer Programs developed by individuals upon granting prior approval by NIA shall be acceptable in the conduct of slopes and foundations stability analysis of embankment dams. The application of the particular method shall depend on the suitability, practicability, applicability and the preference option based on degree of confidence of the design engineer responsible for the soundness and safety of the project.

1. Non-circular Failure Surface Methods (Sliding Block method/Wedge Method/Wedge-Shaped Sliding Mass Method)
2. Circular Failure Surface (Equilibrium of Free Body as a Whole) Method
3. Circular Failure Surface Method of Slices
   3.1.1. Swedish Circle Method (Fellenius Method)
   3.1.2. Simplified Bishop method
4. Infinite Slope method

2. The FINITE ELEMENT METHOD (FEM)

There are now FEM computer application programs/Software with Static and Dynamic Response Modeling or Analysis Procedures Capability that are acceptable in the international dam engineering community which may be used as tool for the design / analysis of (Embankment and Concrete) Dams Stability which may be used for adoption subject to the conditions and limitations prescribed in this NIA Guidelines.
Prior approval by NIA shall be required in the Utilization of any FEM Application Software and shall be requested by the Design Entity/Dam Design Engineer/Structural designer/Consulting Firm to DSD-CO prior to its utilization as a tool.

### 14.3.1.1. STABILITY AND FACTOR OF SAFETY CONSIDERATIONS FOR EMBANKMENT DAMS

Embankment dams irrespective of type (Earthfill or Rockfill Type) and material composition shall be investigated for the safety and adequacy of the foundation strength and stability of embankment and abutments slope against all perceived loading condition.

### 14.3.1.2. Slope Stability Conditions and Minimum Factor of Safety Requirement

**Table-14.3.1A** Provides the loading conditions that the Dam embankment and abutments slopes should be subjected to and the minimum factor of safety required.

**TABLE -14.3.1A - Loading Conditions & Minimum Factor of Safety Requirements for Slope Stability of Embankment Dams**

<table>
<thead>
<tr>
<th>CONDITIONS</th>
<th>UPSTREAM SLOPE</th>
<th>DOWNSTREAM SLOPE</th>
<th>MIN. FACTOR OF SAFETY (FS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. JUST AFTER CONSTRUCTION (WITH or WITHOUT EARTHQUAKE)</td>
<td>ok</td>
<td>ok</td>
<td>Without EQ &gt; 1.25 With EQ &gt; 1.00</td>
</tr>
<tr>
<td>2. STEADY SEEPAGE – Normal Full Water Level CONDITION (WITH or WITHOUT EARTHQUAKE)</td>
<td>ok</td>
<td>ok</td>
<td>Without EQ &gt; 1.50 With EQ &gt; 1.00</td>
</tr>
<tr>
<td>3. Design Flood Max. Water surface Level (Without Earth Quake)</td>
<td>ok</td>
<td>ok</td>
<td>Without EQ &gt; 1.25</td>
</tr>
<tr>
<td>4. Intermediate Water Surface Level (With or Without Earthquake)</td>
<td>ok</td>
<td>Not applicable</td>
<td>Without EQ &gt; 1.25 With EQ &gt; 1.00</td>
</tr>
<tr>
<td>5. SUDDEN DRAWDOWN (WITH or WITHOUT EARTHQUAKE)</td>
<td>ok</td>
<td>Not applicable</td>
<td>Without EQ &gt; 1.25 With EQ &gt; 1.00</td>
</tr>
<tr>
<td>6. Foundation Shear</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>&gt; 2.5</td>
</tr>
</tbody>
</table>
14.3.2.1. METHODS OF STABILITY ANALYSIS OF CONCRETE (CMC or RCC) DAMS

I. Conventional Mass Concrete (CMC) or Roller Compacted Concrete (RCC) GRAVITY, BUTTRESS AND ARCH DAMS

The methods or one of the following methods enumerated under these guidelines shall be an acceptable tool or basis and shall be allowed for use depending on the complexity of the structure and its applicability and suitability of analysis with due consideration of the conditions and provisions under the applicable SECTIONS for the Stability analysis of Gravity, Buttress and Arch dams:

1.1. The Gravity Method
1.2. Trial Load Method
1.3. Lattice Analogy Method
1.4. Slab Analogy Method
1.5. Finite Element Method
1.6. Experimental (Numerical & Physical Modeling) Method
   1.6.1. Planar/Two (2) and/or Three (3) Dimensional Model
   1.6.2. Photo-elastic Model
   1.6.3. Numerical Model

II. ARCH DAM

The design of Arch dams shall be based on various anticipated or expected forces acting on the structure which are of relatively the same loading and forces applicable for gravity and buttress dams. However, the importance and significance of the external forces and induced internal stresses is different in arch dam. The internal stresses caused by Temperature change (thermal stresses) and yielding of supports (abutments) shall be the most significant and primary consideration in arch dam design.

Methods of Arch Dam Design acceptable under these guidelines shall be but not limited to the following:

2.1. Preliminary Methods
   2.1.1. Thick cylinder theory
   2.1.2. Thin cylinder theory
   2.1.3. Independent arches method (Elastic theory)
2.1.4. Plunging arches method
2.1.5. Tolke method
2.1.6. Cain’s method

2.2. Elaborate Methods
2.2.1. Trial load analysis-USBR
   i. Crown cantilever method
   ii. Radial deflection method
   iii. Amplified trial load analysis
2.2.2. Shell method
2.2.3. Three dimensional elastic solution
2.2.4. Energy method
2.2.5. Finite Element method

2.3. Experimental
2.3.1. Photo elastic model
2.3.2. Other latest internationally acceptable Numerical and Physical modeling.

14.3.2.2. STABILITY AND FACTOR OF SAFETY CONSIDERATIONS FOR (CMC or RCC) CONCRETE (GRAVITY, BUTTRESS & ARCH) DAMS

Concrete (CMC or RCC) dams wither Gravity, Buttress and Arch type including respective appurtenant elements shall be designed to withstand all specified or expected/design Load Cases/Conditions at certain specified limitation or degree of Factor of Safety. The structure must be safe, stable and capable of exhibiting degree of satisfactory performance within or even beyond its economic and serviceable life.

14.3.2.3. LOAD CASES AND FACTOR OF SAFETY REQUIREMENTS

Gravity and Buttress Dams shall be subjected and designed for the following LOAD CONDITIONS/CASES with the corresponding Allowable Factor of Safety:

14.3.2.3.1. LOAD CONDITIONS/LOAD CASES FOR CONCRETE GRAVITY DAMS

1.1. Usual Load/Load Case – A: Just After Construction (Completion Condition)

   Dam completed, No water in reservoir, No tail water.
1.2. Usual load/Load Case – B: Normal Operation Condition.
   Full reservoir level, Normal dry weather, Tail water, Normal Uplift and Silt.

1.3. Usual load/Load Case - C: Flood Discharge Condition
   Reservoir at Maximum Flood Level, All Gates Open, Tailwater at Flood Level, Normal Uplift and Silt

1.4. Unusual load/Load Case – D: Load Case-A with Earthquake

1.5. Unusual load/Load Case – E: Load Case – B with Earthquake

1.6. Extreme load/Load Case – F: Load Case – C with Extreme uplift

1.7. Extreme load/Load Case – G: Load Case – E with Extreme Uplift

14.3.2.3.2 FACTOR of SAFETY (F.S) REQUIREMENT

A. Factor of Safety Against Overturning
   \( (FS\text{-}O.T) = \frac{\Sigma M_r}{\Sigma M_o} = 1.5 \text{ to } 2.5 \)

   Where:
   \( \Sigma M_r \) = Summation of Resisting Moment
   \( \Sigma M_o \) = Summation of Overturning Moment

B. Factor of Safety Against Sliding
   \( (FS\text{-}\text{Sliding}) = \frac{\Sigma H}{\Sigma V} < f \)

   Where:
   \( f \) = Coefficient of friction
   = 0.40 to 0.75 (safe value)
   \( \Sigma H \) = Summation of Horizontal forces causing sliding
   \( \Sigma V \) = Summation of Vertical forces causing frictional resistance to Sliding forces.

   When:
   “\( f \)” value is greater than 0.75 (\( f > 0.75 \)), Use the Shear Friction Factor (SFF) as the basis for the measure of Safety for Sliding.
C. Shear Friction Factor (SFF)

For preliminary design calculations and in the absence of in situ and laboratory test results, the Shear Friction Factor (SFF) shall be calculated by the Formula:

Shear Friction Factor (SFF) shall be calculated by the Formula:

\[ SFF = f \cdot \sum V + k \cdot S \cdot A \]

Where:
- \( f = 0.75 \) (maximum value)
- \( S \) = Shearing Strength
  - = 140.0 Tons/sq.m (for Poor Rock)
  - = 500.0 Tons/sq.m (for Good Rock)
- \( K \) = Averaging Factor
  - = 0.50 (Usual value)
- \( A \) = Area of base in Sq.meter

*Table 14.3.1B* provides the tabulated load condition or Load Cases with the corresponding minimum allowable Shear Friction Factor (SFF)

<table>
<thead>
<tr>
<th>LOADING CONDITIONS/(LOAD CASE)</th>
<th>SHEAR FRICTION FACTOR (SFF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. USUAL LOAD/ (Case- A, B &amp; C)</td>
<td>4.0</td>
</tr>
<tr>
<td>2. UNUSUAL LOAD/ (Case-D &amp; E)</td>
<td>3.0</td>
</tr>
<tr>
<td>3. EXTREME LOAD/ (Case-F &amp; G)</td>
<td>1.5</td>
</tr>
</tbody>
</table>
### Table 14.3.1C: CONCRETE (CMC & RCC) GRAVITY AND BUTTRESS DAMS STABILITY AND STRESS CRITERIA

<table>
<thead>
<tr>
<th>Load Conditions</th>
<th>Resultant Location at Base</th>
<th>Min. Sliding Factor of Safety (F.S.)</th>
<th>Foundation Bearing Pressure</th>
<th>Allow. Concrete Stress in Psi /(MPa)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Compressive</td>
</tr>
<tr>
<td>USUAL</td>
<td>Middle 1/3</td>
<td>2.00</td>
<td>≤ Allowable</td>
<td>0.30F'c'</td>
</tr>
<tr>
<td>UNUSUAL</td>
<td>Middle 1/2</td>
<td>1.70</td>
<td>≤ Allowable</td>
<td>0.50F'c'</td>
</tr>
<tr>
<td>EXTREME</td>
<td>Within Base</td>
<td>1.30</td>
<td>≤1.33x Allowable</td>
<td>0.90F'c'</td>
</tr>
</tbody>
</table>

**Note:**
1. F'c' is the one (1)year unconfined compressive strength of concrete.
2. The Sliding Factor of Safety (F.S.) are based on comprehensive field investigation and testing program.
3. Concrete allowable stresses are for static loading conditions.

### 14.3.3. LOAD CASES, STABILITY AND FACTOR OF SAFETY CONSIDERATIONS FOR GRAVITY TYPE HARDFILL DAMS

Load Cases and Factor of Safety Requirements applicable to CMC and RCC Gravity Dams shall be applicable to Gravity type Hardfill dams.
SECTION 15.0 DAMS, RESERVOIRS AND WATERSHED MONITORING INSTRUMENTATIONS AND EQUIPMENTS

15.0.1. **All Dams & Reservoirs** regardless of Size and Potential Hazard Classification and considering infrastructure /structure complexity shall be provided and installed with the appropriate and practical type of instrumentations to check the design assumptions made in the analysis and to gather data of the post construction hydraulics and structural behavior and monitor the performance and response of the structure and its elements to the internal and external loads.

The **Watershed** regardless of size shall also be provided with the appropriate and practical instrumentations to monitor its performance, behavior and response to hydro-geological and meteorological conditions and events occurring including the influence of the events within the area.

15.0.2. **Minimum required Instrumentations** that shall be provided and be installed for Dams and its Reservoir shall depend on the complexity of the infrastructure and shall also be based on the prescribed Potential Hazard & Risk Classification (PHRC) and Size Classification (SC) defined under Sections 3.1.1.0 and 3.1.2.0,

15.1. **EMBANKMENT (Earthfill & Rockfill) DAM AND RESERVOIR INSTRUMENTATIONS**

15.1.1 **EMBANKMENT (EARTHFILL & ROCKFILL) DAMS INSTRUMENTATIONS:**

15.1.1.1 Standpipe Piezometers
15.1.1.2 Pneumatic Piezometers
15.1.1.3 Observation Wells
15.1.1.4 Seepage interceptor/Collector channel and flow rate measuring weirs
15.1.1.5 Surface measuring points, Collimation points & reference benchmarks.
15.1.1.6 Seismic monitoring apparatus (Strong motion seismograph)
15.1.1.7 Other instrumentations that shall be required due to structure complexity (ie. embankment & foundation settlement & stresses measurement instruments)

15.1.2. RESERVOIR INSTRUMENTATIONS

15.1.2.1. Wind vane & Anemometer (Wind direction and Speed monitoring equipment)
15.1.2.2. Water Surface Level/Staff gage or automatic Water surface recorder
15.1.2.3. Rainfall gauging station
15.1.2.4. Evaporation (Pan) measuring station
15.1.2.5. Reservoir Sedimentation Monitoring Range/Stations
15.1.2.6. Others that shall be required (ie. Mini-weather station)
15.1.2.7. Reservoir Triggered Earthquake (RTE), Monitoring Instrument (Micro-Seismic Monitoring Apparatus)

15.1.3. WATERSHED MONITORING INSTRUMENTATIONS & EQUIPMENTS

15.1.3.1. Rainfall gauging stations
15.1.3.2. Evaporation (Pan) measuring stations
15.1.3.3. Soil Erosion Monitoring/measuring Stations
15.1.3.4. Sediment Transport Monitoring/measuring Stations
15.1.3.5. Mudflow Monitoring/measuring stations
15.1.3.6. Others that shall be required (ie. Mini-weather station and Vegetation cover monitoring equipment/Drone equipment)
15.2. GRAVITY, BUTTRESS AND ARCH (CONCRETE AND MASONRY TYPE) DAMS INSTRUMENTATIONS

Concrete or Masonry Gravity, Buttress and Arch Dams Instrumentations:

15.2.1. Piezometers (standpipe and/or any other type applicable for monitoring dam performance and reaction to seepage pressure)
15.2.1. Plumb Bob- to record vertical deformation
15.2.2. Strain meter-to measure strains (Tensile & Compressive) in the dam body.
15.2.3. Stress meter-Installed at selected locations as a check of strain meter observations. It measures compression stress in concrete
15.2.4. Thermometers-Installed in selected locations in concrete block to give a temperature history of the dam
15.2.5. Joint meter-Installed in between two blocks to give an idea of the opening of the dam joints. It aids in the planning of grouting operations.
15.2.6. Seismic monitoring apparatus (Strong motion seismograph)
15.2.7. Collimation points & reference benchmarks
15.2.8. Seepage flow rate measuring weirs.

15.3. ROLLER COMPACTED CONCRETE (RCC) AND HARDFILL TYPE DAMS INSTRUMENTATIONS

15.3.1 Determine appropriate and minimum required number of Dam Instrumentation to be applied or to be adopted for the monitoring of the dam’s performance, behavior and responses to loadings and physical & service conditions of the appurtenances
15.3.2 Commonly used RCC & Hardfill Dams Instrumentations
15.3.2.1 Standpipe Piezometers
15.3.2.2 Pneumatic Piezometers
15.3.2.3 Observation Wells
15.3.2.4 Plumb Bob- to record vertical deformation
15.3.2.5 Strain meter-to measure strains (Tensile & Compressive) in the dam body.
15.3.2.6 Stress meter-Installed at selected locations as a check of strain meter observations. It measures compression stress in concrete.
15.3.2.7 Joint meter-Installed in between two blocks to give an idea of the opening of the dam joints. It aids in the planning of grouting operations.
15.3.2.8 Seepage interceptor/Collector channel and flow rate measuring weirs
15.3.2.9 Surface measuring points, Collimation points & reference benchmarks.
15.3.2.10 Seismic monitoring apparatus (Strong motion seismograph)

15.4.3 CONCRETE/MASONRY (GRAVITY, BUTTRESS, ARCH), ROLLER COMPACTED CONCRETE (RCC) AND HARDFILL DAMS INSTRUMENTATIONS

15.4.3.1 Plumb Bob- to record vertical deformation
15.4.3.2 Strain meter-to measure strains (Tensile & Compressive) in the dam body.
15.4.3.3 Stress meter-Installed at selected locations as a check of strain meter observations. It measures compression stress in concrete
15.4.3.4 Thermometers-Installed in selected locations in concrete block to give a temperature history of the dam
15.4.3.5 Joint meter-Installed in between two blocks to give an idea of the opening of the dam joints. It aids in the planning of grouting operations.
15.4.3.6 Seismic monitoring apparatus (Strong motion seismograph)
15.4.3.7 Collimation points & reference benchmarks
15.4.3.8 Seepage flow rate measuring weirs.
15.4.4. **WATERSHED, RESERVOIR AND DOWNSTREAM RIVER FLOOD MONITORING AND WARNING INSTRUMENTATION**

15.4.4.1. Seismic monitoring Instruments

15.4.4.2. Hydro-Meteorological Monitoring Instruments (Mini-Weather Station), Rainfall gage, Evaporation, Wind Speed and Direction, telemetry transmission and receiving and data processing stations

15.4.4.3. Water Surface Level and Reservoir Wave Height Monitoring Instruments

15.4.4.4. Sedimentation Monitoring Ranges/Stations

15.4.4.5. Flood Forecasting and Warning Systems
SECTION 16.0  DAM AND RESERVOIR MISCELLANEOUS (CONSTRUCTION, OPERATION & MAINTENANCE (O&M) SECURITY/SAFETY) FACILITIES

16.1. Dam and Reservoir Miscellaneous Facilities shall be required and provided as design requirement of the Infrastructure to cater for the needs during Construction, Operation & Maintenance and security/safety. These miscellaneous facilities shall be used both by the Implementing Staff during construction of the project and by the O&M Staff during the Operation and maintenance phase of the system.

16.2. The Design Engineer shall be responsible for the provision and the integration of such facilities in the design of Dam and Reservoir. These appurtenances and other miscellaneous facilities shall ensure the maximum and full utilization of the envisioned function, purpose and requirement of the project/facility.

16.3. The following miscellaneous facilities and appurtenances when so required or as needed shall be incorporated in the design of the dam and reservoir:

16.3.1 Inspection Access/Service/O&M Roads (Dam Appurtenances and Reservoir Rim Access).

16.3.2 Camp and/or O&M Staff Office /housing Facilities

16.3.3 Recreation and Tourism Facilities

16.3.4 Environmental and Wildlife sanctuary/ safety Entry and Exit facilities

16.3.5 Hydro-Meteorological (Weather Station) Instrumentation/ Monitoring facilities.

16.3.6 Health, Safety, Emergency &Security Facilities (e.g. Guard house/post at strategic sites, CCTV or any human movement/activity monitoring gadgets and instrumentations.)

16.3.7 Others (Communication/logistic/transportation/service vehicles)
SECTION 17.0  RESERVOIR FILLING GUIDELINES & CRITERIA

17.1. INITIAL RESERVOIR FILLING REQUIREMENTS

17.1.1 The plugging of the Inlet portion of the Outlet Works or Intake Structure for Irrigation and Diversion Conduit/s signals the start of partial reservoir filling activities. This activity shall be allowed to commence only upon the recommendation of the NIA Project Manager or Contractor’s Authorized Representative in charge of the Construction, after completion of inspection of NIA-CO-DSD, NIA Dam Safety Organization (NDSO) and approval of the Manager, Engineering Department or the duly Delegated Authority, subject to the conditions under Section 9.0 and its applicable Sub-Sections provisions including other construction completion prerequisites.

17.1.2 Partial reservoir filling activity shall be required to be undertaken to establish and to test the initial water tightness condition of the reservoir and to observe initial performance of the installed dam instrumentations, reaction and behavior of the completed parts of the dam against the anticipated loading conditions and to be able to resume construction of remaining works at the outlet portion of the Outlet Works prior to commencing to full reservoir filling.

17.1.3 Preliminary observation and testing of installed steel guard gates/valves and or flow regulator gates/valves for leakages shall be undertaken at this stage prior to final setting and installation. A leakage test data shall be collected at every change in reservoir water level to be able to establish the leakage flow rate and to be able to rectify and adjust gate fittings to reduce leakage flow rate to allowable or tolerable condition and level.

17.2 FULL RESERVOIR FILLING REQUIREMENTS

17.2.1 Full reservoir filling shall be allowed only after completion/compliance of all prerequisite activities prescribed under Section 9.0 and Sub-sections 17.1.1 to 17.1.3 of these Guidelines.

17.2.2 The reservoir area and portion of the rim up to the Normal Water Surface Level shall be cleared of vegetations and debris prior to full reservoir filling.
17.2.3 Plugging or closure of the construction diversion outlet works shall not be permitted or allowed unless the reservoir area cleared of vegetation, debris and specific requirement stipulated and prescribed for sealing of borrow areas in accordance with Section 9.0 and the temporary construction works and facilities located within the reservoir area had been dismantled and hauled at the designated disposal area and the major construction activities has been declared completed.

