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Situational Assessment Report for Dam Safety Management in the Eastern Nile Sub-Basin

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EXECUTIVE SUMMARY

This "Situational Assessment Report for Dam Safety Management in the Eastern Nile Sub-Basin" has been prepared as part of the Eastern Nile Technical Regional Office (ENTRO) Dam Safety Program being carried out under Contract NC/ENT/C-Y1/3.2.3.2.

This report presents an updated assessment of the baseline conditions for dams in the EN and identifies key issues and actions that should be addressed to develop and implement a dam safety regulatory framework and dam safety management plans at the regional, national and dam owner levels. A plan to address these issues is presented in the subsequent report: "Roadmap for Preparation of a Regional Dam Safety Framework". In addition "Reference Dam Safety Guidelines" and "Small Dams Safety Guidelines" have been drafted with the intent that they can be adopted by member countries.

A comprehensive listing of large dams in the EN has been compiled which includes a "Potential Consequences Classification" (PCC) system. This classification is to be used to help identify the level of care that the various dams require and select appropriate design criteria for new dams. The classification considered both national and international or trans-boundary factors. The dam classes vary from VERY HIGH (level 4) to REMOTE (level 0) and are determined by the highest potential consequences, whether loss of life, infrastructure, economic and social or environmental and cultural losses. There are presently VERY HIGH potential consequence classification existing dams in Egypt, Ethiopia and Sudan plus new VERY HIGH classification under construction. At this time there are no large dams in operation in South Sudan but several large dams are being planned.

A review of the existing water and energy institutions in the EN countries identified substantial infrastructures in each country which would be capable of hosting dam safety regulatory organizations. A variety of legislations were identified regarding water resources in general but specific organizations with regulations dealing with dam safety do not exist.

Based on the intial dam safety reviews carried out, is clear that comprehensive dam safety management programs operated by the dam owners and supervised by appropriate regulatory agencies are required for all existing and new large dams in each of the EN countries, coupled with the necessary transfer of technological know-how to help them protect the assets and the public from dam failure.

In addition, there is no regional framework or institute responsible for dam safety management addressing the potential trans-boundary impacts of dam mis-operation or other safety incidents. It is therefore necessary to establish such a regional framework to increase the functionality and safety of the structures, the service they provide, and protect downstream communities who may be at risk if dam safety is compromised. This could be achieved through development of a regional EN dam safety unit which encompasses the technical, institutional and legal framework, and capacitated human resources.

Guidelines on dam safety are required to help establish the required components of the dam safety programs. These EN guidelines should address local conditions and incorporate trans-boundary issues that are particularly important in this area. Safe design, construction and operation of dams in the EN also requires a major program of capacity building. This should include ongoing training programs for all levels of personnel from management to field operators and maintenance staff.

A program to address these needs is outlined in the associated report to ENTRO, "A Roadmap for Preparation of a Regional Dam Safety Framework"

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Symbol or abbreviation	Definition
ANCOLD	Australian National Committee on Large Dams
CDA	Canadian Dam Association
CODS	Committee on Dam Safety
COM	Committee of Ministers
D2SI	Division of Dam Safety and Inspections
DBSA	Development Bank of Southern Africa
DID	Department of Irrigation and Drainage
DSAC	Dam Safety Action Class
DSO	Dam Safety Office
EAP	Emergency Action Plan
ECSA	Engineering Council of South Africa
EEAA	Egyptian Environmental Affairs Agency
EEPCO	Ethiopian Electrical Power Corporation
EIA	Environment Impact Assessment
EN	Eastern Nile
ENSAP	Eastern Nile Subsidiary Action Plan
ENTRO	Eastern Nile Technical Regional Office
EPA	Environmental Protection Authority
ESM	Environmental and Social Management
ESP	Environment and Social Policy
ETCOLD	Ethiopian Committee on Large Dams
FEMA	Federal Emergency Management Agency
FERC	United States Federal Energy Regulatory Commission
FLC	Failure likelihood confidence
GERD	Grand Ethiopian Renaissance Dam
HAD/AHD	High Aswan Dam/Aswan High Dam

Symbol or abbreviation	Definition
HADA	High Aswan Dam Authority
HPPEA	Hydro Power Plants Executive Authority
IBC	International Boundary Commission
IBWC	International Boundary and Water Commission
ICOLD	International Commission on Large Dams
IJC	International Joint Commission
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
JMP	Joint Multipurpose Program
KOBWA	Komati Basin Water Authority
KSD	Key Strategic Direction
MEDIWR	Ministry of Dams, Irrigation and Water Resources (South Sudan)
MHPPE	Ministry of Housing, Physical Planning and Environment (South Sudan)
MHUNC	Ministry of Hosing, Utilities and New Communities (Egypt)
MOEE	Ministry of Electricity and Energy (Egypt)
MOHP	Ministry of Health and Population (Egypt)
MWRE	Ministry of Water Resources and Energy (Sudan)
MoWIE	Ministry of Water, Irrigation and Energy (Ethiopia)
MWRI	Ministry Water Resources and Irrigation (Egypt)
NBI	Nile Basin Initiative
NBSF	Nile Basin Sustainability Framework
NOPWASD	National Organization for Potable Water and Sanitary Drainage
NRCS	Natural Water Resource Conservation Service
NWRP	National Water Resources Plan
O & M	Operation and Maintenance
ODSP	Owners Dam Safety Program
PAR	Population at Risk

Symbol or abbreviation	Definition
PFM	Potential Failure Mode
PFMA	Potential Failure Mode Analysis
PMF	Probable Maximum Flood
PTC	Potential Impact Classification
RCC	Roller Compacted Concrete
RCEM	Reclamation Consequence Estimating Methodology
RIDM	Risk Informed Decision Making
SANCOLD	South African National Committee on Large Dams
SAPs	Subsidiary Action Plans
SMP	Surveillance and Monitoring Plan
SSNEP	South Sudan National Environment Policy
STID	Supporting Technical Information Documentation
SWD	Small Distribution System
TCTP	Tripartite Permanent Technical Committee
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Program
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation

1. INTRODUCTION

1.1. Introduction and Scope

This Situational Assessment Report has been prepared as part of the Eastern Nile Technical Regional Office (ENTRO) Dam Safety Program being carried out under Contract NC/ENT/C-Y1/3.2.3.2. This dam safety program includes an updated assessment of the baseline conditions as a starting point and then development of a generic set of dam safety guidelines applicable to the region and available for adoption by the Eastern Nile (EN) countries, a "Road Map" for the preparation of an EN dam safety regulation framework and training in dam safety management.

This report presents an updated assessment of the baseline conditions for dams in the EN and identifies key issues and actions that should be addressed to develop and implement a dam safety framework and dam safety management plans at the regional and national levels. The plan to address these issues is presented in the subsequent report: "Roadmap for Preparation of a Regional Dam Safety Framework".