17.2.4 An Authorization to Fill Up the Reservoir shall be secured first by the contractor to NIA if the project is being implemented by contract and to be Approved and Issued by duly authorized NIA Official under the latest NIA Delegation of Authority. Reservoir Filling for Dam construction implemented through Force Account shall be approved and issued by the NIA Project Manager duly noted by the NIA-CO Engineering Department Manager upon verification and confirmation by DSD-CO and by the Agency Dam Safety Group/Organization that all pre-Filling Prerequisites has been fully met and complied by the PMO/Implementors.

17.2.5 The Authorization to Fill the Reservoir shall be issued only to the Contractor after all the prescribed pre-filling requirements has been validated and confirmed complied by the DSD-CO and NIA-Dam Safety Office (NDSO) Inspectors/Representatives.
SECTION 18.0 EXISTING DAMS REHABILITATION, MODIFICATION AND DECOMMISSIONING GUIDELINES AND CRITERIA

All existing storage dams that has been subjected to routine, regular/normal, especial and emergency inspection and undergone Dam Integrity & Safety Inspection and Thorough Evaluation and has been found and ruled that there shall be an appropriate action to be taken in order to address the identified deficiencies or any deterioration/s shall be subjected to either Rehabilitation, Modification or Decommissioning whichever is applicable.

18.1 REHABILITATION

18.1.1 DEFINITION

Rehabilitation shall be defined as the process of restoring the configuration, functionality, efficiency and safety of the existing Reservoir/Storage Dams and Appurtenances from the deteriorated condition (due to aging, recurrent loads/stresses and weathering) to the original condition and function/s and/or better than the original designed condition.

18.1.2 REHABILITATION GUIDELINES AND CRITERIA

Rehabilitation of Existing Dams and Appurtenances shall be properly planned and implemented when the following conditions are identified, already present and has visually manifested in the dam and reservoir facilities:

18.1.2.1 Deterioration of dam body, foundations, abutments, appurtenances and instrumentations due to aging and weathering process.

18.1.2.2 Updating of design standards and criteria including increased hazard and risk classification level and rating of the facilities.

18.1.2.3 Identified deficiencies after the conduct of Dam Safety Inspection and Assessment.

18.1.2.4 Mitigation of anticipated/identified hazard and risk associated with improper operation of the appurtenant/facilities. These includes the repair of damages incurred due to improper or prolonged use to electro-mechanical facilities, structural fatigue of elements/parts after disastrous events. Rehabilitation shall be done to protect the structure/facilities from
further damages and to ensure safety and integrity of same and to protect the owner/operator against claim and legal suit in case of unusual incidents.

18.1.3 REHABILITATION TECHNIQUES

Rehabilitation Techniques shall be properly planned and explored by the Dam Design Engineer and shall consider the latest development/observations and findings of the Dam Safety Inspection Team in prioritizing the implementation of rehabilitation measures.

The following Rehabilitation Techniques shall be considered when applicable and when situation dictates its adoptability and priority:

18.1.3.1 Repairing of dam body (for Concrete and Masonry dams) by sealing developed and formed cracks. For existing Embankment (Earthfill/Rockfill) Dams by providing flatter upstream/downstream slopes, widening of dam crest width, widening of the dam embankment at the downstream toe to crest level if improved dam slope stability and additional freeboard is required. Provision of parapet retaining wall as an extended part of the dam crest shall be explored as an alternative measure to increase the dam freeboard.

18.1.3.2 Improving the spillway capacity, structural integrity and safety. The intervention shall be done by ensuring the approach /inlet channel and chute sections of the spillway are free and clear of any form of obstructions like deposited debris and the provision of measure to prevent the passage of large floating tree trunks/debris and the occurrence of rock fall, earth/mud slides from the upper side slopes of the channel.

18.1.3.3 Control of backward erosions at spillway outlet channel. The backward erosion shall be mitigated immediately once identified to slow down the process and can be addressed by providing the proper and tested effective scour protection on the whole or part of the erosive portion of the channel.

18.1.3.4 Measure to address Spillway Structure deformation over Embankment. Embankment susceptible to settlement and consolidation process due to un-anticipated weight or overloading of the spillway structure shall be subject for rehabilitation through the application of but not limited to
consolidation grouting or any other applicable and effective measures to stabilize the structure.

18.1.3.5 **Erosion of the Abutments walls between the embankment and spillway and at interface /intersection of the embankment and abutments slopes.** The erosion/scouring process on the intersection or interface of the slopes of the abutments and embankment shall be mitigated and addressed by any applicable and tested measures but not limited to providing stepped concrete channel liner to collect and convey accumulated runoff to downstream toe without surface scouring and erosion between the interfaces.

18.1.4 **REHABILITATION TECHNIQUES FOR IMPROVING EMBANKMENT DAM SAFETY**

The following Rehabilitation Techniques for Improving Embankment Dam Safety shall be explored and applied when necessity of the measure is dictated by the urgency of the situation.

**18.1.4.1 Overcoming Flood Handling Problems due to design flood hydrology updating incurring design flood exceeding the original Inflow Design Flood (IDF).**

Measures to address the issue shall include the following:

a. Parapet wall construction on the dam crest

b. Raising of the Dam Embankment crest

c. Provide erosion protection of embankment against overtopping like articulated concrete blocks and/or provision of RCC Sections.

**18.1.4.2 Conduct Dam Embankment Slope Stability Analysis with formulated implementable Measures.**

**18.1.4.3 Provision of Piping Control Measures**

**18.1.4.4 Provision of Seepage Control Measures**
18.2 MODIFICATION

18.2.1 DEFINITION

Modification shall be defined as the alteration of the original functions or purposes, physical configuration, efficiency and upgrading the structural integrity and safety of the existing reservoir/storage dam and appurtenant facilities with the view of improving and adding safety and functional features not originally provided/included in the original designed purpose of the facilities.

18.2.2 MAJOR REASONS AND EVENTS THAT REQUIRES DAM MODIFICATION

The following Criteria shall be considered when undertaking Dam modifications:

18.2.2.1 Alteration of reservoir storage capacity or imposition of additional storage for variety of reasons.

18.2.2.2 Aesthetic reasons when the area adjacent to the dam has or will become developed.

18.2.2.3 Unsafe conditions may have developed in some parts of the dam.

18.2.2.4 Compelling new standards are imposed by a regulatory agency.

18.2.3 FACTORS TO CONSIDER IN THE REVIEW OF EXISTING DAMS PRIOR TO UNDERTAKING THE PLANNING, DESIGN AND IMPLEMENTATION OF MODIFICATION WORKS.

18.2.3.1 Dam and Reservoir Size and Hazard & Risk Classifications including potential additional cost.

Size and Hazard Classification of the dam shall be updated, thoroughly investigated and properly established first based on proposed scheme of development and formulated /modified functions/purposes of the facility prior to implementation of the interventions.

18.2.3.2 Right of Way, Easement, Land Acquisition and Resettlement

Right of way and easements shall be thoroughly reviewed for adequacy. Required utilities may need new or additional easements particularly if the adjacent area has been fully developed.
Additional easements maybe required for access roads and for new borrow or waste disposal area. Investigation for the presence of Project affected Persons or Families (PAPs/PAFs) shall be a mandatory process which may require the provision of Resettlement Area. Acquisition of Acceptable Resettlement Sites for these PAPs/PAFs shall be a prerequisite.

Land Acquisition and Resettlement Plan (LARP) shall be formulated first and developed with proper consultation and approval of the PAPs/PAFs prior to finalization of the scope and extent and the Plan. The said LARP shall be included in the Project Overall Program of Works to ensure that all issues shall be adequately funded and addressed during the implementation stage.

### 18.2.3.3 Environmental and Social Factors/requirements

Environmental and social issues and concerns shall be identified and evaluated based on the modification scheme being planned. Identified issues shall be formulated with appropriate intervention/measures acceptable to stakeholders and in accordance and compliant with government regulations.

### 18.2.3.4 Meteorology, Hydrology and Hydraulics Parameters

Meteorological, hydrological and hydraulics studies and parameters used in the original design of the existing dam and reservoir facilities shall be assessed and evaluated for adequacy and sufficiency prior to application or adoption for the proposed modification works.

Updated drainage area condition shall be used in the assessment if the original design were based on older maps where drainage area surface condition/vegetation cover/ differs that with the present. Hydrologic and hydraulic analysis and review shall be made based on available design records and compare with the current accepted technique and criteria.

### 18.2.3.5 Sediment Storage

Sediment survey of the existing reservoir shall be conducted to determine the amount/volume of sediment that has accumulated to date. Future land use of the reservoir vicinity and rim shall be anticipated and carefully considered. Increased sediment storage shall be evaluated if future land use of the reservoir vicinity, rim and catchment area/watershed will be projected for human occupancy and or agricultural activity.
18.2.3.6 Geologic Explorations

Existing dam foundation and abutments shall be thoroughly examined for any sign of deteriorations and potential damages including excessive seepages and piping. Borings shall be undertaken to determine in-place properties of dam body and foundation materials. Reservoir flanks/rim shall be investigated for excessive leakages and potential slope failure.

18.2.3.7 Dam body Section Design/ Embankment Design

As-built records shall be reviewed along with the geologic information. Existing Dam section shall be investigated for any signs of deteriorations, deficiencies and damages or potential design failure needing retrofitting or modification. Stability assessment shall be undertaken utilizing in-situ properties of the existing structure.

18.2.3.8 Spillway and Other Outlets (Main/auxiliary and emergency spillway and outlet) Structures Including Hydro-Electrical/Mechanical Works and Electronics Control Facilities Design.

Capacity of the existing spillway and other outlet structures shall be reviewed using the updated Inflow Design Flood (IDF) derived based on the latest hydrological parameters and acceptable estimation procedures. Determine and establish the adequacy of the hydraulic function and performance of the existing based on the result of routing the IDF. Hydraulics and structural integrity and safety requirement shall be ensured and assured.

**Hydro-electrical, mechanical and electronics appurtenances and control facilities** past performance shall be evaluated if needing upgrading/modification to ensure better performance.

18.2.3.9 Dam and reservoir Instrumentations.

Selection/adoption of new or appropriate additional dam and reservoir instrumentations shall be explored and incorporate same to the planned modification scheme and or to augment or if necessary shall replace the existing non-functional instrumentation facilities.
18.2.3.10 Project Cost and Economic Viability Considerations

Project Cost Ceiling and Economic Internal Rate of Return (EIRR) Criteria shall always be observed in pursuing the implementation of Modification Works/Projects of Existing Dams.

18.2.3.11 Modification Design Documentations

Documentation for the modification of existing dams and reservoirs structures shall be as thorough as for new dams design. NIA-Memorandum Circular No.36 series 2016 (Ref. #2) and Appendix -IA & IB of these Guidelines provides the NIA-STANDARD/Sample Outline of the Required Design Documentations.

18.3 DECOMMISSIONING

18.3.1. DEFINITION

Decommissioning shall be defined in these guidelines as the full or partial removal of existing dam and its appurtenant facilities or a major/significant changes or alterations to the operations thereof shall be made.

18.3.2. Decommissioning Guidelines & Criteria for Storage/Reservoir Dam.

Dam and Reservoir Decommissioning shall be done only when the following general conditions, reasons and situations had been observed or manifested:

18.3.2.1. Obsolescence and aging deteriorations

18.3.2.2. Adverse Environmental, Social and Health Concerns

18.3.2.3. Economics (production cost exceeds generated benefits)

18.3.2.4. Safety Criteria (Assessed Factor of Safety margin is un-acceptable)

18.3.2.5. Increased or very high assessed Downstream Hazard and Risk level

18.3.2.6. Excessive/Prohibitive Operation and Maintenance Cost
18.3.3 OTHER ISSUES/REASONS THAT SHALL ALSO BE OBSERVED IN THE DECOMMISSIONING OF THE STORAGE/RESERVOIR DAMS:

18.3.3.1. The facility can no longer fulfill its intended functions and it is no longer economically justifiable to repair or rehabilitate.

18.3.3.2. The Structure no longer meets the required safety standard and not economically viable to incur expenses/investment to rehabilitate or retrofit to make it safe.

18.3.3.3. The stored water is no longer required or has little /negligible contribution and that a better, reliable, dependable alternative source has been explored or developed.

18.3.3.4. The System is incurring legal or financial liabilities.

18.3.3.5. Increased adverse environmental impact/ increased flow requirement for local/domestic, flora and fauna and other indigenous and endangered species.

18.3.3.6. Deteriorated ecosystem or watershed/catchment due human activities will entail massive development, restoration and or rehabilitation.

18.3.4. The NIA shall observe that the main Objectives of Decommissioning storage Dams shall focus on the restoration of the natural flow of water, improve wildlife and aquatic /fish upstream passage, avoid concentration of sediments and to prevent or eliminate all possible and potential danger/risk of losing human lives, destruction of properties, development of water borne diseases and environment degradation that could arise out of an abandoned or unsafe storage dams.

18.3.5. A draft Dam Decommissioning Plan (DDP) based on Decommissioning Process prescribed in Appendix-III of these Guidelines shall be developed and formulated first by the concerned NIA-IMO, RIO , assisted by the NIA Central Office Staff involved in the Dam Integrity and Safety Assessment and Dam Operations in cooperation,
coordination, consultation with the affected stakeholders, the LGUs and other government agencies having concerns on the Regulation and Monitoring of potential adverse environmental Impact that the decommissioning Process will take. The DDP shall be forwarded to Central Office for approval by the Administrator prior to Finalization. APPENDIX-III provides the reference Flow Chart for Dam Decommissioning Process.

18.3.6. A Technical Working Group (TWG) for Dam Decommissioning shall be created by the NIA Administrator with the sole mandate and responsibility to Finalize the initially formulated DDP and to develop it into complete and executable Decommissioning Action Plan and Program (DAPP). The TWG shall be a composite group from the IMO, RIO and Specialist Staff from the C.O. Engineering (PPD & DSD) and Operations (SMD/IDD & IEC) Departments. The TWG shall be headed/Chaired by the Manager, Operations Department and Vice Chaired by the Manger, Engineering Department and to act as Secretariat by the Head of the NIA Central Dam Safety Office (NCDSO) stationed in Central office and to be assisted by the RIO/IMO Dam Safety Unit (RDSU) Heads Concerned where the dam structure has to be decommissioned.

18.3.7. The TWG after finalization/completion of the DDP shall subject and present same for final deliberation and consultation with all the concerned Stakeholders prior to transforming the same as an executable Decommissioning Action Plan and Program (DAPP) then submit/subject the said DAPP to be CONFORMED by the Recognized/Authorized Head/Representatives of the concerned/affected LGU’s and Stakeholders prior to submission to the NIA Administrator for APPROVAL by the NIA Board of Directors prior to execution.
SECTION 19.0 CONSTRUCTION DOCUMENTATIONS AND SPECIAL EVENTS RECORDING GUIDELINES

19.1 The purpose and essence of documenting the NIA Storage Dam Construction Projects is to provide the Agency’s top & middle management and concerned Engineering and Operations Staff information on the records, contents and details of Construction Inspection rendered, Detailed Construction Process and Activities and Completion Documents that shall serve as future references for the formulation and development of the O&M Manual, Dam and appurtenances Safety Inspections, performance assessment and safety surveillance, monitoring and evaluation of the dam and related facilities. The construction records shall also serve as proof of compliance with the approved and prescribed design and specifications and corresponding changes or revisions/modifications made for the project.

19.2 Documentation until completion of the whole construction process and activities of storage dams Projects shall be done and the responsibility of the concerned RIO’s/Project Management Offices (PMO’s) and the Construction Management Division (CMD) under the supervision and control of the Department Manager of the Central Office, Engineering Department.

19.3 Copy of the Construction Documentation/ Records including the AS-BUILT PLANS AND DRAWINGS shall be submitted /furnished and to be distributed and archived to each office of the Engineering Department (CMD & DSD), Operations Department, the NIA-Library and to the Agency’s Dam Safety Office by the concerned RIO’s/PMO’s as permanent file and reference.

19.4 The following Construction Processes and Activities shall be observed and properly documented to ensure completeness of Project information:

19.4.1 PROJECT INSPECTION

NIA- Memorandum Circular MC No.82 s.2017 (Ref. #184) provided policy and guidance for NIA Officials in undertaking Field Inspection and the Preparation of Project Inspection Plan, and prescribed the different Types and Levels of Inspections to be undertaken by the concerned Officials.
19.4.1.1. **Storage Dam Construction Work Inspection**

Prior to the conduct of Construction Work Inspection, Concerned PMO’s, NIA Officials and Central Office Engineering Staff in accordance with the provision of NIA **MC No.82 s.2017 (Ref. #184)** shall prepare and facilitate the approval (Travel Order Memorandum and Proposed Travel Itinerary) of a **Construction Inspection Plan (CIP)**. The said CIP shall **categorize the Level of Inspection** and shall be based and consistent with the **Approved Project Construction Schedule**.

The following **Levels of Inspections** shall be included in the Plan and shall be observed based on the urgency and necessity of the situation or as the need arises:

1. **CONTINUOUS/REGULAR/FULL-TIME INSPECTION**

1.1. The Dam Design Engineer shall specify/identify and designate work items that are to receive or to be subjected to Continuous/Regular/Full-Time Inspection.

1.2. This Level of Inspection shall be required for any work or project implementation stage in which the quality cannot be accurately determined and for any work that cannot be readily replaced if rejected.

1.3. Continuous/regular/full-time inspection of the items of works shall be required when the following situations or conditions were present:

   1.3.1 Complex site condition
   1.3.2 Erratic soil deposits or foundation condition
   1.3.3 Contractors attitude and ability
   1.3.4 Remote project site location
   1.3.5 Nature of Construction
   1.3.6 Local (peace and order/safety) situation

1.4. The work items that shall to receive **Full-Time Inspection** shall include but are not limited to the following:

   1.4.1 Foundation Excavation
   1.4.2 Pile Driving/ Cut off wall construction or installation
   1.4.3 Placing compacted earthfill/Embankment construction & Compaction
1.4.4 Structure backfilling/placing filter & drains/riprap works
1.4.5 Mixing & placing concrete/installation of dam instrumentations

2. PERIODIC INSPECTION

2.1. Periodic Inspection shall be rendered to certain type of Works depending on circumstances prevailing at the site. Works to be subjected to this type and level of inspection shall include but are not limited to the following:

2.1.1 Dewatering of worksite
2.1.2 Clearing & grubbing, stripping, structure demolition or removal, open channel excavation, clean-up.
2.1.3 Borrow pit excavation
2.1.4 Form construction/metal works fabrication/installation & placement of steel reinforcement, painting works
2.1.5 Installation of protection and safety barriers/fences.

3. SPECIAL/EMERGENCY/INDEPENDENT INSPECTION

3.1. Special /Emergency/Independent Inspection is an Inspection Level being undertaken and done by Experts (Dam Design Engr./Specifications Engineer/Geotechnical Engineer or Geologist/Hydro mechanical & Electrical Engineers/Surveyor/Contract administrator) Engineering Staff to verify and confirm issues arising needing immediate management action and decision relative to Force Account or Contract Works implementation having latent condition deferring from that originally approved quantities and cost or scope of works or when there is a potential of incurring Variation(Change or Extra Work) Orders.
3.2. **NIA-MC No. 82 s. 2017 (Ref.#184) and MC No. 40 s. 1990** shall be made as basis and reference in the undertaking/rendering of this type and level of inspection.

19.4.1.2 **Materials Inspection** shall be the responsibility, function and a regular undertaking of the NIA-Materials Testing and Quality Control & Assurance Engineer/Staff and shall be rendered to confirm the Contractor’s compliance with the NIA-Required/Approved Materials Quality & Quantity Control And Testing Program/Procedures prescribed to be used in the project as prepared and submitted by the Contractor and based on the Conformed Technical Specifications of the Works Items being implemented.

19.4.1.3 **Agency Senior Staff/Engineers/Consultants/Top & Middle Management Inspection & Monitoring** shall be done on a periodic and or special inspection basis. This is a mandate and obligation of NIA Officials to have and to acquire a first hand information on the actual situation, condition and status of Project Construction Implementation.

19.4.2 **DAM CONSTRUCTION RECORDS KEEPING**

The IMO’s/RIO’s/PMO’s who are responsible for the implementation of Storage Dam Construction Projects shall be required and shall be the lead Office charge to prepare and submit and archive (Hard & Electronic) file copies of the below enumerated/ specified Construction Records to Central Office, Engineering & Operations Department Offices for future references.

19.4.2.1 **Project Implementation Reports** (Daily Project Inspector’s Inspection Report/ Monthly Progress /Coded Report / Contract Works Monthly Statistical Reports) Project implementation history (based on the above specified reports) from start to completion shall be properly documented and supported with pictures in sequential order. All records of transpired activities including special events, changes in structure design, inclusion of new item of works and the application of new or special construction technique/methods shall be kept and archived for future reference on dam performance evaluation, Safety and Integrity Assessment and for other purposes.
19.4.2.2 Variation Orders

All the changes made on the Dam and appurtenant Structures as approved Variation Orders during the construction stage shall be kept by the PMO and same shall be integrated and be made part of the As-Built Plans and Drawings.

19.4.2.3 An actual Foundation geologic Map shall be prepared and submitted by the Contractor’s Engineering Geologist/geotechnical Engineer when project has been implemented by Contract. The As-Built Foundation Geologic Map shall be duly certified correct by NIA-Engineering Geologist and shall be form part of the As-Built Plans and Drawings. Copy of the said documents shall also be made part of the Construction Completion Records that shall be furnished to concerned offices enumerated under SUB-SECTION 19.5.0

19.4.2.4 All approved Variation Orders integrated in the completion documents shall fully supported with validation, confirmation reports and affirmative recommendation of the Design and Specifications Engineer or Dam Engineering Specialist and with duly approved revised plans and drawings.

19.4.2.5 The RA 9184 and NIA- MC No.82 s.2017 (Ref.#184) shall be made references which provided guidance and policy on the issuance and inspection requirements prior to granting of Variation Order either in the form of Change Order or Extra Work Order.

19.4.3 COMPLETION DOCUMENTS

19.4.3.1 As Built Plans and Drawings

The Implementing PMO and or the Contractor shall be responsible in the preparation of As Built Plans and Drawings and shall ensure that the actual completed Dam and appurtenant structures including the structural elements and parts configuration/geometrics/layout and setting including foundation materials that deviated with the approved design indicated on the Good For Construction (GFC) Plans/drawings shall all be reflected on the said As Built Drawings.

All design revisions rendered on the GFC drawings including changes made on the specifications of the materials shall also be reflected on the As-Built Plans.
19.4.3.2 Completion And Acceptance Inspection Report

Completion and Acceptance Inspection Report shall be required for all dam construction projects implemented through Contract Works. A FINAL INSPECTION AND ACCEPTANCE COMMITTEE FOR CONTRACT WORKS shall be Created as per MC No.47 s.2010 (Ref.#185) for this sole purpose and shall prepare and submit a Report and Resolution of Final Inspection for Acceptance for the Particular Contract Works. The Report and Resolution shall contain and specify the requirements and conditions (If there are any: eg. Punch List of deficiencies/rectifications, remaining works and agreed time table of compliance by Contractor) be submitted as one of the required supporting documents for the Contractors claims and a pre-requisite for the conduct of Final Inventory for Turnover and the Completed Works /Dam and Reservoir facilities from the PMO to the Operational and Administrative control of the RIO and IMO.

Prior to full completion of the dam construction projects implemented through contract works, a Pre-final /Pre-Completion Inspection shall be rendered by the Management created INSPECTION COMMITTEE composed of Central Office Composite Team of Engineers from the Engineering Department (DSD&CMD), Central & Field Dam Safety Group Representative/s, PMO Staff, the Project Engineer and Contractors representative.

The COMMITTEE shall first to determine, verify and confirm that all items of works had been fully completed or nearing completion and was done in accordance to plans and specifications and compatible as truly reflected on the contractor’s submitted and duly certified As-Built Plans and Drawings of the Project.

Any remaining works/activities with the corresponding quantities and cost including observed deficiencies shall be fully declared in the Pre-final/pre-completion Inspection Reports duly supported by pictorials and Resolution Inspection duly signed by the Inspection Team, confirmed by the contractor or his duly authorized representative and the Project Engineer or head of the concerned PMO.

The Pre-Completion Inspection Report supplemented by a Resolution of Inspection shall specify the agreed target date of completion/compliance date of all remaining works including the rectifications of the observed/validated
deficiencies. The agreed date of compliance shall be the basis for the scheduling and undertaking of the Final Inspection for Completion and Acceptance of the project covered under the contract.

19.4.3.3 **Final Inventory and Resolution for Turnover of Dam and Appurtenant Facilities for Operation and Maintenance Control of concerned RIO’s /IMO’s.**

**MC No.3 s.1981(Ref.#186)** provided policy /guidelines in the conduct and items to be considered in the Final Inventory of completed Projects preparatory to turnover for Operation and Maintenance control of the concerned RIO’s/IMO’s.

The task of undertaking the final inventory preparatory to Turnover for Operation and maintenance control shall be the responsibility of an **Inventory Committee** created under **MC No.47 s.2010 issued 13th July 2010 (Ref. # 185)** composed of NIA officials/staff from different departments of the Agency.

19.5. Concerned PMO’s shall be required and shall be the responsible Office to prepare /keep a copy/ provide copy to all concerned NIA offices specified below and to submit for archiving to the Operations Department the approved (Hard & Electronic) copies of the above enumerated Construction Records and Project Completion Documents (as specified under **SECTIONS 19.4.2 to 19.4.3** and **corresponding sub-sections**) for reference of the following NIA Engineering and Operations Offices:

1. Construction Management Division (CMD) - 1 copy
2. Design and Specifications Division (DSD) – 1 copy
3. NIA Dam Safety Office/GROUP (NDSO/G-CO)- 1 copy
4. Irrigation Engineering Center (IEC)- 1 copy
5. Operations Department (OD-CO)- 1 copy
6. Irrigation Management Office (IMO-DSU)- 1 copy
7. Regional Irrigation Office (RIO-DSU) – 1 copy
8. NIA-Central Office Library – 3 copies
SECTION 20.0  RESERVOIR AND DAM OPERATION & MAINTENANCE (O&M) MANUAL PREPARATION GUIDELINES

20.1  DAM AND RESERVOIR O & M MANUAL PREPARATION

20.1.1  Operation and Maintenance Manual shall be the sole document to be used and the process and procedure (Reservoir Operation Rules) to be followed and observed by the Dam Operators in undertaking the System/Appurtenances Operation and Maintenance and Monitoring Guide. The preparation and formulation of this document shall be fitted with the specific and design purpose/s and function/s of the Reservoir with the Dam System.

20.1.2  Upon completion of detailed engineering design, The NIA shall require concerned PMO (with the involvement of the Dam Design Team/Engineers) to facilitate the immediate commencement of the preparation of a Draft Dam and Reservoir Operation and Maintenance Manual. Drafting of the O&M manual Contents and Scope shall commence during or after the completion of the Detailed Engineering Studies (DES) and or Detailed Engineering Design (DED) or during the facilities construction stage and shall be finalized once the project is substantially completed.

20.1.3  Dam design Engineer/s and other experts or Consulting firm involved in the (DES/DED) planning and design of the Dam & Reservoir Infrastructure facilities shall be tapped by the implementing PMO to prepare the said O&M Manual if the preparation of the document has not been included as part of the activity or work assignment /Terms of Reference (TOR) of the experts/Consultants during the conduct of detailed engineering study/design activities.

20.1.4  The completed draft copy of the O&M Manual shall be submitted by the concerned PMO for review by the NIA Deputy Administrator for Engineering and Operations through the Engineering Department with the involvement of the Engineering (DSD, PPD, & CMD) Staff and the Operations Department also with the participations of the Operations (IEC, SMD, EMD &IDD) staff and the NIA- Dam Safety Office/Group. (NDSO/G)

20.1.5  The Final Copy of the Operations & Maintenance Manual shall be subject for approval by the Deputy Administrator for Engineering & Operations prior to issuance to the Concerned (RIO/IMO/Dam &Reservoir Irrigation System) Operator/User.
20.1.6 The draft original copy of O&M Manual together with the Final Detailed Design Report shall be forwarded to NIA-CO-DSD for safekeeping and archiving with the duplicate copies furnished to concerned offices (SMD /IEC-Dam Operations Section/NIA-Dam Safety Offices/Units) until such time that project construction implementation has been completed.

20.1.7 The O&M Manual shall be finalized immediately upon project completion and final acceptance of the Infrastructure and prior to its turn-over. The final copy shall become part of the turnover documents to be provided to the RIO/IMO / for operational control. The NDSO/G or any other Entities who shall be involved and be responsible for the (regular/periodic or special) monitoring, surveillance, maintenance and safety inspection and evaluation of the facilities shall also be furnished with same O&M manual.

20.1.8 A final version of the O&M Manual shall be prepared and be made mandatory requirement and part of the Turn-Over Documents from Project Office to Operational control of the concerned Irrigation Management office (IMO) and or Regional Irrigation Office (RIO) or any other entity legally allowed under the law technically capable to operate and maintain safely the infrastructure.

20.1.9 Dam construction projects shall not be considered and declared completed and ready for turnover unless a duly acceptable and approved O&M Manual has been prepared. The Engineering (DSD & CMD) and Operations Departments (SMD, IDD & Dam Operations Section of the IEC) shall be responsible in the review and/ensuring the veracity and applicability of the contents of the O&M Manual.

20.1.10 An Orientation Training and Operation Simulation of the Completed Dam Appurtenances by the concerned Dam Operation Staff shall be undertaken and prior to endorsement for use of the said O&M Manual to the RIO & IMO concerned for conformance and acceptance.

20.1.11 In addition to the usual Reservoir and Dam Appurtenances Operation & Maintenance for Civil Works aspect, the Electro-Mechanical O&M aspect should be given special attention due to complications of operations. The Dam Safety Inspection procedures and Emergency Action Plan(EAP)/Emergency Preparedness Plan (EPP) should also be given equally the same importance and should be made integral part or mandatorily
be incorporated as part of the Reservoir and Dam’s O&M manual. Copy of the Final O&M Manual shall be furnished to NIA-CO-DSD and the NIA- Dam Safety Offices /Units (NDSO’s/NDSU’s)

20.1.12 For uniformity, a NIA-STANDARD (Sample General Outline) of O & M Manual is presented in Appendix-7. The outline contents shall be changed or modified to suit and shall be fitted depending on the design purpose, components, function and use and complexity of the reservoir and dam infra-facilities.

20.2 MAINTENANCE CATEGORIES, PRACTICES & PROCEDURES

Dam and Reservoir Appurtenant Facilities shall be subject for maintenance in order to ensure safe and sustainable operation. Facility maintenance shall be categorized as follows:

20.2.1 GENERAL OR PREVENTIVE MAINTENANCE

General/preventive maintenance shall be those activities that shall not cause to impair the operational capacity/sustainability of the Reservoir and safety of the Dam and Appurtenances. These activities shall include but not limited to the following:

20.2.1.1 RESERVOIR AREA USE, RESTRICTIONS AND MAINTENANCE

Reservoir area use, restrictions and maintenance policies shall be formulated, established and shall be implemented/observed in cooperation with the concerned LGU’s, Stakeholders and other Government Entities (NIA, DA, DAR, DOH & DENR) to safeguard the facility from improper use, abuse and degradation. These policies shall cover but not limited to the following aspects:

1. Limit (to about 10% maximum for Small to Medium size reservoir and 15% for large/multipurpose reservoirs surface area at the design Normal Reservoir Water Surface Level) the utilization of the reservoir area for freshwater fish culture and for other non-original project or system component/purposes. Prohibit the use of synthetic/high chemical level pollutants fish meals /feeds that contaminates reservoir water with dangerous chemicals.

2. Prohibit the direct discharge of domestic waste/dangerous chemicals and other pollutants into the reservoir.
3. **Prohibit the direct crop cultivation or any agricultural cropping activities on or within the water receded area of the reservoir to avoid, minimize or eliminate pesticide pollutants contamination of the reservoir water and the accelerated process of erosion and sedimentation within the reservoir.**

4. Establish and strictly implement policies with NIA-LGU’s-Stakeholders joint participation the provision of safety barriers and notices to prohibit encroachment of illegal occupants/tillers/informal settlers within the reservoir area.

5. Identification and provision of access/entry facilities into and exit or escape facilities from the reservoir area of **astray domesticated animals and wild life.**

### 20.2.1.2 DAM AND APPURTEANCES

1. Removal of bush or tall weeds

2. Cutting of trees and removal of shrubs from the embankment or spillway. Removal of small stumps provided depth of excavation shall not be more than 90.0 cm into the embankment.

3. Rodent control, removal or extermination. Repair of minor rodent induced damages provided it shall not entail excavation of more than 90.0cm into the embankment.

4. Repair of erosion gullies on the embankment abutments or at the spillway. Large developed gullies that already weakened the dam shall be reported to the NDSO for immediate inspection, formulation and implementation of repair scheme. Implementation of repair shall be supported with duly approved design plans and Program of Works (POW).

5. Surface grading of the embankment crest or spillway to eliminate potholes and provide proper drainage provided that the freeboard shall not be reduced. Materials placed on the dam crest to restore the design freeboard shall be compacted to specifications. Placement of materials more than of 30.0 cm depth to provide freeboard is not considered as general or preventive maintenance.
6. Placement of additional riprap and bedding on the upstream slope or in areas of the spillway that have sustained minor damages. Such placement shall be limited to restoring the original riprap protection where the damages has not yet resulted to weakening of the dam.

7. Painting or caulking metal structures or lubricating mechanical equipment.

8. Patching, sealing or caulking spalled or cracked concrete surfaces to prevent deterioration.

9. Removing debris, rock or earth from outlet conduits, outlet channels or spillway channel.

10. Patching or sealing surface damages to prevent further deterioration within outlet conduits.

11. Replacement of worn or damaged part of outlet valves or controls to restore to original condition

12. Repair or replacement of fences intended to keep traffic or livestock off the dam or spillway.

13. Removal of all naturally grown trees or large vegetation within or shall not be allowed to be planted within the 7.50 meters from the dam toe.

20.2.2. CORRECTIVE MAINTENANCE

Corrective maintenance/repairs are activities or actions that shall be taken to slow down the process or prevent further progression of deterioration or incurred damages of a deficiently constructed or installed facilities and appurtenances. These corrective maintenance and repairs shall include but not limited to the following:

1. Repair/replacement of damaged/non-functional electrical/mechanical/electronics parts of control facilities.

2. Retrofitting of structurally deficient elements/parts of hydraulic structures/appurtenances.
3. Restoration of structural damages induced by hydraulic action (Cavitations on spillway/intake structures/energy dissipator parts)


5. Provision of adequate lighting, air ventilations and safety measures to access going to critical locations/sites of major dam appurtenances.

6. Installation of Protection measures to critical and primary dam appurtenances to prevent vandalism/sabotage.


20.2.3. EMERGENCY MAINTENANCE

Emergency maintenance/repairs are activities or actions that shall be taken as an interim solution only and shall not be considered and shall not serve as permanent solution to the problem being addressed. The said emergency maintenance activities are not limited to the following:

1. Stock filling of materials such as boulders for riprap, earthfill materials, sand, sandbags and plastic sheeting.

2. Lowering the reservoir level by making controlled releases through the outlet or gated spillway, by pumping or by siphoning. Large releases shall require approval of the Operations Manager.

3. Armoring eroding areas by placing sandbags, riprap, plastic sheeting or other suitable materials for erosion/scour control.

4. Plugging leakage entrance on the upstream slope.

5. Increasing freeboard by placing sandbags or temporary earthfill on the dam crest.

6. Diverting flood waters around the reservoir or closing inflow diversions.

7. Constructing training berms to control flood waters.

8. Placing sandbags rings around boils at the downstream toe to provide back pressure.

9. Remove obstruction from outlet/inlet of spillway flow area.
SECTION 21.0 GUIDELINES FOR POTENTIAL HAZARD & RISK CLASSIFICATIONS ASSESSMENTS AND RATING METHODS

21.1 Dam and Reservoirs regardless of the type and size (New and Existing) shall be assessed and establish the appropriate (Downstream) Potential Hazard & Risk Classification and Rating in accordance with that prescribed method and procedure under this Section and the guidelines stipulated under Section 3.1.2.0.

21.2 The Potential Hazard Categories that shall be considered are the following:

1. Hydrologic/Flood Hazard & risk,
2. Environmental & Geologic Hazard
3. Seismic/Reservoir Triggered Earthquake (RTE) Hazard & Risk
4. Structural and Electro-Mechanical Hazard & Risk
5. Human induced (Sabotage) Hazards and Risk.

21.2.1 HYDROLOGIC OR FLOOD HAZARD

For rapid assessment and for the purpose of establishing initial and updating Downstream Flood Hazard Classification of the proposed/new and existing NIA designed and operated storage dams, Table 21.2.1. shall be one of the reference systems to be used. Other systems used/adopted and practiced by the other ICOLD member countries that are consistent and applicable to the Philippines laws and regulations and social condition shall be considered for application.
<table>
<thead>
<tr>
<th>CLASSIFICATION LEVEL</th>
<th>HUMAN LIVES-In-JEOPARDY</th>
<th>ECONOMIC LOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FHC-1 (LOW)</td>
<td>Zero/None</td>
<td>MINIMAL (Affect only undeveloped agricultural lands, Un-inhabited structures, Minimal natural resources)</td>
</tr>
<tr>
<td>FHC-2 (SIGNIFICANT/Moderate)</td>
<td>1.0-5.0</td>
<td>APPRECIABLE (Affect rural area with industrial or worksite or outstanding natural resources)</td>
</tr>
<tr>
<td>FHC-3 (HIGH)</td>
<td>More than 5.0</td>
<td>EXCESSIVE (Affect urban areas including extensive community, industry, agriculture or outstanding natural resources)</td>
</tr>
</tbody>
</table>
**Lives-in-Jeopardy** shall be defined as all individuals within the downstream inundated area, which took no action to evacuate and will be subject to danger corresponding to the conditions and criteria as specified in Tables 21.2.1A to 21.2.1E. **Lives-in-jeopardy** shall be limited to direct downstream impact and effect of flood resulting from or due to dam failure/dam-break.

### TABLE 21.2.1A - FLOOD DEPTH-VELOCITY DANGER LEVEL RELATIONSHIP
for the determination of Lives-in-Jeopardy **FOR HUMANS OCCUPYING HOUSES BUILT ON FOUNDATIONS.** (Ref. # 195)

<table>
<thead>
<tr>
<th>DANGER ZONE (DZ)/ (Level)</th>
<th>Flood Flow Velocity (m/sec)</th>
<th>FLOOD FLOW VELOCITY in meters per second (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>DZ-1</strong> (LOW)</td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Flood Depth (meter)</td>
<td>≤0.915</td>
<td>≤0.838</td>
</tr>
<tr>
<td><strong>DZ-2</strong> (Judgment Zone)</td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Flood Depth (meter)</td>
<td>&gt;0.915 But &lt;1.800</td>
<td>&gt;0.838 But &lt;1.753</td>
</tr>
<tr>
<td><strong>DZ-3</strong> (HIGH)</td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Flood Depth (meter)</td>
<td>≥1.800</td>
<td>≥1.753</td>
</tr>
</tbody>
</table>

**Note:** **DZ-3**/High Danger Zone - Occupants of most houses are in danger from flood waters.
**DZ-2**/Judgment Zone – Danger level is based upon engineering judgment.
**DZ-1**/Low Danger Zone - Occupants of most houses are not seriously in danger from flood waters.
### TABLE 21.2.1B - FLOOD DEPTH-VELOCITY DANGER LEVEL RELATIONSHIP

For the determination of Lives-in-Jeopardy FOR HUMANS OCCUPYING MOBILE HOMES/HOUSES. (Ref. # 195)

<table>
<thead>
<tr>
<th>DANGER ZONE / (Level)</th>
<th>Flood Flow Velocity (m/sec)</th>
<th>FLOOD FLOW VELOCITY in meters per second (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero</td>
<td>0.50</td>
</tr>
<tr>
<td>DZ-1/ LOW</td>
<td>Flood Depth (meter)</td>
<td>≤0.579</td>
</tr>
<tr>
<td>DZ-2/ Judgment Zone</td>
<td>Flood Depth (meter)</td>
<td>&gt;0.579</td>
</tr>
<tr>
<td></td>
<td></td>
<td>But &lt;0.762</td>
</tr>
<tr>
<td>DZ-3/ HIGH</td>
<td>Flood Depth (meter)</td>
<td>≥0.762</td>
</tr>
</tbody>
</table>

Note: DZ-3/ High Danger Zone- Occupants of almost any size mobile homes/houses are in danger from flood waters.

DZ-2/ Judgment Zone – Danger level is based upon engineering judgment.