The Nile Basin Initiative (NBI) is a partnership initiated and led by the riparian states of the Nile River through the Council of Ministers of Water Affairs of the Nile Basin States (Nile Council of Ministers, Nile-COM). The NBI seeks to develop the river in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security.

The NBI started with a participatory process of dialogue among the riparian countries that resulted in their agreeing on a shared vision: to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources."

Eastern Nile (EN) Basin countries have made significant strides in strengthening Eastern Nile cooperation since the launch of the Eastern Nile Subsidiary Action Program (ENSAP) in 1999, within the framework of the Nile Basin Initiative.

The water resources infrastructure of the EN Basin countries, considered herein to include Egypt, Ethiopia, South Sudan and Sudan, comprises dams with large water storage reservoirs; such as High Aswan and Merowe Dams, with large irrigation systems and hydro-power plants. In addition to these, the Grand Ethiopian Renaissance Dam (GERD) is under construction and the raising of the Rosaries Dam was completed recent and there are also development plans to be implemented in the basin. Many of these structures are located on the Abay/Blue Nile and Main Nile (a trans-boundary watercourse) and generate electricity, control flood, and supply water for agriculture, municipalities, industries, livestock, etc.

A listing of existing and projects currently under construction in the EN Basin and maps for each country are provided in **Appendix A** and **B** respectively.

1.2. The Eastern Nile Region

The Eastern Nile sub-basins consist of the Main Nile, Baro-Akobo-Sobat, the Abay/ Blue Nile and the Tekezze-Settit-Atbara (see **Figure 1**).

The Eastern Nile consists of the countries of Egypt, , Ethiopia, South Sudan and the Republic of Sudan.. Since mid-June of 2010 Egypt and the Republic of Sudan discontinued their participation in the ENSAP as a result of issues with the Cooperative Framework Agreement process. However

beginning November 2012 the three countries of Ethiopia, the South Sudan and Republic of Sudan and have reactivated their participation in ENSAP.

Figure 1: Eastern Nile Region

2. EXISTING AND PLANNED DAMS IN THE EN COUNTRIES

2.1. Listing of Large Dams in the EN

As part of the assessment of Dam Safety in the Eastern Nile, a comprehensive list of all existing and planned dams on the Eastern Nile has been compiled The significant dams in each EN country are listed in **Appendix A**. The major characteristics of each dam are given.. The list of dams uses the same definitions as the ICOLD World Register. Large dams as defined by the Constitution of ICOLD (2011b). as a dam with a height of 15 metres or greater from lowest foundation to crest or a dam between 5 metres and 15 metres impounding more than 3 million cubic metres. Dams can be under design, under construction, in operation. Similar to the ICOLD World Register, tailing dams are also not described in the ENTRO list of dams. The reason for using the ICOLD World Register as basis is that when performing Potential Failure Mode Analysis (PFMA) on the dams of the Eastern Nile not only will all the information become available but the large majority of the dataset is provides an overview of the dams' essential information. A summary of the current extended list is provided in **Appendix A** and while location maps of the dams are provided in **Appendix B**. No location information was available for 7 of the listed dams in Ethiopia. It is also important to note that a separate user manual for the extended ENTRO list of dams have been compiled as part of this contract (Charlwood & Hattingh: 2014).

Currently there are 28 existing large dams in the Eastern Nile, 13 in Egypt, 10 in Ethiopia and 5 in Sudan. No large dams currently exist in South Sudan. Another 5 large dams are currently under construction – 4 in Ethiopia and 1 in Sudan and 2 large dams are currently being designed in Sudan. It is important to note that although great strides were made in the update of the basic information for each dam, some significant gaps in the information still exist especially for the Ethiopian dams where the collection of the information proved to be a major hurdle. For example for some dams no information was available with regards to their location or their important physical features.

2.1.1. Egypt

There are two large dams and eleven (11) barrages or groups of barrages in existence in Egypt. The two dams were or are built for irrigation, hydropower generation and flood control. The barrages were mainly built for irrigation, flood control and navigation.

The dams include the following:

- Old Aswan Dam was built by the British and completed in 1902. It is located 6 km from the city of Aswan. The dam wall was subsequently raised in 1907-12 and 1929-34. The dam is a gravity, masonry buttress dam with a raised height of 36 meters. Its initial reservoir capacity was 5 300 million m^3; and

- High Aswan Dam located just upstream of the Old Aswan Dam, was completed in 1970. It is 110 m high with a storage capacity of 162 billion m^3 and a hydro-power generating capacity of 2100 MW. The dam provides long term storage buffering against periods of low flow (e.g. during 1978-88) by providing sufficient water for two crops a year. It also provides flood protection for land downstream. Siltation and evaporation is two of the major issues at the High Aswan Dam.

The barrages include:

- Assiut Barrage;
- Damietta Barrage;
- The original Delta Barrages (replaced by Damietta Barrage and Rosetta Barrage respectively);
- Edfina Barrage;
- Esna Barrage;
- Farascour Barrage;
- Nag-Hamady Barrage;
- New Esna Barrage;
- New Nag-Hamady Barrage;
- Rosetta Barrage;
- Zifta Barrage;

It is important to note that only 8 of the barrages current in operation. The other 3 barrages/group of barrages are longer in operation (the Delta barrages, Esna Barrage and Nag-Mahady Barrage).

2.1.2. Ethiopia

There are ten large dams in operation, and four under construction in Ethiopia. It is important to note that the large majority of dams in Ethiopia are single purpose dams. Typically the dams are used for hydropower generation, irrigation or water storage for domestic and industrial use. Only three of the dams are multi-purpose for irrigation and hydropower generation.

Most of the dams are also typically embankment dams with either uncontrolled or controlled spillways. The typical Potential Failure Modes for these dams would therefore be similar focussing on the internal erosion of the embankments and the foundations, overtopping failure of the embankments and sliding failure of the concrete structures either as a result of relative weak layers or as a result of undercutting of the downstream toe. There are one concrete arch dam with a controlled spillway, a concrete weir with a controlled spillway and the under construction Grand Ethiopian Renaissance Dam with a main Roller Compacted Concrete (RCC) gravity wall.

Some detail on some of these dams is provided below:

- Alwero Dam was completed in 1996. It mainly used for irrigation, is 14 m high and stores 75 million m^3.
- Amerti Dam was completed in 1984. It used for irrigation and hydropower, is 15 m high and stores 110 million m^3.

- Angereb Dam was completed in 1996. It used for water storage for domestic use, is 34 m high and stores 6 million m^3.

- Chara Chara Weir was completed in 1996. It mainly used for hydropower. The dam has an installed hydropower capacity of 420 MW.

- Finchaa Dam was completed in 1973. It mainly used for irrigation and hydropower, is 22.2 m high and stores 650 million m^3. The dam has an installed hydropower capacity of 128 MW.