DZ-1/ Low Danger Zone- Occupants of almost any size mobile homes/houses are not seriously in danger from flood waters.
### TABLE 21.2.1C - FLOOD DEPTH-VELOCITY DANGER LEVEL RELATIONSHIP

For the determination of Lives-in-Jeopardy FOR HUMANS RIDING PASSENGER VEHICLES. (Reference# 195)

<table>
<thead>
<tr>
<th>DANGER ZONE / (Level)</th>
<th>Flood Flow Velocity (m/sec)</th>
<th>FLOOD FLOW VELOCITY in meters per second(m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>2.00</td>
<td>2.00</td>
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<tr>
<td></td>
<td>3.00</td>
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<tr>
<td></td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>4.573</td>
<td>4.573</td>
</tr>
<tr>
<td>DZ-1/ LOW</td>
<td>Flood Depth (meter)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤0.609</td>
<td>≤0.609</td>
</tr>
<tr>
<td></td>
<td>≤0.549</td>
<td>≤0.549</td>
</tr>
<tr>
<td></td>
<td>≤0.534</td>
<td>≤0.534</td>
</tr>
<tr>
<td></td>
<td>≤0.457</td>
<td>≤0.457</td>
</tr>
<tr>
<td></td>
<td>≤0.442</td>
<td>≤0.442</td>
</tr>
<tr>
<td></td>
<td>≤0.412</td>
<td>≤0.412</td>
</tr>
<tr>
<td></td>
<td>≤0.381</td>
<td>≤0.381</td>
</tr>
<tr>
<td></td>
<td>≤0.350</td>
<td>≤0.350</td>
</tr>
<tr>
<td>DZ-2/ Judgment Zone</td>
<td>Flood Depth (meter)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;0.609 But &lt;0.915</td>
<td>&gt;0.609 But &lt;0.915</td>
</tr>
<tr>
<td></td>
<td>&gt;0.549 But &lt;0.854</td>
<td>&gt;0.549 But &lt;0.854</td>
</tr>
<tr>
<td></td>
<td>&gt;0.534 But &lt;0.838</td>
<td>&gt;0.534 But &lt;0.838</td>
</tr>
<tr>
<td></td>
<td>&gt;0.457 But &lt;0.762</td>
<td>&gt;0.457 But &lt;0.762</td>
</tr>
<tr>
<td></td>
<td>&gt;0.442 But &lt;0.747</td>
<td>&gt;0.442 But &lt;0.747</td>
</tr>
<tr>
<td></td>
<td>&gt;0.412 But &lt;0.701</td>
<td>&gt;0.412 But &lt;0.701</td>
</tr>
<tr>
<td></td>
<td>&gt;0.381 But &lt;0.686</td>
<td>&gt;0.381 But &lt;0.686</td>
</tr>
<tr>
<td></td>
<td>&gt;0.350 But &lt;0.600</td>
<td>&gt;0.350 But &lt;0.600</td>
</tr>
<tr>
<td>DZ-3/ HIGH</td>
<td>Flood Depth (meter)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥0.915</td>
<td>≥0.915</td>
</tr>
<tr>
<td></td>
<td>≥0.854</td>
<td>≥0.854</td>
</tr>
<tr>
<td></td>
<td>≥0.838</td>
<td>≥0.838</td>
</tr>
<tr>
<td></td>
<td>≥0.762</td>
<td>≥0.762</td>
</tr>
<tr>
<td></td>
<td>≥0.747</td>
<td>≥0.747</td>
</tr>
<tr>
<td></td>
<td>≥0.701</td>
<td>≥0.701</td>
</tr>
<tr>
<td></td>
<td>≥0.686</td>
<td>≥0.686</td>
</tr>
<tr>
<td></td>
<td>≥0.600</td>
<td>≥0.600</td>
</tr>
</tbody>
</table>

**Note:** DZ-3/ High Danger Zone - Occupants of almost any size passenger vehicle are in danger from flood waters.

DZ-2/Judgment Zone – Danger level is based upon engineering judgment.

DZ-1/ Low Danger Zone - Occupants of almost any size passenger vehicle are not seriously in danger from flood waters.
**TABLE 21.2.1D - FLOOD DEPTH-VELOCITY DANGER LEVEL RELATIONSHIP**

For the determination of Lives-in-Jeopardy FOR **ADULT HUMANS**.

*(Reference # 195)*

<table>
<thead>
<tr>
<th>DANGER ZONE / (Level)</th>
<th>Flood Flow Velocity (m/sec)</th>
<th>FLOOD FLOW VELOCITY in meters per second (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zero</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>3.50</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>3.658</td>
</tr>
<tr>
<td>DZ-1/LOW</td>
<td>Flood Depth (meter)</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td>≤0.915</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td>0.534</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td>0.305</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td>0.228</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td>0.092</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td>0.031</td>
<td>Zero</td>
</tr>
<tr>
<td>DZ-2/Judgment Zone</td>
<td>Flood Depth (meter)</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td>But ≤0.915 But &lt;1.402</td>
<td>≤0.018</td>
</tr>
<tr>
<td></td>
<td>But ≤0.534 But &lt;1.220</td>
<td>&lt;0.125</td>
</tr>
<tr>
<td></td>
<td>But ≤0.305 But &lt;0.762</td>
<td>But &lt;0.228</td>
</tr>
<tr>
<td></td>
<td>But ≤0.228 But &lt;0.457</td>
<td>But &lt;0.092</td>
</tr>
<tr>
<td></td>
<td>But ≤0.092 But &lt;0.305</td>
<td>≤0.031</td>
</tr>
<tr>
<td></td>
<td>But ≤0.031 But &lt;0.228</td>
<td>&lt;0.063</td>
</tr>
<tr>
<td>DZ-3/HIGH</td>
<td>Flood Depth (meter)</td>
<td>0.188</td>
</tr>
<tr>
<td></td>
<td>≥1.402</td>
<td>≥1.120</td>
</tr>
<tr>
<td></td>
<td>≥1.220</td>
<td>≥0.762</td>
</tr>
<tr>
<td></td>
<td>≥0.762</td>
<td>≥0.457</td>
</tr>
<tr>
<td></td>
<td>≥0.457</td>
<td>≥0.305</td>
</tr>
<tr>
<td></td>
<td>≥0.305</td>
<td>≥0.228</td>
</tr>
<tr>
<td></td>
<td>≥0.228</td>
<td>≥0.188</td>
</tr>
<tr>
<td></td>
<td>≥0.188</td>
<td>≥0.125</td>
</tr>
<tr>
<td></td>
<td>≥0.125</td>
<td>≥0.063</td>
</tr>
</tbody>
</table>

**Note:** Adult - shall be defined as any human over 1.50 meters (m.) tall and weighing over 54.0 kilograms (kgs).

- **DZ-3/High Danger Zone** - Almost any size adult is in danger from flood waters.
- **DZ-2/Judgment Zone** - Danger level is based upon engineering judgment.
- **DZ-1/Low Danger Zone** - Almost any size adult is not seriously in danger from flood waters.
### TABLE 21.2.1E- FLOOD DEPTH-VELOCITY DANGER LEVEL RELATIONSHIP
For the determination of Lives-in-Jeopardy FOR CHILDREN.
(Reference # 195)

<table>
<thead>
<tr>
<th>DANGER ZONE / (Level)</th>
<th>Flood Flow Velocity (m/sec)</th>
<th>FLOOD FLOW VELOCITY in meters per second(m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DZ-1/ LOW</td>
<td>≤0.488</td>
<td>Zero, ≤0.152, ≤0.0762, Zero, Zero, Zero</td>
</tr>
<tr>
<td>DZ-2/ Judgment Zone</td>
<td>&gt;0.488 But &lt;0.915</td>
<td>&gt;0.152 But &lt;0.457, &gt;0.0762 But &lt;0.228, &lt;0.076, Zero, Zero</td>
</tr>
<tr>
<td>DZ-3/ HIGH</td>
<td>≥0.915</td>
<td>≥0.457, ≥0.228, ≥0.076, Zero, Zero</td>
</tr>
</tbody>
</table>

Note: Use this Table (TABLE 21.2.1E) for mixed population (Children and Adult) assessment of Lives-In-Jeopardy.

DZ-3/ High Danger Zone- Almost any size Child is in danger from flood waters.
DZ-2/Judgment Zone – Danger level is based upon engineering judgment.
DZ-1/ Low Danger Zone- Almost any size Child (Excluding Infants) is not seriously threatened by flood waters.

### 21.2.2 ENVIRONMENTAL AND GEOLOGIC HAZARD

Environmental and Geologic Hazard Classification and Rating system shall be established for all NIA-proposed and operated Storage Dams Facilities as basis for the formulation of design criteria and mitigating measures to address/reduce or prevent the risk that may be developed or imposed due to the introduction or existence of the facilities.

Table 21.2.2 shall be used as reference in establishing the Environmental and Geologic Hazard Classification and Rating of the proposed and Existing Storage Dams Facilities/Systems.
### TABLE 21.2.2 - ENVIRONMENTAL AND GEOLOGIC HAZARD CLASSIFICATION & RATING SYSTEM FOR RESERVOIR/STORAGE DAMS

<table>
<thead>
<tr>
<th>ENVIRONMENTAL AND GEOLOGIC HAZARD CLASSIFICATION/RATING</th>
<th>ENVIRONMENTAL CONDITIONS</th>
<th>GEOLOGIC CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGHC-1 (LOW)</td>
<td>1. Watershed (Non-PAMB) area submerged by reservoir $\leq$ 10.0 hectares</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Full grown (indigenous) trees to be cut/cleared within the project area $\leq$ 50.0 pcs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Reservoir area has no identified fixed settlers and no established human settlement (Sitio or Barangay), is not a declared habitat nor temporary shelter for wildlife and no presence of endangered species.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Area has been confirmed and declared non-existence or endemic to Malaria and or Schistosomiasis diseases.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Reservoir and dam base area has no identified or mapped volcanic vents or major faults that may serve or cause as potential reservoir leakage path.</td>
<td></td>
</tr>
</tbody>
</table>
| EGHC-2 (MODERATE/SIGNIFICANT) | 1. Watershed area submerged by reservoir $>10.0$ but $\leq 20.0$ hectares  
2. Full grown (indigenous) trees to be cut/cleared within the project area $>50.0$ but $\leq 100.0$ pcs.  
3. Reservoir area has identified fixed settlers (less than 10 families/households) is considered temporary shelter for migrating wildlife and endangered species  
4. Reservoir is identified as potential breeding site for malaria bearing mosquitoes and or snails bearing Schistosomiasis. | 1. Reservoir and dam base area had some identified or mapped naturally filled/clogged volcanic vent/s and or healed in-active major fault/s that may cause and serve as potential reservoir leakage path/conduit/channel. |
| EGHC-3 (HIGH/EXTREME) | 1. Watershed area submerged by reservoir $>20.0$ hectares. Reservoir area is under PAMB.  
2. Full grown (indigenous) trees to be cut/cleared within the project area $>100.0$ pcs. | 1. Reservoir and dam base area had an identified/presence/existence or mapped open volcanic vents and major active or potentially active faults that will |
3. Reservoir area has an identified fixed settler (greater than 10 families/households) and with known or existing settlement area (Sitio or barangay) and is considered/declared habitat and shelter for migrating wildlife and endangered species.

4. Reservoir site had been identified and certified by Govt health officials (DOH) the presence of and as breeding site for malaria bearing mosquitoes and or snails bearing Schistosomiasis.

require special and complex treatment measures.

2. Identified potential and impending rockfall and landslide sites along reservoir rim/plank and at dam abutments.

3. Identified potential and impending debris avalanche or mudflow from tributaries.

4. Presence of human (farming/ agricultural) activities on the watershed or along and above the reservoir rim level resulting to heavy soil erosion and reservoir sedimentation during rainy season.
21.2.3 SEISMIC/EARTHQUAKE HAZARD

For rapid assessment of Seismic Hazard Classification Level and Rating of Dams and Reservoir sites including respective appurtenant structures, the Table 21.2.3 shall be used as reference and guidance.

TABLE 21.2.3 - SEISMIC HAZARD CLASSIFICATIONS & RATING SYSTEM FOR RESERVOIR DAM PROJECTS (Ref. # 197)

<table>
<thead>
<tr>
<th>SEISMIC HAZARD CLASSIFICATION (SHC)/(RATING)</th>
<th>PEAK GROUND ACCELERATION (PGA) CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHC -1 (Low)</td>
<td>PGA &lt; 0.10 g</td>
</tr>
<tr>
<td>SHC - 2 (Moderate)</td>
<td>PGA &gt; 0.10g but &lt; 0.25g /*but no active fault within 10.0 km of the site.</td>
</tr>
<tr>
<td>SHC -3 (High/Extreme)</td>
<td>PGA &gt; 0.25g /*an active Fault is closer than 10km from the site.</td>
</tr>
</tbody>
</table>

Note 1: The above Table applies to Dams & Appurtenances & Reservoirs Sites where good foundation materials are present. (REF.#91/#197- ICOLD Bulletin No.72)

Note 2: /*

21.2.4 STRUCTURAL AND ELECTRO-MECHANICAL HAZARDS/RISK CLASSIFICATION

For the assessment of Structural and Electro-Mechanical Hazard & RISK Classification/Level Rating of Existing Dams and Reservoir sites and including appurtenant structures, Table 21.2.4 shall be used as guidance.
### TABLE 21.2.4 - STRUCTURAL & ELECTRO-MECHANICAL HAZARD & RISK CLASSIFICATION/ RATING SYSTEM

<table>
<thead>
<tr>
<th>HAZARD &amp; RISK CLASSIFICATION/ LEVEL</th>
<th>STRUCTURAL CONDITIONS</th>
<th>ELECTO-MECHANICAL CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HRC-1 (LOW)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Structures and appurtenances / Structural elements designed based on National and local codes requirement and constructed at low seismicity and low wind velocity zone sites.</td>
<td>1. Facilities had been certified without defect and undergone proper and complete load testing prior to commissioning.</td>
<td></td>
</tr>
<tr>
<td>2. Facilities are subjected to regular/periodic/special inspection and maintenance</td>
<td>2. Facilities are subjected to regular/periodic/special inspection, maintenance and repairs.</td>
<td></td>
</tr>
<tr>
<td>3. Facilities had no observed nor sign of structural defects, deteriorations and aging.</td>
<td>3. Facilities are not exposed and subjected to adverse, corrosive /deteriorating environment</td>
<td></td>
</tr>
<tr>
<td>4. Facilities/Structural elements had already sustained structural stresses after subjected to extreme and adverse loading conditions.</td>
<td>4. Facilities service life is less than 10 years</td>
<td></td>
</tr>
<tr>
<td><strong>HRC-2 (MODERATE/SIGNIFICANT)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Structures and appurtenances / Structural elements located, designed and constructed at sites with moderate seismicity and wind velocity zones.</td>
<td>1. Facilities had observed deficiencies and subjected to corrective measures prior to commissioning</td>
<td></td>
</tr>
<tr>
<td>2. Facilities/Structural elements incurred/suffered minor structural/ deformations /distress/ defects when subjected to Unusual loading conditions</td>
<td>2. Facilities Service life is greater than 10 years but less than 25 years</td>
<td></td>
</tr>
</tbody>
</table>
HRC-3
(HIGH)

1. Structures and appurtenances/Structural elements located, designed and constructed at sites with high seismicity and wind velocity zones or at sites and or near with potentially active fault/s.

2. Facilities/Structural elements incurred/suffered appreciable/significant structural/ deformations/distress/ defects when subjected to Usual loading conditions.

1. Facilities has not been subjected to proper technical inspection and load testing prior to commissioning

2. Facilities are extremely exposed and subjected to adverse, corrosive/deteriorating environment.

3. Facilities service life is more than 25 years.

<table>
<thead>
<tr>
<th>21.2.5</th>
<th>HUMAN INDUCED (SABOTAGE) HAZARD CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.2.5.1</td>
<td>Human induced Potential Hazard Classification and Rating shall be established for each proposed and existing storage dam projects as basis for the formulation and updating of design criteria, security protocol/Facility security plan and Emergency Action Plan or Emergency Preparedness Plan (EAP/EPP)</td>
</tr>
<tr>
<td>21.2.5.2</td>
<td>Potential Hazard imposed and induced by human intervention to storage/reservoir dams shall be assessed, evaluated and rated based on the site/vicinity peace and order exposure and conditions to which the proposed or existing storage dam infrastructure facilities shall be subjected to.</td>
</tr>
<tr>
<td>21.2.5.3</td>
<td>For rapid assessment of classification and rating of human induced hazard to NIA proposed and existing storage dams, Table 21.2.5 shall be used as reference to standardized procedure.</td>
</tr>
</tbody>
</table>
**TABLE 21.2.5– Human Induced Potential Hazard Classifications/Rating System for Proposed and existing Storage Dams**

<table>
<thead>
<tr>
<th>HUMAN INDUCED HAZARD CLASSIFICATION (HIHC) / RATING</th>
<th>SITE POTENTIAL EXPOSURE CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIHC -1 (Low)</td>
<td>No known peace and order issue in the locality. No presence and history of terrorist acts/activities recorded for the last five (5) years within and adjacent to the proposed project area. Existing Storage dam facilities has an in-placed security and access restriction. Facility Personnel observed security and safety protocol. Security monitoring facilities and well trained Security personnel are available and positioned/deployed onsite.</td>
</tr>
<tr>
<td>HIHC - 2 (Moderate /Significant)</td>
<td>History of Peace and order issue has been recorded within the last three (3) years. Confirmed presence of terrorist and ideologist influenced group within the locality as certified by the military and police establishment. Existing storage dam Infrastructure facilities has no permanently assigned/deployed security personnel. Dam and appurtenances had No installed security monitoring facilities and area is not restricted to access. Security risk is known to exist.</td>
</tr>
</tbody>
</table>
Area /locality had been declared and certified by military and police establishment as hot spot and susceptible for terroristic activities. Area is under the influence and control of armed/terroristic or ideologist group. Police and or military security/escort is a prerequisite in every conduct of engineering and social/institutional activities within the area. A declared threat by unknown partisans/terrorist group to existing Storage Dam facilities is known and confirmed by intelligence report from military and police establishment.

(Note: The above Table applies to proposed and existing Dams &Appurtenances & Reservoirs schemes where peace and order situation and condition is also a consideration in the project planning, design, selection, prioritization, Implementation and in the conduct of Operation and Maintenance of the existing.)

21.3.0 RISK CLASSIFICATION, ASSESSMENT AND RATING METHOD

Risk Classification, Assessment and Rating Method shall be as prescribed under this SECTION and based on the Table 21.3A and Table 21.3B respectively.
TABLE 21.3A: Potential Risk Rating & Weighing Points for Existing and Proposed Reservoir/Storage Dam Systems/Projects. (Ref. # 197)

<table>
<thead>
<tr>
<th>Risk Factors (RF)</th>
<th>Risk Classification (Rating)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RC-1 (LOW)</td>
</tr>
<tr>
<td></td>
<td>RC-2 (Moderate)</td>
</tr>
<tr>
<td></td>
<td>RC-3 (HIGH)</td>
</tr>
<tr>
<td>1.Capacity (MCM)</td>
<td></td>
</tr>
<tr>
<td>(WP=Weighing Points)</td>
<td>&gt;0.25&lt;3.0</td>
</tr>
<tr>
<td></td>
<td>(WP=0.0 - &lt;6.25)</td>
</tr>
<tr>
<td></td>
<td>&gt;3.0&lt;60.0</td>
</tr>
<tr>
<td></td>
<td>(WP= &gt;6.5 &lt;14.75)</td>
</tr>
<tr>
<td></td>
<td>&gt;60.0</td>
</tr>
<tr>
<td></td>
<td>(WP= &gt;15 &lt;25.0)</td>
</tr>
<tr>
<td>2.Height (Meter)</td>
<td></td>
</tr>
<tr>
<td>(WP)</td>
<td>&lt; 15.00</td>
</tr>
<tr>
<td></td>
<td>(WP=0.0 - &lt;6.25)</td>
</tr>
<tr>
<td></td>
<td>&gt;15.0-75.0</td>
</tr>
<tr>
<td></td>
<td>(WP= &gt;6.5 &lt;14.75)</td>
</tr>
<tr>
<td></td>
<td>&gt;75.0</td>
</tr>
<tr>
<td></td>
<td>(WP=&gt;15 &lt;25.0)</td>
</tr>
<tr>
<td>3.Evacuation Requirements. / Lives-In-Jeopardy (No. of Persons)</td>
<td></td>
</tr>
<tr>
<td>(WP)</td>
<td>None to &lt;10.00 persons</td>
</tr>
<tr>
<td></td>
<td>(WP=0.0 - &lt;6.25)</td>
</tr>
<tr>
<td></td>
<td>10.00 to &lt;100.00 persons</td>
</tr>
<tr>
<td></td>
<td>(WP=&gt;6.5 &lt;14.75)</td>
</tr>
<tr>
<td></td>
<td>100.00 to &lt;1,000.00 persons</td>
</tr>
<tr>
<td></td>
<td>(WP=&gt;15 &lt;25.0)</td>
</tr>
<tr>
<td>4.Cost of Potential Downstream Damages (Econ., Social &amp; Envi.) (WP)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low &lt;P 25.0M</td>
</tr>
<tr>
<td></td>
<td>(WP=0.00 - &lt;6.25)</td>
</tr>
<tr>
<td></td>
<td>Moderate &gt;P25.0M - &lt;P50.0M</td>
</tr>
<tr>
<td></td>
<td>(WP=&gt;6.5 &lt;14.75)</td>
</tr>
<tr>
<td></td>
<td>High &gt;P50.0M</td>
</tr>
<tr>
<td></td>
<td>(WP=&gt;15 &lt;25.0)</td>
</tr>
<tr>
<td>Range of Total (ΣWP)</td>
<td>(0-25)</td>
</tr>
<tr>
<td></td>
<td>(26-59)</td>
</tr>
<tr>
<td></td>
<td>(60-100)</td>
</tr>
</tbody>
</table>

Note 1: The Weighing Points (WP) of each of the four Risk Factors (RF) shown in the parenthesis in the Table are summed to provide the Total Risk Factor shown in TABLE 21.3B and shall be computed by the prescribed equation.
**TOTAL RISK FACTOR** = (Capacity Risk Factor = CRF) + (Height Risk Factor = HRF) + (Evacuation Risk Factor = ERF) + (Potential Downstream Risk Factor = PDRF)

**TOTAL RISK FACTOR** = (CRF) + (HRF) + (ERF) + (PDRF)

**TABLE 21.3B: Risk Classification and Ratings Corresponding with the Computed Total Risk Factor**

<table>
<thead>
<tr>
<th>Risk Classification – (RC) and (Rating)</th>
<th>Computed Total Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC-1 (Low)</td>
<td>0-25</td>
</tr>
<tr>
<td>RC-2 (Moderate)</td>
<td>26-59</td>
</tr>
<tr>
<td>RC-3 (High)</td>
<td>60-100</td>
</tr>
</tbody>
</table>
SECTION 22.0 GUIDELINES FOR THE PREPARATION & IMPLEMENTATION OF EMERGENCY ACTION PLAN (EAPs)/EMERGENCY PREPAREDNESS PLAN (EPPs) AND IMPACT MITIGATION ACTION PLAN (IMAPs)

22.1 An EAPs/EPPs and IMAPs shall be established for all NIA constructed and operated storage/reservoir dams with the objective to anticipate actions to be taken and mitigate the potential or expected impact for the loss of life, damages to properties, social disruptions and the destruction of the environment in case a dam breach/failure/incident/sabotage occurs.

22.2 All reservoir/storage dams (New or Existing) having a MODERATE and HIGH Potential Hazard & Risk classification category and Size Classification shall be formulated, prepared and provided with an approved Initial or Updated Emergency Action Plan (EAP)/Emergency Preparedness Plan (EPP) & corresponding Mitigating Action Plan based on Hazard and Risk Assessment done during the Detailed Engineering Design (DED) stage by the Dam Design Team and during the Operation Stage by the Agency Dam Safety Organization based on the requirements stipulated under Sub-Section 3.1.2.2.3 and Section 20.0 of these guidelines.

22.3 Draft or initial EAPs/EPPs for new storage dams shall undergo into proper consultations and regulatory approval by the concerned government agencies and properly presented to the affected individuals, entities, communities, LGUs, other stakeholders and government offices that has a jurisdiction over certain regulations and policies.

22.4 Copy of the Approved EAPs/EPPs & IMAPs shall be issued /provided to the concerned regulating Government Agencies, Authorized Dam Operator, affected LGU’s, Community leaders/Coordinators and other Stakeholders and copy of which shall be furnished to the NIA- (Central, Regional & IMO) Dam Safety Offices (NDSO)prior to implementation and execution of activities.

22.5 Potential Hazard and Risk associated to possible dam accidents or failure shall be properly identified for existing dams and its Classification (PHRC) level shall be updated (Every two to five years, 2-5 yrs) regularly and/or periodically. EAPs/EPPs shall correspondingly Updated in same frequency for adoption.

22.6 There shall be an established regular or periodic simulation/testing and drill schedule for an updated EAPs/EPPs and ensure same shall be integrated in the overall Operations and Maintenance (O&M) Manual of the Storage Dam System.
22.7  **ASPECTS & ITEMS TO CONSIDER IN THE FORMULATION & DEVELOPMENT OF EAPs/EPPs.**

The formulation and development of EAP/EPP shall consider, but not limited to the following aspects:

22.7.1 Observation of hydrologic and hydrographic behavior of the river/waterways upstream and downstream of the storage dam and the flood forecasting and warning system/scheme to be adopted.

22.7.2 Filling, drawdown and flood control & regulation operation of the reservoir (Operation Rule/Protocol).

22.7.3 Emergency draining/drawdown of the reservoir

22.7.4 Inundation maps for flow up to Design (PMF) Flood and for catastrophic conditions caused by dam breach/failure or sabotage with corresponding Risk analysis.

22.7.5 Evacuation of flood affected populated areas, settlements and communities. (Shall be in accordance with the approved Evacuation Plan)

22.7.6 Environmental impacts.

22.7.7 Rescue operations and other emergency provisions including corresponding responsibility for such operations and provisions.

22.7.8 Equipment, materials and manpower support available for the emergency relief.

22.7.9 Coordination of emergency actions with (third parties) other (public and private) entities and LGUs.

22.7.10 Emergency standby (public & private) utilities.

22.7.11 Emergency operation of power plant, water supply, irrigation systems, navigation locks and other facilities related with dams & reservoir.

22.7.12 Emergency warning, communications, transportations and evacuation facilities.
22.8 **STEPS IN DEVELOPING AN EAPs/EPPs.** The process of developing an EAP/EPP shall generally be in accordance with but not limited to the following STEPS:

**STEP-1:** Determine the potential inundated area downstream by considering two (2) critical scenarios:

1.1. Inundation due to routed updated PMF value of IDF through the spillway without dam failure.

1.2. Inundation due to dam failure. Undertake dam break analysis by considering the different failure modes (according to reason and development such as overtopping, piping, structural failure, earthquake and sabotage).

**STEP-2:** Prepare inundation maps clearly indicating the flooded areas, depth of flow, flow velocity and time at which the flood wave will reach the downstream settlement or important areas.

**STEP-3:** Determine and identify the situations and events that could initiate an emergency action and specify the corresponding actions to be taken and identify the primary responsible entity or person/s. Develop concise and clear instructions with explanations on how the Operation Staff shall react before and during emergency.

**STEP-4:** Identify all entities, jurisdictions, LGUs, agencies and individuals/persons who will be involved in the emergency action. Coordinate the development of EAP with all parties and stakeholders. A dialogue or an interaction with all the affected and concerned shall be properly scheduled to ensure maximum attendance and participation. The discussion shall include and focus on the establishment of Operation Center, discussion on the evacuation protocol and procedures, destinations, priorities, food rations, post incident actions like the recovery and clean up and all other measures. The discussions must be concise and productive and presented with visual information. **During the dialogue it must be emphasized with the public that the development of an EAP/EPP does not mean that the dam and its appurtenances is not safe.** Ensure that the attending public and parties shall feel fully involved in the EAP.
STEP-5: Identify all primary and back-up communication systems for continuous internal and external communication.

STEP-6: List and prioritized all persons and entities involved in the notification process and create a Notification Flow Chart.

STEP-7: Develop a draft of the EAP/EPP. The list of the task must be complete and easy to understand so that it can be readily followed.

STEP-8: Determine the scope and extent of the following individual responsibilities under the Plan:

8.1. Responsibility of NIA (C.O/RIO/IMO)/LGUs/ and other government Agencies.
8.2. Responsibility of the EAP/EPP Coordinator.
8.3. Responsibility for Notifications
8.4. Responsibility for Evacuation.

STEP-9: The EAP/EPP shall be formulated and developed to foresee actions prior to and following the development of emergency situations and conditions. These actions shall include but not limited to:

9.1. Surveillances
9.2. Access to the sites
9.3. Response during time of darkness
9.4. Response during time of adverse weather
9.5. Emergency supplies, resources and transportations provision
9.6. Major and secondary/alternative means of communications
9.7. Information flow and coordination

STEP-10: Review and discuss the Draft EAP/EPP with all parties included in the Notification List. The EAP must be clearly understood by every individual with responsibility, the affected community and concerned public. When due to urgency of the situation dictates a revision of the EAP be rendered for elaboration and improvement and to invite full support to emergency actions.
22.9 EMERGENCY LEVEL CONDITIONS AND DETERMINATION

The following guidance shall be observed in detecting an existing or potential emergency incident/condition and for classifying emergency level in Storage Dam Systems:

I. Emergency Level 1- A non-emergency incident, unusual event, or a slowly adverse situation is developing, which if not mitigated will endanger the structural integrity of the Dam or results in uncontrolled releases of water causing flooding incident downstream.

II. Emergency Level 2- A potential Dam Failure situation is rapidly developing.

III. Emergency Level 3- An urgent Dam Failure is imminent or in progress.

22.10 EMERGENCY RESPONSE

Concerned entities shall formulate and develop Emergency Responses that shall incorporate and integrate all necessary actions and measures to be taken in the immediate aftermath/consequences and effect of an incident to save and sustain lives; meet basic human needs and reduce the loss of property and the adverse effect on critical infrastructures and on the environment.

22.11 EMERGENCY ACTIONS CATEGORIES

Emergency action categories shall be the actions to be taken corresponding to established Emergency Levels prescribed under Section 22.9.0

The Emergency Action Categories that shall be adopted and prescribed under these guidelines shall be as follows:

I. Action Category -1: Are actions to be taken corresponding to and shall address Emergency Level -1 Conditions. The said conditions exhibit and manifest a potential but not necessarily show sign of immediate danger and distress to the structure. The Category -1 Conditions could however develop into more serious problem/issues. NIA Dam Safety Offices (CO/RIO/IMO) or a qualified Dam Safety Engineer/Inspector shall be notified immediately and a prompt inspection shall be made of any Storage Dam Structures and appurtenances that shall exhibit with Category -1 Conditions.
Conditions that are identified & qualified under Emergency Level-1 & Action Category-1 are enumerated below but not limited to the following:

1. Extremely high water level (Determine and specify the high water level limitation for each Storage dams)
2. Dam embankment, abutments and reservoir rim erosion induced by wave action caused by high wind velocity.
3. Landslides or slides in the upstream or downstream slopes of the dam embankment and abutments.
4. Surface erosion on Emergency spillway
5. Excessive dam embankment settlement & consolidation
6. Slumping/bulging/cracking of dam embankment and abutments
7. Development/occurrence/presence of new springs/seeps or boggy areas in the embankment and abutment areas
8. Abnormal dam instrumentation readings.
9. Severe/extreme storm or weather conditions
10. Act of vandalism /sabotage on critical and primary dam appurtenances.

**Action Category -2: Are** actions to be taken corresponding to and shall address **Emergency Level-2 & 3 Conditions** respectively. **Category-2 Conditions** are considered extremely severe occurrences/incidents/situation that present an imminent/impending failure of the storage dam, its appurtenances and immediate danger to downstream areas. The manifestation of any of the **Emergency Level -2 & 3** and **Category-2 Conditions (Failure or impending Failure Conditions)** shall require the mandatory and immediate activation of the EAP/EPP.
Conditions that are identified & qualified under Emergency Level-2 & 3 and Action Category -2 are enumerated below but not limited to the following:

1. Dam embankment is overtopped by flood waters.
2. Slides on the dam embankment slopes.
3. Presence/development of (impending piping failure) large cloudy seepage.
4. Occurrence of (Piping Failure) flows through the dam embankment, abutments and or foundation.
5. Failure of appurtenant structures such as outlet works or Spillway.
6. Mass movement of the dam body on its foundation or mass sliding failure.
7. Severe erosion in the principal spillway area.
8. Earthquake induced structural, hydro-electrical & hydro-mechanical facilities failures.
9. Sabotage induced failures on dam and vital appurtenances.

22.12 DEVELOPMENT OF EMERGENCY EVACUATION PLAN

Emergency Evacuation Plan (EEP) shall be formulated & developed and shall be integrated as part of the EAP/EPP. The EEP shall be based on a worst-case scenario and shall address the following activities, elements/components/factors and situations:

1. Identification of critical facilities including buildings/ shelters.
2. Initiate Emergency Warning System (EWS). (Who shall be responsible and what is the method.)
3. Evacuation procedures. (Consider the flood wave travel time, evacuation of populations, special needs/logistics and the lifting of evacuation order.)
4. Route and distance to high and safe grounds.
5. Traffic routes and traffic control measures.

6. Evacuation sites and shelters in-place.

7. Potential adverse effect of weather or dam release on evacuation routes. (Identify/verify whether portion of the evacuation routes maybe flooded prior to dam incident/break occurs.)


9. Security and safety measures for the evacuation sites, dam perimeter and affected areas.

10. Re-entry into affected areas.

22.13 HAZARD & RISK MITIGATION PLANNING

22.13.1 Hazard & Risk Mitigation Planning shall be an activity or process that requires the rendering of proactive effort to reduce loss of lives and properties by reducing the effect of disasters.

22.13.2 Proper planning shall be achieved through identifying the potential hazard and risk associated with the construction of storage dams and the potential danger they pose in downstream areas. Mitigation planning shall also include identifying alternatives in reducing risk.

22.13.3 Hazard mitigation plan (In case of dam failures and incidents) shall include and involves identifying the population at risk and identifying actions to reduce their vulnerability. Actions shall include setting up a centralized emergency calling/reporting/action center system, establish and provide advance Flood Warning System/Network and relocating critical infrastructure and facilities out of the inundation/danger zone.

22.13.4 Hazard mitigation planning shall require real time data that defines the dam breach hazard. Information needed shall include but not limited to the breach inundation zone boundaries, depth of flooding, velocity and time of flood wave arrival.
SECTION 23.0  DAM & RESERVOIR MONITORING, SAFETY INSPECTION AND EVALUATION GUIDELINES

23.0.1  NIA through its Project Implementing Office (PIO) or Project Management Office (PMO) and prior to turnover of the Dam and Reservoir Facilities to the Operational and Administrative Jurisdiction of the RIO/IMO shall formulate and prepare an Inspection and Safety Evaluation Schedules/Guidelines and shall ensure that same shall be incorporated part of the Operations, Maintenance & Monitoring/Surveillance Manual of the Facility.

23.0.2  All Dams & Reservoirs (Storage Dams) irrespective of Hazard Category and Size Classification shall during and after implementation especially during the Operation Stage shall be scheduled and be subjected for Routine/Regular, Periodic/Special and Formal Dam Inspection and Safety Evaluation depending on the necessity and urgency of the situation.

23.1  DAM MONITORING GUIDELINES

23.1.1  Dam monitoring shall be done (and shall be undertaken on) by the quantitative method basis with the use of selected measuring instruments and installed at specific positions/locations to give information on the changes of dam behavior.

23.1.2  The dam monitoring system shall be designed according to the type, dimensions and the specific technical features of the dam and its foundation.

23.1.3  Monitoring shall be rendered in accordance with the prescribed period/frequency and degree/level of observations to detect anomalies and be able to evaluate how fast occurring and how and when they will probably end. The monitoring data shall be used to help and aid the Dam Safety Inspector/Specialized Engineer/authority (CDSO/RDSU/FDSU) or entity responsible for the dam to decide on the urgency of the required measures.

23.2  MONITORING INSTRUMENTS FOR LOW HAZARD & RISK CLASS DAMS

In SECTION 15.0 (Dam and Reservoir Instrumentations) of these Guidelines provides the required Instrumentations for All Types of Storage Dams (Embankment/Concrete/Masonry & Hardfill Types) and Related Appurtenances.

23.2.1  For Low Hazard and Risk Class (PHRC-I) Dams, the monitoring system shall be made to consist of simple, robust and easy to install instruments.
23.2.2. Priority Instrumentations that shall be installed for surveillance, monitoring, assessment of performance and observation of behavior of PHRC-1 class dams shall be but not limited to as follows:

1. **Reservoir Water Surface Level Measurement Instrument/s.**
   - The Instrument shall be installed to determine the influence of the reservoir water level on measurements taken from other instruments for seepage flow rates and uplift pressures.
   - To determine the volume of water available in the reservoir at a given time in order to properly implement reservoir operation rules and improve management.
   - To gather hydrological and hydraulics data through measurement of reservoir flood level, generated wave heights and (Inflows/Outflows) discharges.

2. **Leakage Measurement Instrument/s**
   - To monitor for unusual changes in seepage water flow rates and quality (turbidity, clearness, temperature, cloudiness). It is the most common method used for detecting internal erosion and piping at the dam body and foundation.

3. **Uplift and Pore Pressure Monitor Instruments**
   - To monitor water table level positions at a given date/time and how pore pressures are evolving in the embankment, abutments and foundation.

4. **Displacement (Vertical & Lateral) Measurement Instruments**
   - To measure the absolute displacement of the dams survey targets with respect to fixed benchmarks.

23.2.3. Frequency of readings for Monitoring Instruments shall be established as guide for the Operations and Maintenance Staff for taking records and the same records taken on specified frequency shall be made as reference by the Dam Safety Inspectors/evaluators. **Table 23-1** provides the suggested standards for the Frequency of Readings of Monitoring Instruments for Embankment Dams.
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONSTRUCTION PERIOD</th>
<th>INITIAL (1ST) RESERVOIR FILLING</th>
<th>INITIAL (1ST) YEAR OF OPERATION</th>
<th>OPERATIONS STAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.Settlement</td>
<td>monthly</td>
<td>weekly</td>
<td>Every 2 months</td>
<td>Every 6 months to yearly</td>
</tr>
<tr>
<td>2.Uplift pressure</td>
<td>weekly</td>
<td>3times/wk</td>
<td>weekly</td>
<td>Every 2 weeks</td>
</tr>
<tr>
<td>3.Pore water Pressure</td>
<td>weekly</td>
<td>3 times/wk</td>
<td>weekly</td>
<td>Every 2 weeks</td>
</tr>
<tr>
<td>4.Leakage</td>
<td>none</td>
<td>Daily</td>
<td>2 times/wk</td>
<td>weekly</td>
</tr>
</tbody>
</table>

23.3. SURVEILLANCE/INSPECTION AND EVALUATION PRACTICES

23.3.1. Dam safety inspection shall be an activity/task using simple equipment and technique. It shall be done to ensure the long term safety and survival of the Dam and its appurtenances. The main purpose is to monitor the condition and performance of the dam, appurtenances and surroundings and to ensure maintenance of observed deteriorations prior to formation and development of potential hazard and risk.

23.3.2. Persons who shall participate in undertaking Dam Safety Inspection must have the knowledge, familiarity with the dam structure and experienced in undertaking the specific activity and an expert in particular Dam Engineering discipline (Hydraulics & Structural Design, construction, Operation & Maintenance, Instrumentations, Reservoir Sedimentation and Hydro –Electrical and Mechanical) and other field of concern.
23.3.3. The Inspection/surveillance practices differ and depend on each dam features and degree of complexities but generally the Inspection activities are carried out for the detection of changes in the behavior and performance of the dam and its influences to the environment around the dam. These activities shall include but not limited to the following:

1. Regular and close visual observation, inspection, examinations of the dam surface, reservoir rim/planks and all appurtenant structures/facilities including adjacent surroundings.

2. Measurement of surveys like deformations, leakages, pressures and internal stresses.

3. Reading of instruments (manual and/or automatic)

4. Maintenance of surveillance facilities

5. Testing of safety systems

6. Data assessment, evaluation and interpretation of gathered information and observed facilities performance.

7. Accurate, concise recording of observations and proper keeping and archiving of the documents/records of inspection and evaluation.

23.4. DAM SAFETY INSPECTION PROCEDURES

Dam safety inspection procedure shall vary and depends on the complexity of the existing designed features, type and function of the storage dam and its appurtenances.

23.4.1. Engineers/expert who shall be commissioned/tasked to perform the dam safety inspection and evaluation must be a professional with adequate, extensive and intensive experience and familiarity on dam design, construction, operation and maintenance. Experiences on other technical and engineering aspect/disciplines such as dam instrumentation, technical analysis, electro-mechanical and electronic equipment operation and maintenance are ideal additional qualifications.
23.4.2. As a general rule and guidance, all type of dams shall be subjected to certain type, category and level of Safety Inspection which shall be part and the basis of assessment and evaluation of dam performance and condition. Each type/particular Storage dam shall be provided with a well suited and properly formulated INSPECTION CHECKLIST which shall serve as guidance in an orderly and sequential undertaking of the Dam and appurtenant facilities Inspection. In APPENDIX-9: NIA-STANDARD GENERAL DAM SAFETY INSPECTION CHECKLIST has been prepared and formulated as initial reference which shall be subject for revision/modification of contents to suit the specific Dam type, functions and Physical Configuration.

23.4.3. The prescribed type of Dam Safety Inspections to be rendered as the need requires shall be as follows:

I. ROUTINE/REGULAR VISUAL INSPECTION

(Shall be conducted on daily/weekly/monthly/every onset or outset of wet and dry season)

II. FORMAL INSPECTION

(Shall be conducted for the purpose of Comprehensive Dam Safety Review and shall be rendered preferably every after two (2) to five (5) years) for older dams having age of more than fifty (50) years. For new dams, the frequency of inspection shall be based on necessity and urgency but not more than every after ten (10) years.

III. PERIODIC/SPECIALIZED INSPECTION

(Shall be conducted every after the occurrence of special/calamitous/extreme events such as: major flood, earthquake (MMI>4) and sabotage)

23.4.3.1. ROUTINE/REGULAR VISUAL INSPECTION shall be undertaken on a frequent visual observation basis by concerned IMO Dam & Reservoir Operation and Maintenance Staff (IMO-DROMS) in order to have a continuous surveillance of the dam and appurtenant structures. Any observed unusual conditions during the inspection must be promptly reported to the Field (IMO) Dam Safety Officer (FDSO).

For Guidance, TABLE 23-2 provides Suggested Frequency of Routine Visual Inspection regardless of dam size classification:
### TABLE 23-2: FREQUENCY OF ROUTINE VISUAL INSPECTION FOR RESERVOIR DAMS AND APPURtenances

<table>
<thead>
<tr>
<th>Potential Hazard &amp; Risk Classification Level (PHRC Level)</th>
<th>PERIOD OF ROUTINE VISUAL INSPECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>During Initial Filling</td>
</tr>
<tr>
<td>PHRC-1</td>
<td>Every after two (2) days</td>
</tr>
<tr>
<td>PHRC-2</td>
<td>Every after two (2) Days</td>
</tr>
<tr>
<td></td>
<td>Daily</td>
</tr>
</tbody>
</table>

#### 23.4.3.2. FORMAL INSPECTIONS

are inspections conducted under the supervision of a Senior Dam Safety (Professional) Engineer with the participation of Specialist from within or outside of the Dam Safety Organization of the Agency. A third party and Independent Dam Safety Inspectorate Team/Organization may be commissioned by NIA to undertake this activity.