- Koga Dam was completed in 2006. It mainly used for irrigation, is 21.5 m high and stores 77 million m^3.

- Midimar Dam was completed in 1999. It mainly used for water storage for domestic use, is 33 m high and stores 10 million m^3.

- Neshe Dam was completed in 2010. It mainly used for irrigation and hydropower, is 38 m high and stores 448 million m^3. The dam has an installed hydropower capacity of 97 MW.

- Tekeze Dam the only concrete arch dam in the Eastern Nile sub-basin, was completed in 2009. It mainly used for hydropower, is 188 m high and stores 9 300 million m^3. The dam has an installed hydropower capacity of 300 MW. It also provides multiple benefits, such as flood regulation , to downstream riparian countries.

Three of the four dams under construction (Arjo Dedessa Dam, Megech Dam and Ribb Dam) are solely for irrigation. The other dam under construction, Grand Ethiopian Renaissance Dam, will primarily be used for hydropower. This dam when completed would be 145 m high, store 74 billion m^3 and have installed hydropower capacity of 6 000 MW.

2.1.3. South Sudan

Apart from small dams for water supply, there are no major dams in South Sudan due to the civil strife that continued for decades. This explains the lack of dam safety regulations development. But after the Comprehensive Peace Agreement (Sudan: 2005) several studies were done to establish the feasibility of generating hydropower from sites on the Bahr el-Jebel River, and multipurpose use on The Bahr el-Ghazal River and the Sobat River. These projects were all investigated previously by the Dams Implementation Unit at the national level in Khartoum. The greatest hydropower potential was found at Fula 1 site on the Bahr el-Jebel River, with a proposed installed capacity of 900 MW. The Government of South Sudan, and MEDWIR for that matter, has prioritized this site to be considered under the current East Africa Northern Corridor Infrastructure Project established by the Head of States Summit. Other prospective sites studied at prefeasibility level that, Bedden (570 MW), Shukoli (235 MW), and Lakki (410 MW).

2.1.4. Sudan

There are five large dams in operation, and one under construction in Sudan. All these dams are multi-purpose dams and the large majority were or are being built for irrigation and hydropower generation. They also have an important secondary purpose of flood control. Most of the dams also typically consist of concrete spillway sections in river section and embankment walls on either side in wide valleys with thick alluvial soils covering the underlying rock. All these spillways are also gate controlled. The typical Potential Failure Modes for these dams would therefore be similar

focussing on the internal erosion of the embankments and the foundations, overtopping failure of the embankments and sliding failure of the concrete structures either as a result of relative weak layers or as a result of undercutting of the downstream toe.

Some detail on each of these dams is provided below:

- Construction on Jebel Aulia Dam was completed in 1937; it is located about 50 km southwest of Khartoum. The dam was built to support Aswan dam in southern Egypt, but handed over to Sudan government in 1977. It is 22 m high and stores 3 500 million m^3.

- Rosaries Dam located close to the town of Damazin on the Blue Nile about 530 km south east of the Sudanese capital of Khartoum, was completed in 1950. It was recently raised to a height of 78 m and the raising was completed in 2012. It stores 6 000 million m^3. The dam has an installed hydropower capacity of 380 MW.

- Khashim el Gerba Dam is located on the Atbara River and completed in 1964. It main purpose initially was the irrigation of the Al-Gerba agricultural scheme and later on New Halfa scheme. In addition the dam has an installed hydropower capacity of 12.5 MW. It stores 1 300 million m^3.

- The Merowe Dam, also known as Merowe High Dam, Merowe Multi-Purpose Hydro Project or Hamdab Dam, located near Merowe Town in northern Sudan about 350 km north of the capital Khartoum, was completed in 2009. It is 67 meter high and stores 12 500 million m^3. The dam has an installed hydropower capacity of 1 250 MW.

- The Sennar Dam located close to the town of Sennar on the Blue Nile about 250 km south east of the Sudanese capital of Khartoum, was completed in 1925. It is 26 meter high and stores 930 million m^3. The dam has an installed hydropower capacity of 45 MW.

- The dam complex of the Upper Atbara River on the Upper Atbara River and the Setit River in Eastern Sudan are currently under construction. This dam complex are located upstream of the Khashim el Girba Dam. The dam complex will have a maximum height of 55 m and a combined storage capacity of 2 700 million m^3. The scheme has an installed hydropower capacity of 135 MW.

2.2. Potential Consequences Classification for EN Dams

As part of this project a potential consequences classification system for EN sub-basin dams has been developed based on international experience (see **Table 2-1**) and has been applied to the listed dams in the EN. This classification system was used in the country PFMAs and can also be used to provide guidance on the standard of care expected of dam owners and designers. Estimates of potential incremental consequences of dam failure are categorized to distinguish dams where the risk is higher than others. The classification considered both national and international or trans-boundary factors.

As a starting point, a Population at Risk (PAR) assessment may be used to conservatively estimate the potential loss of life and classify the dam and determine required safety levels and procedures. However, in areas with a large permanent PAR, a more detailed classification may be appropriate on the basis of estimates of potential loss of life using various tools such as DSO-99-06, A Procedure for Estimating Loss of Life Caused by Dam Failure, (USBR, 1999), or the recent Interim

Guidelines for Estimating Life Loss for Dam Safety Risk Analysis, RCEM – Reclamation Consequence Estimating Methodology, (USBR, February 2014).

For the classification of a dam to be based on estimated loss of life the effectiveness of the Emergency Action Plan (EAP) should be considered. For example, if considering a natural flood, then the specific characteristics of the flood and evacuation scenarios should be considered to ensure that the appropriate level of safety is provided.

Environmental, cultural, and third-party economic losses, considering both national and international or trans-boundary factors should be estimated separately and taken into account in assigning a dam to a class.

The dam class should be determined by the highest potential consequences, whether loss of life, infrastructure, economic and social or environmental and cultural losses.

For the purposes of general management oversight, as well as design, construction, inspection, maintenance, and surveillance programs, an overall classification for the dam system should be used, based on the failure scenario that would result in worse consequences: either sunny- day failure or flood failure.

For determining design criteria for specific components at a site, the consequences of failure of the components may be considered separately for the relevant individual failure modes and their combinations.