This type of Inspection shall be required to be undertaken to comply with the Agency policy or governmental regulation or due to complexity of potential issues/problems involved. Such inspection shall comprise visual inspection, instrumentation reading, surveys, review of previous inspections and operation & maintenance records and a review to determine if the dam including its appurtenant structures and equipment meet acceptable design criteria and practices.
Under water structures which are not accessible and visible at the time of the inspection when necessary shall be examined by diving or under water devices.

The result of this type/level of inspection together with the photographs performed and taken during the conduct of this type of inspection shall be properly documented in a detailed report which will present the main findings and analysis of the gathered monitoring data, observed deteriorations, main conclusions about the dam performance with recommendations about minor repairs or major remedial measures to improve the Dam Safety condition.

For guidance, TABLE 23-3 provides Suggested Frequency of FORMAL INSPECTION regardless of dam size classification:

**TABLE 23-3: FREQUENCY OF FORMAL INSPECTION FOR RESERVOIR DAMS AND APPURTENANT STRUCTURES**

<table>
<thead>
<tr>
<th>Potential Hazard &amp; Risk Classification Level (PHRC Level)</th>
<th>PERIOD OF FORMAL INSPECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>During the Initial Filling</td>
</tr>
<tr>
<td>PHRC-1 (LOW)</td>
<td>After six (6) Months</td>
</tr>
<tr>
<td>PHRC-2 (MODERATE)</td>
<td>After six (6) Months</td>
</tr>
<tr>
<td>PHRC-3 (HIGH)</td>
<td>After three (3) Months</td>
</tr>
</tbody>
</table>

**23.4.3.3. PERIODIC/SPECIAL INSPECTIONS** are inspections that shall be required to be undertaken by a team of specialist after a major or catastrophic event induced by typhoon, flooding, earthquake reservoir rim collapse/landslides and debris avalanche from watershed/catchment area/drainage area and dam and appurtenant facilities sabotage.

**Periodic/Special Inspection shall also be required for the following situations:**

1. Every after Wet and Dry Cropping Seasons operation
2. After occurrences of extremely Low and high reservoir water surface level

3. Every Spillway spilling events after flood occurrences.

4. Undertake Immediate Inspection if an Earthquake has been felt or has been reported to have occurred or after the occurrence of Tectonic or Reservoir triggered Earthquake events felt near or at the damsite having a Modified Mercalli Intensity Scale greater than 4.0 (MMI>4) or with the following RICHTER Magnitudes (RM):

   4.1. RM> 4.0, within 25.0 km of site
   4.2. RM> 5.0, within 50.0 km of site
   4.3. RM> 6.0, within 80.0 km of site
   4.4. RM> 7.0, within 125.0 km of site
   4.5. RM> 8.0, within 200.0 km of site

23.5. DATA MANAGEMENT, ANALYSIS, PERFORMANCE & SAFETY EVALUATION AND REPORTING GUIDELINES

Data management, analysis and performance and safety evaluation and reporting are mandatory activities that shall be properly planned and undertaken by the NIA Dam Safety Office (NDSO) Inspectorate Team or officials. The activity is necessary to fully understand and precisely interpret any manifestation of behavior of the monitored/inspected dams and related appurtenances. The main purpose of these activities is to detect and determine any sign of development of unsafe condition.

23.5.1. DATA MANAGEMENT shall include the process of Data Collection based on prescribed type of Dam Safety Inspection, frequency, and established schedules stipulated under Sub-Sections 23.4.3. to Sub-Section 23.4.3.3. and shall adhere to the following GUIDELINES:

1. Data taken from instrumentations shall be collected by the same (Operations Staff/Dam Instrumentation Reader Staff) Person/s.

2. For consistency of reading data, Use of the same calibrated monitoring readout unit and reading device shall be imposed and prescribed.

3. Instrumentation data entry shall include the following:

   • Project/System Identification: ________:
• The Type of Instrument: ____________:
• Instrument reading: ________________:
• Name of Instrument reader: ________:
• Date & Time of Reading: ____________:
• Climate/weather: _________________:
• Reservoir Water Surface Level______:
• Any Visual Observations and Remarks regarding site condition that might affect the value of the reading: ____________________________:

4. All readings shall be recorded on the same field data book to allow for comparison of the current or real time readings with the previous same time readings that were collected. The readings recorded on the field book shall be transferred to data sheet/computer file as soon as possible after being obtained and extracted.

5. Readings that deviated appreciably or exceeded the established normal level shall be reported immediately to the Chief of Office/IMO manager/Chief, Dam operations through the Head of Local/RIO/IMO/Field Dam Safety Unit.

6. When reports of readings manifested and as described under Item no.5 above, has been received by the concerned officials, the first Step of action to be taken shall be to CONFIRM the condition of the measuring device (Re-calibrate if necessary) and to perform a new measurement. If measurement is confirmed and validated, the Chief, Operations & Maintenance and the head, Dam Safety Unit should be notified to further observe/interpret/assess the situation if a problem or potentially dangerous situation is occurring.

7. Instrumentation data entry shall always be checked for possible errors. Instrumentation readings should be compared with the ranges specified and estimated by Design Engineer during design and as established based on As-built tested materials by the Dam Safety (Geotechnical) Engineer during and after construction. Determine conformance of the recent instrument reading entered with previous established trends. Presentation of Data shall be in a manner conducive to detecting trends by preparing Plot of Data to provide visual comparison between actual and predicted behavior. A TIME-HISTORY PLOT which displays Time VS. Change in Parameters such as water level, seepage quantity/flow rate, pore water pressure, displacements and temperature.

23.5.2. ENGINEERING DATA ANALYSIS

Data Analysis shall be executed as a process and tool for the interpretation and evaluation of the acceptability of the information extracted that might have been affected by various conditions. The Dam Safety Data Evaluator shall at every step of the analysis should be conscious and be aware of the potential for invalid data/information and the improper use of the calculations so that misinterpretation or incorrect assessment are not made or shall be avoided.

Analytical Technique of data analysis shall be considered in viewing and reviewing the current information based on past experience in predicting behavior of the Dam and Appurtenances being monitored.

The Dam Safety Unit/O&M Staff or official/s responsible for review of the analysis should consider the following technique when undertaking data analysis:

1. Current data taken shall be compared with the most recent data to detect anomalies or instrument malfunctions.

2. Instrument data currently taken at a Source point shall be compared with the historical performance of the same data source point over a significant (2 to 5 years) period of time, to ascertain consistency of instrument performance.

3. Compare currently extracted instrument data at certain source point with the initial reading for the same source point to determine the magnitude of change over time.

4. Compare the performance of instruments installed in similar (Upstream/Downstream) locations/positions of the dam or its foundations, but in different cross-sections, to understand their similarities and differences.

5. Compare trends of behavior over time with trends predicted during design, with values relating to calculated factor of safety and with any other predicted behavior.

6. Compare trends of behavior over time with trends observed with the monitoring of other dams with similar type, dimensions and geological foundations condition.
24.0.1.1. Miscellaneous dam and reservoir appurtenances and related civil, structural, architectural, hydro-electrical and mechanical facilities including Operations and Maintenance & Monitoring/Surveillance equipment, guest & local Tourism, camping & Recreation, health (clinic) & sanitary Facilities or Special /Emergency inspection Access and Transports Appurtenances(Air Strips/Runways or Helipads), Wildlife sanctuary(entry to and exits from the reservoir) facilities shall be considered and integrated in the design of the infrastructure depending on the prescribed need and components of the project.

24.0.2. Security Protocol that is not included in the specific sections of these guidelines shall be established for every Dam and Reservoir Infrastructures considered as being a primary and critical Government Asset.

24.0.3. The Infrastructure Security protocol shall be subject for the mandatory formulation/preparation including its implementation with rules and regulations supplemented/supported with physical infra and Logistics by the Agency or by the NIA concerned (IMOs/RIOs) Heads of dam operators depending on the needs and urgency of the situation.
APPENDICES

APPENDIX-1  LIST OF NIA MEMORANDUM CIRCULARS RELATED TO PLANNING, DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF STORAGE DAMS

1. NIA-MEMORANDUM CIRCULAR (NIA-M.C. No.55 S. 2017)- REVISED DELEGATION OF AUTHORITIES, SERIES 2017
2. NIA-M.C. No.36 S. 2016 – NIA GUIDELINES FOR THE PREPARATION OF CONCEPTUAL PLANS AND DETAILED DESIGN DRAWINGS FOR EXISTING AND NEW IRRIGATION, DRAINAGE AND RELATED INFRA-FACILITIES.
3. NIA-M.C. No.59 S. 2016 – AMENDMENT TO ITEMS 1.1 AND 1.2 OF SECTION 1 OF MC No.36 S.2016.
5. NIA-M.C. No. 58 S. 2017 – NIA GUIDELINE FOR THE ADOPTION OF THE SI-METRIC SYSTEM OF UNITS AS SOLE MEASUREMENT SYSTEM TO BE APPLIED IN ALL TECHNICAL DOCUMENTS, ENGINEERING STANDARDS, PRODUCTS, COMODITIES, MATERIALS, UTILITIES, SERVICES, TRANSACTIONS, ALL CONTRACTS, DEEDS, AND OTHER OFFICIAL AND LEGAL INSTRUMENTS, AND DOCUMENTS IN ACCORDANCE WITH THE PROVISIONS OF PD No.187 AS AMMENDED BY PD No.748 AND BATAS PAMBANSAN BILANG 8 AND THEIR IMPLEMENTING RULES AND REGULATIONS.
6. NIA-M.C. No.82 S. 2017 – INVOLVEMENT OF NIA DESIGN AND SPECIFICATIONS ENGINEERS, CONSULTANTS AND OTHER OFFICIALS IN UNDERTAKING FIELD INSPECTION WORKS DURING PROJECT INCEPTION, IMPLEMENTATION AND POST COMPLETION.
7. NIA-M.C. No.91 S. 2017 – NIA STANDARD PROCESS AND PROCEDURE FOR THE PREPARATION AND CONDUCT OF DETAILED ENGINEERING DESIGN (DED) AND REVIEW OF PLANS/DRAWINGS INCLUDING THE DESIGN DOCUMENTATION/REPORTS OF STORAGE/RESERVOIR DAMS.
8. NIA-M.C. No.58 S.2018 – CREATION OF THE INTERIM NIA DAM SAFETY GROUP ORGANIZATION (INDSGO)
9. NIA-M.C. No.47 S. 2010 – Composition of the Final Inspection and Acceptance Committee for Civil Works Contracts.
10. NIA-MC No.3 S.1981 - Items to be considered in the Final Inventory of completed Projects preparatory to turnover by Project Managers to Regional Irrigation Directors of Newly Constructed/Upgraded National Irrigation Projects/Systems.
### APPENDIX -2

**TABLE 3.3.1-** NIA-STANDARD TABULATION OF EXTRACTIBLE/AVAILABLE TYPES OF MATERIALS AT IDENTIFIED AND DESIGNATED SOURCES (BORROW/QUARRY AREAS) FOR EMBANKMENT DAMS. *(SAMPLE ENTRY ONLY)*

<table>
<thead>
<tr>
<th>DAM ZONE Designation</th>
<th>ZONE DESCRIPTION</th>
<th>MATERIALS CLASSIFICATION</th>
<th>SOURCE DESIGNATION</th>
<th>MATERIALS DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core</td>
<td>Silty Sand, Sandy silt, Clayey Sand &amp; Sandy Clay</td>
<td>Borrow Area No.1(BA#1) &amp; BA#2</td>
<td>6” (150.0mm) max; 20% to 80% passing #200(0.074mm) sieve, Min. PI=20.0</td>
</tr>
<tr>
<td>1A</td>
<td>Core at Cutoff trench &amp; base</td>
<td>Clayey sand and sandy clay</td>
<td>BA#1 &amp; BA#2</td>
<td>3” (75.0mm) max; 20% to 80% passing #200(0.074mm) sieve, min. PI=20.0</td>
</tr>
<tr>
<td>2</td>
<td>Blanket Drain</td>
<td>Quartzite</td>
<td>BA#3</td>
<td>30” (762.0mm) max ≤20% passing #4 (4.75mm) sieve.</td>
</tr>
<tr>
<td>2A</td>
<td>Coarse Filter</td>
<td>Quartzite</td>
<td>BA#2</td>
<td>6” (152.40mm) max ≤5% passing #4 (4.75mm) sieve.</td>
</tr>
<tr>
<td>3</td>
<td>Shell</td>
<td>Quartzite &amp; Phyllite</td>
<td>BA#2, BA#3 &amp; IO Channel</td>
<td>30” (762.0mm) max ≤20% passing #4 (4.75mm) sieve</td>
</tr>
<tr>
<td>3A</td>
<td>Rock shell</td>
<td>Weathered Quartzite &amp; Phyllite</td>
<td>BA#2, BA## &amp; IO Channel</td>
<td>9” (228.60mm) max. ≤35% passing #200 (0.074mm) sieve</td>
</tr>
<tr>
<td>3B</td>
<td>Filter</td>
<td>Weathered Quartzite &amp; Phyllite</td>
<td>BA#2, BA## &amp; IO Channel</td>
<td>3” (76.20mm) max. 5% to 25%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>passing #200 (0.074mm) sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Upstream Slope Protection</td>
<td>Quartzite &amp; Phyllite</td>
<td>BA#2, BA#3 &amp; IO Channel</td>
</tr>
<tr>
<td>5</td>
<td>Upstream Filter</td>
<td>Gravelly sand</td>
<td>BA#2</td>
</tr>
<tr>
<td>6</td>
<td>Downstream Filter</td>
<td>Sand</td>
<td>BA#2</td>
</tr>
<tr>
<td>7</td>
<td>Drain</td>
<td>Gravel</td>
<td>BA#2</td>
</tr>
<tr>
<td>8</td>
<td>Random Fill</td>
<td>Earth &amp; or Rock</td>
<td>Rock borrow, Overburden, Req’d Excavation</td>
</tr>
</tbody>
</table>

NOTE: 1/ The Tabulation of information entry presentation may vary depending on the available materials, type and configuration of the Embankment Dam.

2/ Any deviation from this format shall be allowed provided the items included/excluded will support the design or not part and unnecessary. Any items included and supplemented shall support the design and be fully explained.

- BA # – Borrow Area Number
- P.I. – Plasticity Index
APPENDIX – 3

NIA- STANDARD DESIGN REPORT OUTLINE
(CONCEPTUAL DESIGN LEVEL)
FOR RESERVOIR/STORAGE DAMS PROJECTS

I. LOCATION, PURPOSE AND CLASSIFICATION
   1.1. Region, Municipality, Barangay
   1.2. Location with respect to other features
   1.3. Accessibility
   1.4. Purpose
      1.4.1. Amount of storage-Dead Storage, Live Storage, Surcharge Storage
      1.4.2. Type of Storage-Irrigation, Flood, Power, Domestic, Multi-purpose, Etc.
      1.4.3. Water Surface Elevations
      1.4.4. Place/s where water will be used
   1.5. Dam Classification Designations
      1.5.1. Size Classification:
              (Small/Medium/Large)
      1.5.2. Potential Hazard & Risk Classification (PHRC) Level:
              (PHRC-1/2/3)

1.6. Alternative Design (Value Engineering Done If Any)

II. SUMMARY OF DESIGN
   2.1. Dam Classification
      2.1.1. Size Classification---------- Small/Medium/Large
      2.1.2. PHRC Level------------------- PHRC-1/PHRC-2/PHRC-3
   2.2. Storage Capacity-----------------MCM
   2.3. Spillway Capacity-------------- CMS @ WS Elevation ____m.
   2.4. Outlet Works Capacity:
      2.4.1. Diversion Works Outlet Cap. _________ CMS @ WS El. ____m.
      2.4.2. Irrigation Outlet Cap. _________ CMS @ WS El. ____m.
      2.4.3. Power/Domestic Supply Outlet Cap. _____CMS @ WS El. ____ m.
   2.5. Top of Dam (Crest Level)---------Elevation ______m.
   2.6. Normal Water Surface-----------Elevation ______m.
   2.7. Minimum Water Surface---------Elevation ______m.
   2.8. Maximum Water Surface--------Elevation ______m.
   2.9. Freeboard above Max. WS Level----Meters
2.10. Max. height of Dam above Stream Bed----------------------Meters
2.11. Estimated Cost of Dam & Reservoir =_____________Php Million
2.12. Total Project Cost =_____________Php Million
2.13. General Plans and Sections (Drawing Nos.____)

III. DESIGN DATA
3.1. Topography and Survey data/PRS-92 Survey Reference points.
3.2. Geological and Seismicity Report
3.3. Logs of Bore or Drill Holes/Test Pits
3.4. Hydraulic Data, Capacities and Requirements
3.5. Flood/Hydrological-Meteorological Data
3.6. Borrow Areas, Aggregate Sources, quantified deposits, waste disposal location/s, accessibility and transportation/equipment available
3.7. Right of Way Information
3.8. Photographs

IV. RESERVOIR DATA
4.1. Proposed capacities with corresponding water- surface elevation (reservoir Area-Capacity-Elevation Curve), Reservoir Inflow Design Floods and developed Hydrographs for Dam height, Spillway sizing, cofferdams and diversion structure sizing.
4.2. General Dimensions
4.3. Existing structures affected
4.4. Nature of land flooded and clearing required
4.5. Facilities to be relocated
4.6. Maximum reservoir water surface level limit
4.7. Geology & Seismicity
   a. General formation
   b. Reservoir losses
   c. Tributaries & contributory springs
   d. Deleterious minerals and salt deposits
4.8. Right of way & people affected (if any)
V. DAMSITE DATA
5.1. Geologic features, formations (Nature of stream bed and Abutments)
5.2. Interpretation of test pits and drill holes
5.3. Percolation test, ground water

VI. DAM & APPURTENNANCES DESIGN
6.1. Number & type of schemes and estimates prepared
6.2. Features governing design
6.3. Drawings
6.4. Water surface elevations, storage capacities, Freeboard & Camber requirement
6.5. General dimensions
   6.5.1. Top or Crest width, Length and roadway requirement
   6.5.2. Description of Section, Slopes, Height, Zoning, etc.
   6.5.3. Length of base at maximum section
   6.5.4. Cut-off trench requirement and cut-off wall dimensions
   6.5.5. Filter drains, Toe drains, drain holes requirement
   6.5.6. Foundation Treatment /Grouting requirements
6.6. Factor of Safety Criterion
6.7. Hydraulics and Structural Design Criterion
6.8. Hydraulics & Structural Design Calculations
APPENDIX-4

NIA-STANDARD DESIGN REPORT OUTLINE
(DETAILED ENGINEERING DESIGN LEVEL)
FOR STORAGE/RESERVOIR DAMS (Extracted from MC No. 36
s.2016 & MC No.91 s.2017)

1. INTRODUCTION
   1.1. Scope
   1.2. Design development
   1.3. Principal features

2. PROJECT AREA
   2.1. Location
   2.2. Access
   2.3. Topography
   2.4. Geology
   2.5. Hydrology and floods
   2.6. Sedimentation
   2.7. Construction materials.
   2.8. Social and Environmental Considerations:
       (Presence of and issues on ROWs/IP’s/FPIC/PAMB/LARP)

3. DAM & RESERVOIR DESIGN CONSIDERATIONS
   3.1. Dam & Reservoir Classification
       3.1.1. Size Classification
       3.1.2. Potential Downstream Hazard & Risk Classification
   3.2. Design concept (Site condition & available materials)
   3.3. Design Criteria/parameters (Loads and loading conditions)
   3.4. Dam foundation
   3.5. Dam stability (Static & Dynamic Analysis Procedures) supported with
       Numerical and Physical Structural modeling if required and necessary
       depending on the complexity of the structure and foundation
   3.6. Dam section
3.7. Dam crest width & freeboard
3.8. Dam Section & Surface Slopes
3.9. Dam and Reservoir Instrumentations

4. SPILLWAY
4.1. Spillway channels (Approach or Inlet/Outlet or exit) and Chute width, Chute Slab anchorage requirement & wall height & freeboard& Hydraulic performance
4.2. Spillway control weir, crest profile, Steel gates & lifting or hoisting mechanism & hydraulic performance
4.3. Energy dissipator Hydraulics performance
4.4 Hydraulics and Structural design (duly supported with a numerical & Physical Hydraulics & Structural Modeling when required depending on the complexity and configuration of the structure)
4.5 Instrumentations, Inspection & Security access, pedestrian & equipment footbridge / bridge.