Table 2-1 Potential Consequences Classification for Eastern Nile Dams

Dam Class	Loss of Life	Infrastructure, Economic and Social Factors	Environmental & Cultural Factors
VERY HIGH Level 4	Large potential for multiple loss of life involving residents and working, travelling and/or recreating public. Development within the potential inundation area (the area that would be flooded if the dam fails), considering both national and international or trans-boundary areas, typically includes communities, extensive agricultural, commercial and work areas, main highways, railways, ports and locations of concentrated recreational activity. Estimated loss of life could exceed 1 000.	Very high economic losses affecting infrastructure, public and commercial facilities in and beyond the inundation area considering both national and international or trans-boundary areas. Typically includes destruction of or extensive damage to large residential areas, concentrated agricultural and/or commercial land uses, hydroelectric generation facilities, highways, railways, ports and shipping facilities, power lines, pipelines, water supply and other utilities. Estimated direct and indirect (interruption of service) costs could exceed $100 million.	Loss or significant deterioration of nationally or locally important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and/or practicality of restoration and/or compensation are low.
HIGH	Some potential for multiple loss of life	Substantial economic losses affecting infrastructure, public,	Loss or significant deterioration of nationally

Dam Class	Loss of Life	Infrastructure, Economic and Social Factors	Environmental & Cultural Factors
Level 3	involving residents, and working, traveling, and/or recreating public. Development within inundation area typically includes highways and railways, ports, agricultural, commercial and work areas, locations of concentrated recreational activity and scattered residences. Estimated loss of life between 100 and 1 000.	agricultural and commercial facilities in and beyond inundation area. Typically includes destruction of or extensive damage to concentrated agricultural and/or commercial land uses, hydroelectric generation facilities, highways, railways, ports and shipping facilities, power lines, pipelines, water supply and other utilities. Scattered residences may be destroyed or severely damaged. Estimated direct and indirect (interruption of service) costs could exceed $1 million.	or locally important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Feasibility and practicality of restoration and/or compensation is high.
MODERATE Level 2	Low potential for multiple loss of life. Inundation area is typically underdeveloped except for minor roads, temporarily inhabited or non-residential farms and rural activities. There must be a reliable element of natural warning if larger development exists. Estimated loss of life between 10 and 100.	Low economic losses to limited infrastructure, public and commercial activities. Estimated direct and indirect (interruption of service) costs could exceed $100,000.	Loss or significant deterioration of regionally important fisheries habitat (including water quality), wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance. Likelihood of recovery or feasibility of restoration or and/or compensation is high.
LOW Level 1	Minimal potential for any loss of life. The inundation area is typically undeveloped. Estimated loss of life between 1 and 10.	Minimal economic losses typically limited to owners' property. Virtually no potential for future development of other land uses within the foreseeable future.	No significant loss or deterioration of fisheries habitat, wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance.
REMOTE Level 0	No potential for any loss of life. The inundation area is typically undeveloped.	Minimal economic losses typically limited to owners' property. Virtually no potential for future development of other land uses within the foreseeable future.	No significant loss or deterioration of fisheries habitat, wildlife habitat, rare and/or endangered species, unique landscapes or sites of cultural significance.

2.2.1. Egypt

The two large dams are situated upstream of populated areas as well as large irrigation schemes. The consequences classification for these dams in general are be VERY HIGH. The barrages in turn are situated in the river channel and the consequences of their failure might be slightly less although still be considered as HIGH.

2.2.2. Ethiopia

The large majority of existing Ethiopian dams are situated upstream of populated areas as well as large irrigation schemes. The consequences classification for these dams in general therefore ranges from HIGH to VERY HIGH.

2.2.3. South Sudan

There are no major dams currently in South Sudan.

2.2.4. Sudan

All the existing dams in Sudan are also situated upstream of populated areas as well as large irrigation schemes. The consequences classification for these dams in general is therefore be VERY HIGH.

3. WATER AND ENERGY INSTITUTIONS IN EN COUNTRIES

The relevant institutional structures and major role players in each country are reviewed.

3.1. Egypt

Water sector activities in Egypt are shared among many governmental and non-governmental authorities. The Ministry of Water Resources and Irrigation (MWRI) is the official authority in charge of development, allocation and distribution of all conventional and non-conventional water resources of the country. In addition, around 10 other ministries have some involvement in one way or another in the water resources management such as Ministry of Electricity and Energy, Ministry of Agriculture and Land Reclamation, Ministry of State for Environment (with the Egyptian Environmental Affairs Agency), Ministry of Housing, Utilities and Urban Communities, Ministry of Finance, Ministry of Planning and International Cooperation, Ministry of Industry and Foreign Trade , Ministry of Health and Population and Ministry of Transport.

The Ministry of Water Resources and Irrigation includes various departments and sectors such as irrigation department, drainage department high Aswan dam authority, mechanical and electrical department, national water research centre and planning sector.

At a non -central level, the Ministry of Water Resources and Irrigation has 22 irrigation directorates, subdivided into around 62 inspectorates and about 206 districts (Egypt, 2005b).

As part of the policy of the Ministry of Water Resources and Irrigation, it is in the process of hand over part of its management responsibilities at district and lower levels to Water Boards at branch canal and district levels and Water User Associations at mesqa level.

The main institutions responsible for planning, implementing, operating and management of dams and hydraulic structures are the Ministry of Water Resources and Irrigation (MWRI) that is responsible for establishing, operating and maintaining dams and barrages and other water structures of the country.

The key authorities and departments which are responsible for dam and barrages works within MWRI are:-

- High Aswan Dam Authority; which operates, maintains and rehabilitates the High and Old Aswan dams and their reservoirs. It is also responsible for the implementation of any related complementary projects such as increasing the capacity of Toshka spillway and depression. It monitors the earthquake activities at the two dams area and sedimentation in Lake Nasser;

- Reservoir and Grand Barrages Sector, which is responsible for rehabilitation and maintenance of existing barrages and locks, supervision of the design and erection of new barrages and locks on the mail Nile and its main branches and canals; and

- Inspectorates (under Irrigation sector) in different Governorates, which are responsible for the operation of barrages for irrigation purposes.

Responsibilities for establishing, operating and maintaining dams appears to be defined primarily at the Ministry of Water Resources and Irrigation (MWRI) with the Ministry of Electricity and

Energy (MoEE) responsible for hydroelectric projects. The Hydro Power Plants Executive Authority (HPPEA) is the key authority for hydropower stations and is directly responsible for planning, implementing and operating hydropower stations.

3.2. Ethiopia

The Ministry of Water Resources (MoWR) was established in 1996 and was the Central Government body for policy, implementation, operation and regulatory work. It has subsequently been replaced by the Ministry of Water and Energy of Ethiopia which most recently was changed to the Ministry of Water, Irrigation and Energy of Ethiopia (MoWIE) which is a federal organization established to undertake the management of water and energy resources of Ethiopia. This involves development, planning and management of water and energy resources, development of polices, strategies and programs, develop and implement water, irrigation and energy sector laws and regulations, conduct study and research activities, provide technical support to regional water and energy bureaus and offices and sign international agreements. In matters of trans-boundary waters the Ministry is the responsible federal organization.

The powers and duties given to the former Ministry of Water Resources and the Ministry of Mines and Energy, with respect to energy, by the provisions of other laws, currently in force, and with respect to rural electrification, to the Ministry of Agriculture and Rural Development and the Ethiopian Rural Energy Development and Promotion Centre, under Proclamation No.317/2003 are given to the Ministry of Water, Irrigation and Energy. Reference should be made to the website of the Ministry as it contains a lot of detail and useful documentation (see www.mowr.gov.et).

The Ethiopian Electrical Power Corporation (EEPCO) was established as a public utility enterprise in 1997 and conformed with the powers and duties of the previous Ethiopian Electric Light and Power Authority which was formed in 1948. The purpose of the Corporation was to engage in the business of producing, transmitting, distributing and selling electrical energy in accordance with economic and social development policies and priorities of the government. Most recently EEPCO has been transformed into two institutions, Ethiopian Electrical Power (EEP) responsible for construction of power generation projects and Ethiopian Electrical Utility (EEU) responsible for operating the hydro-electric projects, distributing and selling of electrical power. EEU operates some 15 hydropower stations with an installed capacity of 1,500 MW. Further detail can be obtained at www.eepco.gov.et . Ethiopia has a large hydropower potential and the water resources policy indicates major expansion plans.

The Ministry of Water, Irrigation and Energy is also responsible for management of dams and other hydraulic structures which are constructed using the federal budget, if the structures are not transferred or entrusted to other bodies. The dams and hydraulic structures managed by the Ministry include irrigation structures.

Other main actors for development, operation and overall management of dams and hydraulic structures include:

- Regional Water Bureaus responsible for planning and management of dams and other hydraulic structures developed using the regional budget. These structures are mainly developed for water supply and irrigation purposes, since energy facilities are solely managed by the federal state owned enterprise, EEPCO;

- Ethiopian Sugar Corporation (www.etsugar.gov.et) that is a state owned enterprise responsible for developing and managing sugar estates and factories. The Corporation is the owner of hydraulic structures and dams that are used to regulate and store water; and

- Urban water supply utilities responsible for managing dams and hydraulic structures which are part of its facilities. Examples include Addis Ababa Water and Sewerage Authority of Addis Ababa Region (Region 14) which manages several dams around Addis Ababa for Water Supply purpose;

3.3. South Sudan

The Ministry of Water Resources and Irrigation was established in 2005 (MWRI), with a mandate of drawing up of policies, standard, guidelines, plans for water resources management, development and utilization. In 2013 the Ministry of Water Resources and Irrigation was combined with the Ministry of Electricity and Dams by presidential decree, and it became the Ministry of Electricity Dams, Irrigation and Water Resources (MEDIWR). MEDIWR is responsible for the development of vital water infrastructure investments, including rural water supply systems (boreholes) and small water distribution systems (SWDSs). It also oversees construction of hafirs (underground reservoirs), dams, weirs, irrigation networks, flood management facilities such as dikes and gates, and river training and regulation works. The Ministry is also responsible for trans-boundary water resources management.

3.4. Sudan

The Ministry of Water Resources and Electricity (MWRE) www.med.gov.sd is responsible for all water resources. Its functions are set out by Presidential Decree No. 45, of 2013 and cover a wide range of activities including policies, planning, development … etc (Sudan: 2013). Dam safety is mentioned in the context of public safety which is quoted below from (Abdallah, 2005) report.

"In order to ensure adequate public protection, regulatory and administrative instruments which balance the cost of safety measures with an acceptable level of risk to public safety will be developed and implemented at national and federal level as appropriate."

The measures mentioned above for public safety is yet to be established and implemented.

The 1998 Constitution of Sudan (Sudan: 1998) states that the federal government is responsible for planning, regulating and executing interstate waters and national electricity projects. Thus, management of the Nile waters falls under federal ministries and institutions.

The main institutions responsible for planning, implementing, operating and management of dams and hydraulic structures are the Ministry of Water Resources and Electricity (MWRE) that is responsible for planning, implementation, operation and management of water resources projects including projects with dams and other hydraulic structures. Operation and maintenance of dams is listed as one of the administrative functions of the Ministry. Under the Ministry the "dams and Nile control" unit is established.

The Ministry has also established major development projects unit such as "Merowe Dam Electricity Company" www.mdec-sd.com currently responsible for operation and maintenance of Merowe Power Station and Merowe Dam, and "Sudanese Hydro Generation Company Ltd." www.shgco-sd.com responsible for all hydro power generation plants in other dams in Sudan

(Roseires, Sennar, Kashm Algirba and Jebel Awlia) and there are plans to include the Dams housing these plants within their operation and maintenance responsibilities. These two companies are operating directly under the Ministry to operate and manage the hydropower stations and dams

4. WATER AND ENERGY LEGISLATION IN EN COUNTRIES

The existing water and energy (hydropower) legislation are described broadly for each country in order to provide a general understanding of the water resources management environment. The legislative sections also include reference to Acts and any Regulations promulgated in terms of these Acts. The delegation of management activities related to water resources to other authorities (local or provincial/state) is also highlighted, if applicable.

4.1. Egypt

Water management requires an adequate legal framework that provides the water managers with laws, guidelines and instruments for the planning of new development, the allocation of water, the operational management and maintenance of irrigation and drainage systems, operation and maintenance of hydraulic structures, the management of water quality and financing these kind of activities. In Egypt, a number of laws exist to manage its water resources. These include the following key ones:

- Irrigation and Drainage
    - **Law No. 12 of 1982** for irrigation and drainage (Egypt: 1982a): The law defines public properties related to the irrigation and drainage such as the Nile, the main canals, branch canal, distributary canals, main drains, and lesser order open drains with either embankment of each waterway; and
    - **Law No. 213 of 1994** for farmer participation in users' organizations for new lands (Egypt: 1994a). The law has been modified to include Water Users' Associations (WUAs) and Water Boards (WBs) for the operation and maintenance of mesqas and branch canals respectively.
- Water Quality Management
    - **Law No. 48 of 1982** for Nile water and open waterways protection against pollution (Egypt: 1982b). The law provides water quality standards for Nile River, canals, groundwater, domestic and industrial discharged wastewater, and the reused water.
- Environmental Protection
    - **Law No. 4 of 1994** (Egypt: 1994b)**, updated by Law No. 9 of 2009** (Egypt: 2009) for the environment. The law provides the overall framework for the protection of the environment.
    - **Law No. 93 of 1962** (Egypt: 1962) for the discharge to open streams and its modifications for the years 1962, 1982, and 1989.
- Private Sector Involvement
    - **Law No. 67 of 2010** for private sector participation (Egypt: 2010a). The law provides a framework and organizes the involvement of the private sector in the infrastructure and utilities projects including the IWRM programs and projects.