5. OUTLET WORKS
5.1. Overall layout of Diversion (Tunnel or Cut & Cover Section) & or irrigation outlet conduit, irrigation intake, gate chamber, emergency & or sediment flushing outlets
5.2. Flow Control & Regulating Valves and guard &regulating steelgates
5.3. Hydraulics & structural design (duly supported with a numerical & Physical Hydraulics & Structural Modeling when required and necessary depending on the complexity and configuration of the structure)
5.3 Instrumentations, Inspection, monitoring, Repair or replacement & maintenance access provisions (i.e. Adits& Galleries)

6. CONSTRUCTION AND O&M CONSIDERATIONS
6.1. Proposed Construction sequence
6.2. Diversion & care of river
6.3. Construction Access /O & M Service Roads and Appurtenant Structures
6.4. Security and Safety facilities and provisions
7. APPENDICES
   7.1. APPENDIX -A- GEOLOGY
   7.2. APPENDIX-B -HYDROLOGY
   7.3. APPENDIX -C - SEDIMENTATION
   7.4. APPENDIX -D -DAM STABILITY
   7.5. APPENDIX -E -SEEPAGE
   7.6. APPENDIX-F -ELECTRICAL / ELECTRONICS & HYDRO-MECHANICAL APPURTENANCES AND CONTROL FACILITIES
   7.7. APPENDIX-G - DAM BREAK SIMULATION STUDIES
        (Potential Hazard and Risk Assessment Studies and Formulation of Emergency Preparedness Plan)

8. REFERENCES & BIBLIOGRAPHY
9. FIGURES
10. TABLES
APPENDIX- 5

NIA-STANDARDS FOR RESERVOIR/STORAGE DAMS PROJECT: DETAILED ENGINEERING DESIGN PLANS & DRAWINGS ARRANGEMENT, SEQUENCE & CHRONOLOGY. (Extracted from NIA MEMORANDUM CIRCULAR, MC#36 S.2016- NIA GUIDELINES FOR THE PREPARATION OF CONCEPTUAL PLANS AND DETAILED DESIGN DRAWINGS FOR EXISTING AND NEW IRRIGATION, DRAINAGE AND RELATED INFRA-INFRA- FACILITIES, SECTION 5B: STORAGE DAM PLANS AND DRAWINGS AND MC#59 S.2016-AMMENDMENT TO ITEM 1.1 AND 1.2 OF SECTION 1 OF MC#36 s.2016)

I. SIZE OF PLANS (REFER TO NIA MC#59 S.2016-AMMENDMENT TO ITEMS 1.1 AND 1.2 OF SECTION 1 OF MC#36 S.2016)

II. DRAWING ARRANGEMENT, SEQUENCE AND CHRONOLOGY

1. Cover Sheet
2. Table of contents
3. Drawing Sheets
   3.1. General (Maps & Drawings) Items
   3.2. Survey Data and Parameters
   3.3. Hydrology and Meteorological Data and Parameters
   3.4. Geology and Geotechnical Data and Parameters
   3.5. Civil Works (Embankment, Concrete, Masonry gravity, Buttress & Arch Dams, Spillway, Outlet Works, Other Appurtenant Facilities, Tunnel/Adits/Galleries, Structural Details, Construction Access / Service & O&M Roads/Bridges/Crossing Structures and other Miscellaneous Drawing Details.
   3.6. Dam and Reservoir Instrumentations
   3.7. Hydro-Mechanical and Hydro-Electrical Appurtenances, Electronics Monitoring and Control Facilities
APPENDIX-6

NIA-STANDARDS FOR RESERVOIR/STORAGE DAMS PROJECT: DETAILED ENGINEERING DESIGN PLANS & DRAWINGS SHEET CONTENTS. (Extracted From NIA Memorandum Circular, Mc#91 S.2017-NIA Standard Process And Procedure For The Preparation And Conduct of Detailed Engineering Design (DED) And Review of Plans/Drawings Including The Design Documentation/Reports of Storage/Reservoir Dams, Mc#36 S.2016- NIA Guidelines For The Preparation Of Conceptual Plans And Detailed Design Drawings For Existing And New Irrigation, Drainage And Related Infra-Facilities, Section 5b:Storage Dam Plans And Drawings And Mc#59 S.2016-Amendment To Item 1.1 And 1.2 Of Section 1 Of Mc#36 S.2016)

PLANS & DRAWING SHEETS & CONTENTS:

1. COVER SHEET

The Cover Sheet shall contain the following information:

1.1 Country Name: REPUBLIC OF THE PHILLIPPINES

1.2 Agency Name: NATIONAL IRRIGATION ADMINISTRATION

1.3 Agency Address: EDSA, Diliman, Quezon City

1.4 Agency Logo

1.5 Project Title, Location (Brgy/Municipality/Province/Region)

1.6 Implementing Office (RIO/PMO/IMO)

2. TABLE OF CONTENTS SHEET/S

The Table of Contents shall contain the applicable Title Block as prescribed under NIA Memorandum Circular, MC# 36 s.2016 and MC#59 s. 2016 with the orderly/sequential and chronological listing of Plans/Drawings with their corresponding Drawing Number (in Alpha-Numerical Code) and Drawing Sheet Number. Each drawing sheet shall be grouped and classified accordingly.
3. **DRAWING SHEETS**

3.1. **GENERAL (INFO/DATA MAPS & DRAWINGS) ITEMS SHEET**

3.1.1. Project Location Map, Provincial Map, Vicinity Map

3.1.2. Project Data and Features

3.1.3. General Notes (For Embankment/Concrete (MCC & RCC) Dams Construction/Masonry/Steel Structures)

3.1.4. Engineering Data (Tabulation of Materials for Zoned Embankment Dam with corresponding Engineering and Index Properties including other Construction Materials/Earth Foundation Materials Index and Engineering Properties). Borrow Areas for each material identified during the Feasibility Study and during the detailed Engineering Study shall be identified by designation with corresponding estimated extractible quantities to be reflected (Refer to Appendix-2).

3.2. **SURVEY DATA AND PARAMETERS SHEET/S**

3.2.1 General Layout of Project Area reflecting the delineated design irrigable area, Irrigation and drainage canal networks, canal structures, Contour lines with elevations that could readily identify the highest and lowest irrigable area, Location of the Storage Dam reflecting the geographic/grid coordinates of the damsite and extent of the reservoir area. Include and reflect on the plan any other existing facilities (i.e. roads & public infra-facilities).

3.2.2 Topographic map of damsite and the whole reservoir area and reservoir rims/flanks reflecting the contour lines with contour interval of 0.25 to 0.50 meter with corresponding contour elevations. The contour lines shall be extended at least 20.0 meters above the maximum estimated reservoir water surface level.

3.2.3 Reflect on the topographic map the Dam axis centerline alignment, Spillway center line, Outlet works/Diversion Conduit or Tunnel centerline alignment with respective reference
Stationing of the traverse centerline for each appurtenances. Include to reflect the locations (in Grid and or Geographic coordinate system), designation or identification and elevations of the Horizontal and Vertical Survey Control Points and Bench marks established for the project.

3.3. HYDROLOGY AND METEOROLOGICAL DATA AND PARAMETERS SHEET/S

3.3.1. Inflow Design Flood (IDF) Discharge & Routing Hydrograph for Spillway Sizing and Dam Height & Freeboard estimation.

3.3.2. Inflow Design Flood (IDF) Discharge & Routing Hydrograph for Diversion Conduit Sizing and Permanent/Temporary Cofferdam Height & Freeboard estimation.

3.3.3. Reservoir Elevation-Area-Capacity Curve, Tail Water Rating Curve, Spillway and Diversion Conduit Elevation-Discharge Capacity Rating Curve and other relevant engineering design data that were used and stipulated in the design report needed to support the Plans and Drawings.

3.3.4. Meteorological Information to include but not limited to the following: Rainfall & Evaporation data/Mean daily/monthly/annual basis, Maximum Design Wind speed, Humidity, Maximum Temperature Variation and other relevant meteorological data that has direct effect on construction activities.

3.4. GEOLOGY AND GEOTECHNICAL DATA AND PARAMETERS SHEET/S.

The Geology and Geotechnical Data Sheets shall contain the following information/s:

3.4.1 Regional and local geologic map and Seismicity Map, identifying the locations, relative positions/alignment/direction of the Fault Lines that may have potential effect and as potential generator of Faulting System on foundation of the dam, reservoir area and appurtenant structures.

3.4.2 Geologic map of the damsite and reservoir area reflecting the exact location, alignment of the dam axis, centerline alignment of the Spillway, diversion conduit/tunnel and other appurtenances. Reflect
the reference stationing of the centerline traverses of the appurtenances consistent with that reflected on the Topographic Map under the Survey Data Sheet/s. The Geologic map shall also contain/reflect the locations and designations of test pits, borrow areas of embankment, quarry sites of boulders/cobbles/rock fragments and concrete aggregate materials. Include on the Sheet a prepared tabulation of materials with corresponding Classifications, identified quarry or borrow area/site /sources and estimated extractible quantities.

3.4.3 Geologic Profile/Cross section of Dam foundation along the Dam axis reflecting the locations and designations of Drillholes/boreholes with the corresponding log of borehole or the factual description of the foundation materials. For Rock Foundation the Hardness Nos. (Hn), Joint Nos. (Jn), Weathering Nos. (Wn) and Lugeon values (Lv) at every level of the foundation drilled shall be reflected. Must also indicate the level of the firm or competent foundation level, cut-off -trench/ cut-off- wall level, the location with specified stationing the center lines of the spillway Diversion conduit/Outlet works (Irrigation and or Hydropower) Conduits and other specially provided appurtenances (ie. Tunnels, galleries, adits and emergency outlet works/facilities).

3.4.4 Geologic Profile/Sections along Spillway center line and Outlet works conduit line reflecting locations and designations of the boreholes/Drillholes and the corresponding log of boreholes or factual information/s and outline of the appurtenant structures.

3.4.5 Drilling and Grouting Plan and Profile and Section/details of any other foundation treatment measures.
3.5. CIVIL WORKS SHEETS (EMBANKMENT, CONCRETE, MASONRY GRAVITY, BUTTRESS & ARCH DAMS, SPILLWAY, OUTLETWORKS, OTHER APPURTEANENT FACILITIES, TUNNEL/ ADDITS/GALLERIES, PENUMSTOCKS, POWERHOUSE, STRUCTURAL DETAILS, CONSTRUCTION ACCESS / SERVICE & O&M ROADS/BRIDGES/CROSSING STRUCTURES, AND OTHER MISCELLANEOUS DRAWING DETAILS.)

The Sheet contents for Civil Works shall include but not limited to the following items:

3.5.1. Overall/General Site Development Plan reflecting the overall dam layout/configuration, Spillway, Outlet works and any other appurtenances configuration and layout/alignment including proposed construction /O&M access roads linkages with the existing, location of the dam operators’ quarter, including the Project construction camp and facilities.

3.5.2. Foundation Excavation Plan & Profile reflecting depth/bottom of Cut-Off-Trench and the corresponding design width of the trench and variation thereof if there is any. Reflect the natural ground line/level.

3.5.3. Dam Body Sections (Embarkment, Concrete either Conventional Mass Concrete Construction (CMC) or Roller Compacted Concrete (RCC), Masonry, Composite materials) Longitudinal and Transverse Sections at 20 meters interval consistent with the reference longitudinal Stationing and Specific Transversal sections stationing. Special Details (Dam Crest width, Embarkment Dam Section Zoning details, Permanent & Temporary Cofferdams, Upstream and Downstream slopes details and protection works requirement, cut-off-trench width & depth/cut-off-wall depth/details, Filter/Seepage drains & rock toe details. Reflect the natural ground line/level.

3.5.4. Full or Partial Plan of Spillway, Longitudinal and transverse sections at 20 meters interval and or where required to show special details. Shall include structural and construction details for Hydro-mechanical and hydro-electrical facilities, operation bridge, footbridge, inspection access facilities, Spillway chute floor slab reinforcement and foundation anchorage when so required, seepage drains, weepholes, Spillway side/retaining walls structural details, Stilling basin or energy
dissipator, upstream or approach channel, downstream or exit channel, scour protection works and structure excavation pay line limit. Reflect the natural ground profile line/level.

3.5.5. **Full or Partial Plan of Diversion Conduit/Outlet Works** (Irrigation and or hydropower outlets/Tunnel), longitudinal and transverse sections with preferred 20 meters stationing interval, complete with structural and construction details including the structure excavation pay line limit. Reflect the natural ground profile line/level.

3.5.6. **Access/Service/O & M Roads Plan & Profile** with tabulation of traverses, center line distances, Stationing, azimuth, strip topo/contour lines and contour lines elevation. Road Profile with design grade lines, road gradient, design road cross-sections, side drains requirement, road side slope scour/erosion protection, road /traffic and safety signages and details. Reflect or include in the plan/drawings the horizontal and vertical curve elements appurtenant structures and details.

3.6. **DAM AND RESERVOIR INSTRUMENTATIONS SHEET/S**

3.6.1. Location Plan, Type and Instrumentation I.D./designation & Legends

3.6.2. Tabulation of all the required Instrumentations with the corresponding location or stationing or coordinates referred to the dam axis or dam crest and elevation setting.

3.6.3. Installation /placement drawing details

3.6.4. Structural details.

3.7. **HYDRO-MECHANICAL AND HYDRO-ELECTRICAL APPURTENANCES, ELECTRONICS MONITORING AND CONTROL/REGULATION FACILITIES**

3.7.1. Hydro mechanical gates and lifting mechanism, embedded parts and electrical control system and details.

3.7.2. Control and regulating valves, bypass valves, connecting steel pipes, flanges, joint fittings and details.

3.7.3. Control house, control panel for electronics and electrical facilities
3.7.4. Tabulation of gates and lifting mechanism parts/elements with corresponding materials and specifications.

3.8. MISCELLNEOUS OPERATIONS & MAINTENANCE, EMERGENCY WARNING SYSTEM & SECURITY FACILITIES

3.8.1. Operation Staff/ guard houses located at strategic locations

3.8.2. Maintenance Equipment, service vehicle and Shade

3.8.3. Standby/emergency power facility

3.8.4. Access facilities and security barriers to critical and important dam appurtenances.

3.8.5. Emergency communications, Security, and warning systems
APPENDIX-7

NIA-STANDARD OPERATIONS AND MAINTENANCE MANUAL (GENERAL OUTLINE FORM) FOR RESERVOIR/STORAGE DAM IRRIGATION SYSTEM/S

I. OPERATION & MAINTENANCE (O&M) MANUAL PREPARATION

1.1. DATA GENERATION & PREPARATION
The following initial activities/ steps shall be undertaken in the generation of data for the O&M Manual preparation.

1.1.1. Prepare O&M Staff Organization Chart
1.1.2 Prepare & Develop the Cropping Calendar/ Schedule for the System.
1.1.3 Develop the Reservoir Operation Rule Curve
1.1.4 Prepare & develop the Area Irrigation Operation Plan
1.1.5 Prepare the Repair & Maintenance Plan / Schedule (Civil & Electro-Mechanical Facilities)
1.1.6 Prepare the System Facilities Inspection Plan / schedule
1.1.7 Prepare the Dam safety inspection Plan /schedule
1.1.8 Prepare the Emergency Preparedness Action Plan
1.1.9 Formulate Dam Operation Protocol.
1.1.10 Formulate the Dam Complex/Appurtenances Security Protocol

II. GENERAL OPERATIONS & MAINTENANCE (O&M) MANUAL OUTLINE

TABLE OF CONTENTS

1.0. INTRODUCTION
  1.1. Purpose of the O&M Manual
  1.2. Water Management & Operation
  1.3. Objective of Water Management & Operation

2.0. DESCRIPTION OF THE SYSTEM
  2.1. Location of the System
  2.2. Irrigation Network & Facilities
  2.3. Service Area

3.0. WATER SOURCES & CATCHMENT AREA
  3.1. Water Source & Capacity
  3.2. Rainfall & Other Climatic Parameters
  3.3. Watershed Description & Development Plan.

4.0. IRRIGATION DIVERSION REQUIREMENT (IDR)
  4.1. Procedure in preparing the IDR & Delivery Schedule
  4.2. Preparing the Cropping Calendar


Page 229
5.0. ORGANIZATION FOR SYSTEM MANAGEMENT
   5.1. Organizational Set-up for the System
   5.2. Organizational Set-up for the IA
   5.3. NIA Staff for O&M
   5.4. Duties & Responsibilities of IA Officers
      5.4.1. The IA Board of Directors
      5.4.2. The IA Officers
      5.4.3. The Committees
      5.4.4. The Turnout Service Area Group (TSAGs)
6.0. OPERATIONS PROCEDURES
   6.1. Operation Principle & Objective
   6.2. Operation of the Reservoir, Dam & Appurtenances.
      6.2.1. Reservoir Operation Rule Curve
      6.2.2. Operation of Irrigation Outlet Control Gate Valve & Regulating Butterfly Valves
   6.3. Operation of the Irrigation Intake Gates & Main Canal
   6.4. Operation of Headgates & Lateral Canals
   6.5. Operation of the Terminal Facilities (T.O’s/ MFD’s/ SFD’s)
   6.6. Equipment Requirement for Operations
7.0. ENVIRONMENTAL COMPLIANCE & MONITORING
   7.1. Environmental Compliance Requirement
   7.2. Monitoring & Evaluation
   7.3. Responsibility for Environmental Compliance
8.0. MAINTENANCE PROCEDURES
   8.1. Type of Maintenance Works
      8.1.1. Routine Maintenance
      8.1.2. Periodic Maintenance
      8.1.3. Special or Emergency Maintenance
   8.2. Maintenance Requirement of the Dam and Appurtenant Facilities
   8.3. Inspection Survey for Maintenance Requirement
      8.3.1. Dam Safety Inspection Procedure
   8.4. Preparation of Maintenance Plan
9.0. ADMINISTRATION & FINANCIAL MANAGEMENT
10. MONITORING AND EVALUATION
11. PERIODIC PERFORMANCE ASSESSMENT AND PLANNING
   11.1. Dam Integrity and Safety Evaluation
   11.2. Emergency Preparedness Plan
   • APPENDICES
   • LIST OF ABBREVIATIONS AND ACRONYMS
   • UNITS OF MEASURES

APPENDIX-8

NIA-STANDARD GENERAL FLOW CHART FOR DAM DECOMMISSIONING PROCESSES (Based on Section 18.3 of this Guidelines)

STEP 1
DEFINE CASE/ISSUES FOR DECOMMISSIONING

With or Without ISSUES

IF DECOMMISSIONING IS BEING CONSIDERED THEN PROCEED TO STEP 2

STEP 2
IDENTIFY KNOWN MAJOR/OTHER POTENTIAL ISSUES AND OPTIONS

STEP 3
COLLECT AND ASSESS DATA AND CONFIRM ISSUES

CONFIRM ALL ISSUES & OPTIONS IDENTIFIED AND ENSURE ADEQUATE DATA IS AVAILABLE TO BASE THE DECISION ON

CONSULTATION AND REGULATORY APPROVAL

NO CASE OR ISSUES FOR DECOMMISSIONING

STEP 4
DECISION MAKING (Yes/No)

YES

PROCEDURE ON THE PLANNING OF THE PREFERRED OPTION (Formulate & Prepare Dam Decommissioning Plan (DDP))

STEP 5 (Facilitate Approval of DDP)

EXECUTE DAM DECOMMISSIONING

STEP 6
MONITOR EFFECTIVENESS OF DECOMMISSIONING

END
APPENDIX-9

NIA- STANDARD GENERAL (DAM SAFETY) INSPECTION CHECKLIST FOR RESERVOIR DAMS

- Name of Project/System: ________________________________
- Name of Dam: ________________________________
- Type of Dam: (Zoned Embankment (Earthfill/Rockfill) Type Dams or Concrete (CMC/RCC) Gravity Type Dams)
- Date of Inspection: ________________________________
- Reservoir Water LEVEL:  EL. ______M.  Tail Water Level: EL._______M.
- Weather Condition: _______________  Temperature : _________°C
- Dam Classification:
  i. SIZE (Total Storage Cap. /Height) Classification:
     - Storage Capacity= _____________________________ MCM.
     - Dam (Structural/Hydraulic) Height:
       Structural height =_______M.
       Hydraulic height =_______M.
  ii. Potential Hazard & Risk Classification level:
      (Encircle assessed/prescribed level)
     - Original = PHRC- 1 / 2 / 3
     - Updated = PHRC- 1 / 2 / 3

NOTE: Mark a √ in the YES or NO Column. If an Item does not apply, Write “ N/A” in the REMARKS Column. Additional Remarks shall be provided for any Observations needing attention and proper action.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>YES</th>
<th>NO</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PERTINENT DOCUMENTS</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1.1. Design &amp; Inspection Reports (available /copy on file)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>a) Original design scheme</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Retrofitting scheme</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Modification/Rehabilitation scheme</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>d) Reconstruction scheme</td>
<td></td>
<td></td>
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<tr>
<td>e) Inspection/Damage Reports</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>1.2. O&amp;M Manual</strong></th>
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<tbody>
<tr>
<td>a) Original Copy Version</td>
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<td>Date Implemented: (DD/ MM/ YY)</td>
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<tr>
<td>b) Updated /Amended copy</td>
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<tr>
<td>Date Implemented (dd/ mm/ yy)</td>
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<tr>
<td><strong>1.3. As-Built Plans &amp; Drawings</strong></td>
<td></td>
</tr>
<tr>
<td>a) Based on Original Scheme</td>
<td></td>
</tr>
<tr>
<td>b) Based on Retrofitted scheme</td>
<td></td>
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<tr>
<td>c) Based on modified/rehabilitated</td>
<td></td>
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<tr>
<td>d) Based on Re-constructed scheme</td>
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<tr>
<td><strong>2. EMBANKMENT</strong></td>
<td></td>
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<tr>
<td><strong>2.1. CREST</strong></td>
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</tr>
<tr>
<td>a. Visual Settlement</td>
<td></td>
</tr>
<tr>
<td>b. Misalignment</td>
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<tr>
<td>c. Longitudinal Cracking</td>
<td></td>
</tr>
<tr>
<td>d. Transverse Cracking</td>
<td></td>
</tr>
<tr>
<td>e. Growth of trees/shrubs</td>
<td></td>
</tr>
<tr>
<td><strong>2.2. UPSTREAM SLOPE</strong></td>
<td></td>
</tr>
<tr>
<td>a. Deficient Slope Protection</td>
<td></td>
</tr>
<tr>
<td>b. Erosion/Scour/Slides</td>
<td></td>
</tr>
<tr>
<td>c. Growing Shrubs/Trees</td>
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<tr>
<td>d. Longitudinal Cracks</td>
<td></td>
</tr>
<tr>
<td>e. Transverse Cracks</td>
<td></td>
</tr>
<tr>
<td>f. Deficient Riprap protection</td>
<td></td>
</tr>
<tr>
<td>g. Deteriorated/decayed Boulder/Rock Riprap</td>
<td></td>
</tr>
<tr>
<td>h. Visual depression/bulges</td>
<td></td>
</tr>
<tr>
<td>i. Visual settlement</td>
<td></td>
</tr>
<tr>
<td>j. Burrows</td>
<td></td>
</tr>
<tr>
<td><strong>2.3. DOWNSTREAM SLOPE</strong></td>
<td></td>
</tr>
<tr>
<td>a. Deficient Slope Protection</td>
<td></td>
</tr>
<tr>
<td>b. Erosion/Scour/Slides</td>
<td></td>
</tr>
<tr>
<td>c. Growing Shrubs/Trees</td>
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<tr>
<td>d. Longitudinal Cracks</td>
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<td>e. Transverse Cracks</td>
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<tr>
<td>f. Deficient Riprap protection</td>
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<tr>
<td>g. Deteriorated/decayed Boulder/Rock Riprap</td>
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<tr>
<td>h. Visual depression/ bulges</td>
<td></td>
</tr>
<tr>
<td>i. Visual settlement</td>
<td></td>
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<tr>
<td>j. Burrows</td>
<td></td>
</tr>
<tr>
<td>k. Seepage appearing at surface</td>
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</tbody>
</table>
l. Seepage quantity excessive and with colored/murky/cloudy and fine particles |   |

### 2.4 LEFT ABUTMENT

- Erosion/scour at upstream/downstream interface with embankment
- Differential movement
- Cracks
- Slides
- Presence of seepage

### 2.5 RIGHT ABUTMENT

- Erosion/scour at upstream/downstream interface with embankment
- Differential movement
- Cracks
- Slides
- Presence of seepage

### 2.6 SEEPAGE AND DRAINAGE FACILITIES

- Seepage collectors/toe drains functional & flowing
- Relief wells functional
- Presence of boils
- Seepage measurement/weir functional
- Presence of cloudy seepage flowing

### 3. RESERVOIR AREA, PERIMETER/RIM AND WATERSHED

- Debris producing area in watershed
- Sediment producing area in watershed
- Slides in reservoir rim
- Depressions, sinkholes and vortices in reservoir area
- Low ridges/saddles along the rim allowing overflow from reservoir
- Presence of structures below elevation of maximum surcharge storage.
### 4. SPILLWAY

#### 4.1.0 APPROACH CHANNEL (Spillway)

- a. Eroding/scouring channel bed & side slopes
- b. Silted sections/channel bed
- c. Constricted sections by growing trees/shrubs/vegetations/eroded earth materials/rockfall
- d. Obstructed by debris
- e. Deficient section to accommodate updated /observed maximum Inflow design flood

#### 4.2.0. CONTROL /WEIR STRUCTURE (UNGATED) of SPILLWAY

**4.2.1. CONCRETE**

- a. Shows Spalling
- b. Decay & disintegration
- c. Cracking
- d. Erosion/Abrasion/Cavitations
- e. Scaling
- f. Exposed Reinforcement
- g. Rusted reinforcements

**4.2.2. CONCRETE JOINTS**

- a. Show displacement or offset
- b. Damaged waterstop
- c. Loss of Joint Filler Materials
- d. Leakage Emission
- e. Abrasions

**4.2.3 Earth Cut/Emergency Spillway**

- a. Scoured /Eroding Crest
- b. Scoured Side slopes
- c. Growth of shrubs/trees
### 4.3. GATED CONTROL STRUCTURE (SPILLWAY)

- a. Gates bent/broken/deformed
- b. Corroded/rusted metal parts/accessories
- c. Control, hoist, etc. deteriorated/needs repair/not maintained
- d. Leakages at seals (Measured leakage flow rate = _____ lps/cm)
- e. Not operated periodically/ Without exercise
- f. Date last operated (mm/dd/yy)
- g. Control weir in deteriorated condition
- h. Control weir structure in proper location/alignment/position
- i. Electrical & Electronics control system in good/functional/ operating condition
- j. Date last simulated (mm/dd/yy)

### 4.4. CONVEYANCE STRUCTURE (Spillway Chute Section)

#### 4.4.1. CONCRETE STRUCTURE

- a. Surface Show spalling
- b. Cracking
- c. Erosion/abrasions/cavitation
- d. Scaling
- e. Exposed reinforcement
- f. Corroded reinforcement

#### 4.4.2. CONCRETE JOINTS

- a. Show displacement/offset
- b. Abrasions
- c. Damaged water stop
- d. Loss of joint filler material
- e. Leakage

#### 4.4.3. UNLINED CHANNEL (Chute Section)

- a. Channel bed Erosion/scouring
- b. Side Slope scour/sloughing
- c. Inadequate/absence of scour protection
d. Obstructed/constricted with debris/sediments
e. Growth of tree/shrubs

### 4.4.4. WEEPHOLES (Chute Section)
- a. Clogged
- b. Not functional
- c. Functional/seepage pressure relieved
- d. Emitting seepage with fine earth particles

### 4.5. TERMINAL STRUCTURE (Spillway)

#### 4.5.0. CONCRETE ELEMENTS (Floor slab/sidewalls/end sills/ baffle blocks/bucket)
- a. Surface show spalling
- b. Cracking
- c. Abrasions/cavitations
- d. Scaling/decay
- e. Exposed reinforcements
- f. Rusted reinforcements

#### 4.5.1. CONCRETE JOINTS
- a. Show displacement/offset
- b. With abrasions/cavitations
- c. Loss of joint filler material
- d. Damaged waterstop
- e. Presence of leakage

#### 4.5.2. ENERGY DISSIPATORS
- a. Sign of deteriorations/abrasions/cavitations
- b. Silted/Covered with debris
- c. Fully submerged
- d. Sign of inadequacy

#### 4.5.3. WEEP HOLES
- a. Clogged
- b. Functional but emitting fine earth particles
- c. With growth of vegetation
- d. Inadequate
4.6. **OUTLET CHANNEL (Spillway)**
   - Eroding or back cutting
   - Side Slope sloughing/scouring
   - Obstructed with slide materials and debris
   - Scoured bed and slope
   - Inadequate protection for scour

5.0. **OUTLET WORKS (Diversion Conduit/Irrigation and Hydropower/Emergency Outlets)**

5.1. **APPROACH CHANNEL (Outlet Works)**
   - (Lined/Unlined)
     - Bed erosion/scouring
     - Sloughing
     - Side slope scour/slide
     - Obstructed with debris/rock fall materials
     - Growth of trees and shrubs
     - Silted
     - Inadequate/reduced capacity
     - Presence of impending rock fall on upper side slopes

5.2. **INLET/INTAKE STRUCTURE (Outlet Works)**

5.1.1. **CONCRETE STRUCTURES/ELEMENTS**
   - Show spalling/sign of decay
   - Cracking
   - Abrasions/cavitations
   - Scaling
   - Exposed/corroded reinforcements

5.1.2. **CONCRETE JOINTS**
   - Show displacement/offset
   - Breakage/cavitations/abrasion
   - Damaged water stop
   - Loss of joint sealant/filler materials
   - Leakage
5.1.3. **CONCRETE (Inlet) PLUG**
   a. Show cracking/concrete decay
   b. Loss or decay of contact sealant/Filler or grout
   c. Exposed reinforcements
   d. Leakage along contact perimeter

5.1.4. **MISCELLANEOUS METAL WORKS/APPURtenANCES (Thrash racks, Handrails, Metal safety cage/guard rails, ladder rungs, stop logs)**
   a. Corroded/rusted welded joints
   b. Deformed/vandalized
   c. Lack of painting maintenance
   d. Unsecured anchorage
   e. Rust proofing/epoxy paint coating inadequate

5.2. **CONVEYANCE STRUCTURE (Outlet Works)**

5.2.1. **CONCRETE ELEMENTS/PARTS**
   a. Show surface spalling
   b. Cracking
   c. Scaling
   d. Erosion/abrasion/cavitations
   e. Exposed reinforcements
   f. Rusted corroded reinforcements

5.2.2. **CONCRETE JOINTS**
   a. Show displacement
   b. Loss or decay of joint filler/sealant materials
   c. Damaged/sheared waterstop
   d. Leakages

5.2.3. **METAL (ELEMENTS/PARTS) CONDUIT AND LINNERS**
   a. Show Corrosions/rusted surfaces
<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>b.</td>
<td>Deficient protective coatings provisions and maintenance</td>
</tr>
<tr>
<td>c.</td>
<td>Displacement/misalignment</td>
</tr>
<tr>
<td>d.</td>
<td>Internal cavitations</td>
</tr>
<tr>
<td>5.3.</td>
<td>CONTROL STRUCTURE (Outlet Works Hydro-Electrical, Electronic and Mechanical Control Facilities)</td>
</tr>
<tr>
<td>a.</td>
<td>Control and Regulating gates/valves needs repair/maintenance/exercise periodically</td>
</tr>
<tr>
<td>b.</td>
<td>Emergency gates/valves needs repair/maintenance/periodic operation exercise</td>
</tr>
<tr>
<td>c.</td>
<td>Stop logs needs repair/maintenance</td>
</tr>
<tr>
<td>d.</td>
<td>Gate seals needs replacement</td>
</tr>
<tr>
<td>e.</td>
<td>Control/regulating Valves needs repairs/replacement/maintenance</td>
</tr>
<tr>
<td>f.</td>
<td>Lifting/hoisting mechanisms bent/broken</td>
</tr>
<tr>
<td>g.</td>
<td>Bulkhead/Gates / valves leaking at closed position</td>
</tr>
<tr>
<td>h.</td>
<td>Bypass valves needs replacements repair/maintenance</td>
</tr>
<tr>
<td>i.</td>
<td>Low level control gates /valves need repair/maintenance/periodic operation exercise</td>
</tr>
<tr>
<td>j.</td>
<td>Presence of Cavitations on internal parts/surfaces of gates and valves</td>
</tr>
<tr>
<td>k.</td>
<td>Damaged Electrical and electronics control/wiring systems accessories and parts needs replacement/needs periodic operation simulation.</td>
</tr>
<tr>
<td>l.</td>
<td>Automated mechanical/electrical/Electronics control housing facilities needing refurbishment/upgrading/Rehabilitation or modification.</td>
</tr>
</tbody>
</table>
### 5.4. TERMINAL STRUCTURE/ENERGY DISSIPATOR STRUCTURE (Outlet Works)

#### 5.4.1. CONCRETE ELEMENTS/STRUCTURAL PARTS

- a. Presence of Surface spalling
- b. Cracking
- c. Erosion/abrasion/cavitations
- d. Exposed reinforcements
- e. Corroded reinforcements
- f. Concrete decay

#### 5.4.2. CONCRETE JOINTS

- a. Show displacement/offset
- b. Loss of joint sealant/filler materials
- c. Damaged waterstop
- d. Leakage
- e. Abrasion/cavitations

#### 5.4.3. ENERGY DISSIPATOR STRUCTURE/STILLING BASIN

- a. Show Sign of inadequacy
- b. Submerge/under water invert/Not visible for visual surface inspection
- c. Covered with debris (mud & sediments)
- d. Show surface cracking/abrasions/cavitations

#### 5.4.4. WEEP HOLES

- a. Clogged/non-functional
- b. With growth of vegetation
- c. Emission of seepage with fine soil particles
- d. Show sign of internal erosion/piping exit point

### 5.5. OUTLET CHANNEL (Outlet Works)

- a. Scoured channel bed and side slopes
- b. Section obstructed with earth debris
- c. Displaced lining/riprap/scour protection works
- d. Loss of scour/riprap protection
- e. Growth of shrubs and large tree variety at upper side slopes
- f. Presence of potential rock fall or slope instability at upper part of side slopes
6.0. DAM & RESERVOIR AND WATERSHED INSTRUMENTATIONS

6.1. List all types and numbers of Instrumentations Installed.
   a. Functional (Types____ & Numbers___)
   b. Non-functional (Types____ & Nos.____)
   c. For replacement (types___ & nos.___)
   d. For Decommissioning (types___ & nos.____)

6.2. Verify availability and keeping/archiving of Record Book/Data Book entries
   a. With records archived/kept
   b. No records available

6.3. Verify date of last reading of instrumentations
   a. Regular readings;
      date last reading done:
      (mm__/dd__/yy___)
   b. Periodic readings;
      Date last reading done:
      (mm__/dd__/yy__)
   c. Special readings;
      Date last reading done:
      (mm__/dd__/yy__)

6.4. O & M ACCESS (TO DAMSITE/RESERVOIR AREA & APPURTENANT FACILITIES/STRUCTURES)

6.5. Access/O&M Roads conditions:
   a. To dam crest and abutments
      • Needs maintenance
      • Needs repair/rehab
   b. To Spillway
      • Needs maintenance
      • Needs repair/rehabilitation
   c. To Outlet works
      • Needs maintenance
      • Needs repair/rehab
d. To Emergency warning system control sites /house
   - Needs maintenance
   - Needs repair/rehab

e. Along reservoir rim
   - Needs maintenance
   - Needs repair/Rehabilitation

6.6. Access Structures Conditions
   a. Spillway (RCDG-vehicle /foot) bridge
      - Needs maintenance
      - Needs repair/restoration
      - Needs retrofitting
      - For decommissioning
   b. Control gates or valves chamber access adits
      - Needs maintenance
      - Inadequate ventilation (Lighting and air)
   c. Vertical /lift /elevator shafts
      - Needs maintenance
      - Inadequate (lighting & air) ventilation
   d. Drainage tunnel/galleries
      - Needs maintenance
      - Inadequate (lighting & air) ventilation
   e. Access roads drainage culvert /crossing structures
      - Needs maintenance
      - Needs repair/rehab
      - Needs retrofitting
      - For decommissioning

6.7. Regular/Periodic/Emergency Inspection
Access & Safety facilities condition
   a. Safety Railing
      - Rusted/corroded
      - insufficient corrosion protection
      - deformed
- detached anchorages
  - Ladder rungs with steel cages
    - Rusted/corroded
    - Insufficient corrosion protection
    - Deformed
    - Detached anchorages

6.8. Access to Logistics/communication and Emergency Warning/Housing & Evacuation Facilities
- Needs maintenance
- Needs repair/rehabilitation
- Not readily accessible

7.0. COMMUNICATIONS, EMERGENCY PREPAREDNESS AND WARNING FACILITIES, LOGISTICS & SECURITY MEASURES

- Non available
- Un-updated
- Updated periodically
date last updated:
  (MM__/DD__/YY__)

7.2. Emergency Action Plan (EAP)
SIMULATION AND DRILL CONDUCTED
- Regularly
- Periodically
date last simulation/drill conducted:
  (MM__/DD__/yy__)

- COMMUNICATION FACILITIES INVENTORY
  - Functional
  - Non-functional
  - Missing
  - Damaged
  - Outdated
  - For replacement
  - For repair/for maintenance
### 7.3. COMMUNICATION FACILITIES/EMERGENCY WARNING SYSTEM TESTING/SIMULATION/ DRILL CONDUCTED

- Non conducted
- Regularly
- Periodically

Date last simulation/testing/drill conducted: (MM___/DD___/YY___)

<table>
<thead>
<tr>
<th>Date last simulation/testing/drill conducted: (MM___/DD___/YY___)</th>
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### 7.4 EAP/EPP LOGISTICS INVENTORY

- Service/Transport vehicle pooling available
- Fuel and oil stocks available & sufficient
- Emergency lighting facilities/genset/ gadgets/ flashlights available & sufficient
- Medical kits available & sufficient
- Food rations available/sufficient
- Others (Toiletries/sanitary facilities) available

<table>
<thead>
<tr>
<th>Service/Transport vehicle pooling available</th>
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<tbody>
<tr>
<td>Fuel and oil stocks available &amp; sufficient</td>
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<td>Emergency lighting facilities/genset/ gadgets/ flashlights available &amp; sufficient</td>
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<tr>
<td>Medical kits available &amp; sufficient</td>
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<tr>
<td>Food rations available/sufficient</td>
</tr>
<tr>
<td>Others (Toiletries/sanitary facilities) available</td>
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### SECURITY ACTION PLAN/PROTOCOL AND MEASURES

- Available & Observed regularly
- Not available/not observed

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<tr>
<th>Available &amp; Observed regularly</th>
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</thead>
<tbody>
<tr>
<td>Not available/not observed</td>
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</tbody>
</table>

REFERENCES

SECTION 1.0 - INTRODUCTION (PURPOSE, SCOPE & CONTENTS)


7. NIA- MEMORANDUM CIRCULAR (2017).– NIA STANDARD PROCESS AND PROCEDURE FOR THE PREPARATION AND CONDUCT OF DETAILED ENGINEERING DESIGN (DED) AND REVIEW OF PLANS/DRAWINGS INCLUDING THE DESIGN DOCUMENTATION/REPORTS OF STORAGE/RESERVOIR DAMS. M.C. No.91 S. 2017,
issued Dec. 20,2017, National Irrigation Administration, Quezon City, Ph; https://www.nia.gov.ph

SECTION 2.0 - DEFINITIONS, ACRONYMS & ABBREVIATIONS

12. NIA- MEMORANDUM CIRCULAR (1975).--Definition Of Technical Terms On Irrigation And Drainage, M.C. No.86 S.1975, issued Nov. 20,1975, National Irrigation Administration, Quezon City, Ph; https://www.nia.gov.ph
13. NIA- MEMORANDUM CIRCULAR (1979).--Revision Of Chapter XVII Of Definition Of Technical Terms On Irrigation And Drainage for Use In the NIA, M.C. No.6 S.1979, issued January 4,1979, National Irrigation Administration, Quezon City, Ph; https://www.nia.gov.ph
14. NIA- MEMORANDUM CIRCULAR (2015).--Revision Of Definition Of Terms On Irrigation And Drainage As Defined In MC.No.6 S.1979, M.C. No.12 S.2015, issued March 03,2015 National Irrigation Administration, Quezon City, Ph; https://www.nia.gov.ph


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SECTION 3.0 - DAM CLASSIFICATIONS, TYPES OF DAMS, DAM & RESERVOIRS TYPE & SITES SELECTION GUIDELINES & CRITERIA


SECTION 4.0 - ENGINEER’S QUALIFICATIONS, DETAILED ENGINEERING/DESIGN STUDIES AND REPORTS, GOOD FOR CONSTRUCTION (GFC) PLANS AND DRAWINGS & DAM CONSTRUCTION REQUIREMENTS, RECORDS, KEEPING & ARCHIVING GUIDELINES


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SECTION 11 - OUTLET WORKS, (DIVERSION, IRRIGATION OR HYDRO-POWER & EMERGENCY OUTLETS) TUNNELS/CONDUITS, CHANNELS, PERMANENT & TEMPORARY COFFERDAMS


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SECTION 14 - DAM SECTIONS, CONFIGURATIONS/GEOMETRIC DESIGN, LOADING CONDITIONS, STRUCTURAL, STABILITY & FACTOR OF SAFETY CRITERIA


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SECTION 15 - DAMS & RESERVOIRS INSTRUMENTATIONS


SECTION 16 - DAM & RESERVOIR CONSTRUCTION, OPERATION AND MAINTENANCE FACILITIES


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174. REFERENCE No. 163- (ICOLD Bulletin No.118)

175. REFERENCE No. 103 -( ICOLD Bulletin No.127)

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SECTION 22 - EMERGENCY PREPAREDNESS, ACTION PLANNING & IMPLEMENTATION GUIDELINES

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SECTION 24 - MISCELLANEOUS DAM & RESERVOIR FACILITIES


“THE ESSENCE OF KNOWLEDGE IS HAVING IT THEN APPLYING IT.”
++CONFUCIUS++
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**THE THEORITICAL MAN KNOWS WHY...THE PRACTICAL MAN KNOWS HOW... BUT THE MAN WHO SHALL LEAD MUST KNOW BOTH WHY AND HOW...”**

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