- Electricity and Energy
    - **Law No. 67 of 2010**: Promulgating of the regulation of private sector participation in infrastructure project, services and public utilities (Egypt: 2010b);
    - **Law No 67 of 2006**: related to issuing consumer protection law (Egypt: 2006);
    - **Law No. 3 of 2005:** promulgating the law on the protection of competition and prohibition of monopolistic practices (Egypt: 2005a);
    - **Law No. 164 of 2000**: The Egyptian Electricity Authority to be transferred to Egyptian joint stock company (Egypt: 2000);
    - **Law No. 18 of 1998**: Certain provisions for the electricity distribution companies, power plants and transmission grid, as well as amending some provisions of Law No. 12 of 1976 for establishing the Egyptian Electricity Authority (Egypt: 1998);
    - **Law no 8 of 1997**: dealing with the Investment Guarantees and Incentives (Egypt: 1997);
    - **Law No.100 of 1996**: Amend Law No. 12 of 1976 related to establishing the Egyptian electricity body (Egypt: 1996);
    - **Law No 36 of 1984**: Regarding amending some provisions of Law No. 12 of 1976, to establish the Egyptian electricity body (Egypt: 1984);
    - **Law No. 55 of 1977**: Regarding the establishment and management of thermal machines (plants) and steam boilers (Egypt: 1977);
    - **Law No 12 of 1976:** Establish the Egyptian electricity body (Egypt: 1976); and
    - **Law No 63 of 1974:** Concerning establishing the institutions of the electricity body (Egypt: 1974).

After the completion of the High Aswan Dam, a series of water policies and a master plan have been developed starting from the Water Policy of 1975 (Egypt: 1975) until the National Water Resources Plan of Egypt till 2017 (NWRP), developed in 2005 (Egypt: 2005b) that is currently under implementation and the Water Strategy of the Ministry of Water Resources and Irrigation till 2050 that was developed in 2010 (Egypt: 2010c). Both NWRP and the Water Strategy are based on the Integrated Water Resources Management (IWRM) principal.

Egypt is also moving towards the decentralization and transfer of a number of responsibilities from the central government to district and lower levels, implementing systems for cost sharing by all users, and stimulating the private sector participation in water development and management.

Unfortunately, dam safety has not been included explicitly under any of the above-mentioned legislations or policies. However, some elements of safety for the water structures (e.g. dams, barrages) have been considered in the Egyptian Code for Water Resources and Irrigation Works (Egypt: 2003).

The Egyptian Code for Water Resources and Irrigation Works which, was published in 2003, consists of seven volumes. While Volume No. 7 focuses on the design and maintenance of the coastal protection structures while Volume No. 3 focuses on major water structures. Volume No. 3 covers the following:

- Lined irrigation networks;
- Water crossing structures including culverts, syphons and aqueducts;
- Escapes and outlets for canals and dams including dam spillways such as over fall spillways, chute spillways, side-channel spillways and shaft spillways syphon spillways. It also deals with stilling basins;
- Weirs including e.g. sharp crested weirs, solid narrow crested weirs, solid broad crested weirs, ogee crested weirs, free flow weirs, submerged or drowned weirs. It also deals with failure due to sliding and overturning;
- Barrages. It deals with detailed design requirements for each element in the barrages, including the various types of gates;
- Dams. It deals with earthfill, rockfill, gravity and arch dams. It provides design guidelines and indicated in general the possible failure modes for earthfill and rockfill dams and addresses the settlement of rockfill dams;
- Locks. It contains detailed design and construction guidelines; and
- Hydraulic power plants. It includes fore bays, intakes, penstocks, hydraulic turbines, draft tubes, tail water pond, etc.

The Egyptian Code for Water Resources and Irrigation Works in all the above-mentioned water structures focuses mainly on two stages:-

- Design stage in which it provides guidelines on the design criteria that should be considered; and
- Construction stage in which it provides guidelines on the matters to be considered during the construction.

However, there are no guidelines on the operation and maintenance stages.

In practice, the design and implementation of the dam and barrages on the main Nile in Egypt are carried out by foreign international consultancy firms and international construction firms respectively. Both firms usually apply an international standard. However the Egyptian code is used to guide the design and construction of some small dams built for rainwater harvesting and torrential flood protection.

4.2. Ethiopia

In 1999, the Ministry of Water Resources issued the Ethiopian Water Resources Management Policy (Ethiopia: 1999) with the general objective of enhancing and promoting all national efforts towards efficient, equitable, and optimum utilization of the available water resources of the country

for significant socio-economic development on sustainable basis which is based on the principle of Integrated Water Resources Management (IWRM). The same policy is later on (2001) named as the Ethiopian Water Sector Policy (Ethiopia: 2001) while its contents remain essentially the same. The three main categories of the policy are:

- General water resources management policy;
- Policy on cross-cutting issues; and
- Policy on sectoral issues.

As part of the cross-cutting policy issues the Ethiopian Water Sector Policy has provisions in relation to dam safety and management of trans-boundary waters. These include:

- Section 2.2.3 Technology and Engineering – (G) Dams and Reservoirs Management and Operation, Point (4):
    - "Provide guidelines concerning dams and reservoirs operations and safety procedures as well as promote community participation in the development and management of such schemes."

- Section 2.2.7 Disaster, Emergency and Public Safety, Point (3):
    - "Ensure and promote the safety of water retaining, transmission and diversion structures like weirs, barrages, dams, reservoirs and pipelines, against natural and man-made disasters for the:
        - Protection and conservation of the available water, the structures and all systems and equipment.
        - Protection of the environment, human settlements, flora, fauna, socio-economic infrastructure."

- Section 2.2.7 Disaster, Emergency and Public Safety, Point (5):
    - "Establish preparedness and contingency plans for disasters and emergencies, in terms of:
        - Provision and continuation of services during and after emergency,
        - Plans for rehabilitation and repair of water systems,"
- Section 2.2.7 Disaster, Emergency and Public Safety, Point (6):
    - "Put in place routine and random safety checks on existing systems."
- Section 2.2.8 Trans-boundary Waters, Point (6):

- "Comply with those international covenants adopted by Ethiopia, and manage trans-boundary waters accordingly.

- However, the section does not directly indicate the need for safety of structures on trans-boundary rivers."

In addition to the water sector policy, the Government of Ethiopia has endorsed legislative frameworks to define the water resources management issues of the country. Proclamation No. 197/2000 (Ethiopian Water Resources Management Proclamation) (Ethiopia: 2000a) vested power to the supervising body (in this case at that stage the Ministry of Water and Energy – nowadays the Ministry of Water, Irrigation and Energy) to assure the safety of hydraulic structures as indicated in the article below:

- Part II, Supervising Body, Powers and Duties of the Supervising Body, Point (1g):

  - "The supervising body shall have the powers and duties to issue directives pertaining to the safety of hydraulic structures for the prevention of damages caused by dam water to dams, persons, property and crops."

A regulatory framework for Proclamation No. 197/2000 was endorsed in 2005 (Ethiopia: 2005), which is Proclamation No. 115/2005 Ethiopian Water Resources Management Regulation. However, the regulation does not include any provisions for dam safety.

The federal Environmental Protection Authority (EPA) issued the *Environmental Policy of Ethiopia* in 1997 (Ethiopia: 1997) and the policy has provisions in relation to dams, including:

- Section 3.4 Water Resources

  - Point "a" of the section states one of the policy objectives as:

    - "To ensure that the control of environmental health hazards be a necessary condition in the design, construction and use of dams …"

Further, the *Environmental Impact Assessment Guideline Document* published in 2000 by the EPA (Ethiopia: 2000b) dedicated a separate section (Section 5.5) for dams and reservoirs. However, the guideline document doesn't include dam safety and downstream risk as one of the issues to be focused on.

4.3. South Sudan

The Rapid Water Sector Needs Assessment and a way Forward prepared by The World Bank (World Bank: 2013) states that, "development of dams for hydropower needs to address four major strategic issues: (1) nature and scale of trans-boundary water issues; (2) future social, economic, and environmental benefits that might be forgone consequent to construction and operation of dams; (3) impacts on the environment and hydrology of Sudd and wetlands; and (4) impacts on downstream communities and their livelihoods dependent on Nile waters."

The World Bank needs assessment report further highlights the challenges and what needs to be done in order to develop the hydropower projects identified in South Sudan.

Pertinent to this assessment report the following are extracted from the said report:

- The need for assessment of the optimum sequencing of dam cascade development;
- Building capacity and a program for dam safety monitoring and management is a priority;
- The need for greater understanding and capacity to mitigate the environmental and social impacts resulting from dam construction; and
- The need for upstream watershed management.

The government's water policy report developed by the Ministry of Irrigation and Water Resources (MWRI) in 2007 (South Sudan: 2007) spelled out the basic principles for water sector development and management in the context of recovery efforts. The water policy was followed by the WASH strategic frame work (South Sudan: 2011), action plans (2012-13) and the compilation of a water act (2013-ongoing).

The Japan International Cooperation Agency (JICA), in collaboration with the MEDIWR, is helping with the development of an irrigation development master plan (IDMP) that was launched in September 2012 (JICA 2012) which is part of a Comprehensive Agricultural Development Master Plan. The aim is to formulate master plans for the agriculture sector and irrigation development that will help to achieve steady economic growth through efficient, effective, and sustainable rain-fed and irrigated agriculture.

4.4. Sudan

There is no existing one single document that governs the development, management and utilization of water resources in Sudan. In the past, the water policy used to appear in each water sub-sector (irrigation, hydropower, domestic, etc..) as these units were under different institutions although the major part of the water resources policies, plans, development and management were under the responsibility of the Ministry of Irrigation and Hydropower, now the Ministry of Water Resources and Electricity (MWRE). Starting from 1992, the MWRE has been responsible for most of the sub-sector's policy making and legislation, planning as well as coordination of all water related institutions in the country.

Many laws and regulations have been drafted over the years to deal with the use and protection of the water resources systems. They include among others the following:

1. The Nile Pump Control Act (Sudan: 1939);
2. The River Transport Act (Sudan: 1950);
3. The Fresh Water Fisheries Act (Sudan: 1954);
4. The Water Hyacinth Control Act (Sudan: 1960);
5. The Public Health Act (Sudan: 1975);
6. The Environmental Health Act (Sudan: 1975);
7. The Regulation of Inland River Navigation Act (Sudan: 1980);
8. The Irrigation and Drainage Control Act (Sudan: 1990);

9. The Gash Basin Water Development and Utilization Act (Sudan: 1992a);
10. Wadi Nyala Water Development and Utilization Order (Sudan: 1993); and
11. The Water Resources Act (Sudan: 1995a).

The main legislation currently in use in relation to water resources management in Sudan is the "Water Resources Act of 1995" (Sudan: 1995a) and the "Irrigation and Drainage Act of 1990" (Sudan: 1990). This legislation mainly focuses on water allocation and efficient utilization of the water resources of the country. The 1995 Water Resources Act (Sudan: 1995a) has repealed the Nile Pump Control Act of 1939 (Sudan: 1939) but saved its regulations. The Water Resources Act of 1995 (Sudan: 1995a) also modified the 1951 regulation which gives a mandate to the Ministry in licensing and arbitration of various water users. The regulations of 1951 give provision for the following:

- Solving dispute through arbitration;
- Obliging the licensee to maintain canals to avoid seepage;
- Organization of rotation of crops;
- Obliging the licensee to cultivate crops making optimal use of water; and
- Annual fees to be paid for each license.

The other legislation of Irrigation and Drainage Act of 1990 (Sudan: 1990) regulates irrigation and drainage in Sudan according to the following:

- Maximize benefit from available water resources;
- Ensure safety of planning and design of irrigation projects;
- Determine responsibilities of administration, operation and maintenance;
- Maximize operation efficiency and boost production;
- Protect water environment; and
- Protect irrigation schemes from violation and misuse.

The "Water Resources Act of 1995" (Sudan: 1995a) comprehensively addressed and cleared the following:

- It applies to water resources and not Nile water alone and defines water resources to mean and contain surface water and ground water resources whether it crosses national borders or not;
- It covers the use of water for all purposes unlike the previous legislations which were confined to irrigation and drainage; and

- The institution entrusted with the implementation of the 1995 Act (Sudan: 1995a) are the National Council for Water Resources chaired by the Minister of Water Resources and Electricity, the Ministry itself and the States Organs which act under the powers delegated to them by the MWRE.

In 1992 the government endorsed the "Sudan National Water Policy and Strategies" (Sudan: 1992b). The water policy mainly focuses on management and sustainable development of the country's water resources. Limitations and lessons learnt from the 1992 water policy (Sudan: 1992b) and considering future water related issues, a multi-disciplinary multi-sectorial committee was organized to update the policy. The resulting document, "The National Water Policy Draft of 2000" (Sudan: 2000) has a hydropower section which states an integral operation and maintenance of dams shall be adopted to optimize the use of water. However, part of the policy in relation to dam safety issues is addressed in the "Disaster Management and Public Safety" section of the policy. The section states that:

- A national "Disaster Management Plan" will be developed to enable both avoidance of disasters and effective response to disasters (which include floods and droughts which threaten the public safety and major structures such as dams and reservoirs).

- International cooperation is critical for proper and adequate response to natural and other disasters. The Sudan will seek to participate in and contribute to international efforts.

- In order to ensure adequate public protection, regulatory and administrative instruments which balance the cost of safety measures with an acceptable level of risk to public safety will be developed and implemented at national and federal level as appropriate.

The water resources policy developments in the Sudan are described by (Abdallah: 2005).

5. INTERNATIONAL DAM SAFETY PRACTICES

5.1. Principles, Requirements and Effectiveness

5.1.1. International Commission on Large Dams

The efforts of ICOLD and its national organisations have resulted in the improvement of the safety of dams and the consistent decline in the frequency of failures of such structures over time. In the Foreword of (ICOLD: 1987) the following relevant historic developments of the dam safety initiatives are quoted below:

"During the International Congress on Large Dams in New Delhi in 1979, more direct and forceful action by ICOLD in the field of dam safety was suggested. In 1980, an ad hoc committee was established to investigate this matter and propose possible terms of reference. Following the recommendation of the ad hoc committee, a new technical committee, the Committee on Dam Safety, (CODS) was formalized during the 1982 Executive Meeting in Rio de Janeiro. Mainly, three reasons led to this recommendation:

- *Several dam incidents with severe consequences during recent years had given rise to general concern about the safety of dams, and indicated the necessity for a formal safety approach.*
- *The height of new dams and the volume of new reservoirs is increasing, while many older dams are approaching an age at which material deterioration and decreasing operational reliability may dictate some repair and upgrading. Certainly, both the growing dimensions of new dams and the aging of older dams suggest a more rigid approach to safety aspects.*
- *An ever increasing number of dams is being built in countries with little or no tradition and experience in dam engineering. The formalization of safety considerations and the issuance of summarized safety requirements would be part of the necessary transfer of technological know-how to these countries.*

The ICOLD Committee on Dam Safety was established as a coordinating body to assure an integrated approach of all Technical Committees to safety issues, to guide toward action where shortcomings or gaps may be perceived, to define a common safety philosophy and to prepare general guidelines on dam safety outlined along this philosophy."

A statistical analysis of dam failures (ICOLD: 1995) revealed that the incidence of such events has reduced progressively over the years. This is no doubt due to the improvements in dam safety regulation and practice.

In 1987 ICOLD published Bulletin 59: Dam Safety Guidelines (ICOLD, 1987) which covered all phases of the life of a dam from design, construction, operation through to decommissioning. The primary importance of Bulletin 59 was in directly addressing the challenge posed to the Committee by ICOLD.

Since then more detailed dam safety guidelines on safety philosophies and specific aspects have also been produced.

In 2005 ICOLD issued "Bulletin 130 – Risk Assessment in Dam Safety Management: A Reconnaissance of Benefits, Methods and Current Applications" (ICOLD: 2005). The new Bulletin pointed out that steadily growing societal demands for transparency and accountability in the areas of decision making which affect safety required a profound philosophical change in how the decision-making framework should be formulated. Taking into account the significant progress in the development and application of advanced risk-informed and risk-based methods in the fields of safety assessments, the Bulletin outlined a general framework of a risk-informed approach to decision making in dam safety. This new Bulletin has been perceived by some professionals in the dam engineering field as an attack on the traditional ways of assessing dam safety outlined in Bulletin 59 (ICOLD: 1987) . However, the position of the ICOLD Committee on Dam Safety (CODS) on this subject is different, and their reasons are explained below:

"The traditional approach to dam safety assessment (often called standards-based) begins with the establishment of safety requirements and criteria associated with a predetermined classification system reflecting either the hazard potential or the consequences of dam failure. The uncertainty is not addressed directly and it is accounted for in an indirect manner by applying safety coefficients and conservatively safe values for resistance variables and loads.

Most of these deficiencies in the process of assessing the safety of dams can, in principle, be eliminated by an appropriate application of either the risk-based or the risk-informed approach. Bulletin 130 pointed out the major limitations of the risk approach, (quantification of probabilities, estimation of consequences, definition and societal acceptability of the tolerable risk concept), and it is encouraging to note that major progress has been made in all of these areas since the issuance of the Bulletin in 2005. Therefore, the time when the conditional term "in principle" can be dropped from the sentence above is getting closer and the expectation that a credible and comprehensive risk assessment could provide a solid basis for a transparent and effective risk management of dams is becoming more and more realistic.

At the present, the dam engineering community is divided between the slowly declining majority which insists that the traditional approach is the only one which can be trusted; a minority constituted of those who deny the validity of the traditional school concepts; and finally the third group which is slowly but constantly gaining more support, and which is of the opinion that the systematic but gradual expansion of risk techniques into the area of dam safety assessment and management is the proper way to proceed. The expansion should be conditional not only on the satisfactory progress in developing the analytic site of the risk assessment process, but also on the availability of financial and human resources. Taking into account that risk-based analyses not only cost more, both in terms of time and financial input, but also that they demand a different set of skills and knowledge than traditional dam engineering, the necessity for a gradual approach should not be surprising."

In 2011 ICOLD published "Bulletin 154: Dam Safety Management: Operational Phase of the Dam Life Cycle" (ICOLD: 2011a). This Bulletin is devoted to the development and the implementation of a dam safety management system for dams in the operational phase of their life cycle. It outlines the general structure of a systems approach to safety management, and strives to develop a system that can address all the interdependencies, and encompass all the arrangements necessary to ensure proper dam safety management. The outline is built on the principles established in Bulletins 59 (ICOLD: 1987) and 130 (ICOLD: 2005), as well as the general philosophy that informs them both. In that respect this Bulletin is not intended to update or replace the Bulletin 59 which although

written in 1987 (ICOLD: 1987) is still valid and should remain as a primary source of guidance for those professionals who are applying traditional approach to dam safety.

Bulletin 154 (ICOLD: 2011a) includes the following important comments with respect to the decision-making processes involved in managing the safety of existing dams:

"Depending on the various decision-making problems which may occur during a dam's operation, the nature of this process can vary substantially. On the one hand, these decisions can be made using the approach of simply comparing the outcomes of deterministic analyzes and observed values with standards and safety requirements. On the other hand, if the risk-informed approach is to be used, then the analytic part becomes much more complex, but the resulting comparison of assessed risks provides a more complete picture of the safety status, and ensures full transparency of the decision-making process by comparing the assessed risk with the tolerable risk criteria. This Bulletin is in a way neutral with respect to which type of decision-making approach should be selected. The safety management system presented in the Bulletin allows for the use of either of the two approaches."

Bulletin 154 (ICOLD: 2011a) includes a recommended set of overarching principles for dam safety management. These start with a definition of the Fundamental Dam Safety Objective:

The fundamental dam safety objective is to protect people, property and the environment from harmful effects of mis-operation or failure of dams and reservoirs.

This objective is achieved by retaining the stored volume of water and controlling all flows through and around the dam within specified limits determined through the approvals and licensing process established by government. "Mis-operation" involves any departure from the design norms for safe operation of any part of the dam or its safety critical systems. The objective of protecting people, property, and the environment from the effects of dam failure has to be achieved without unduly limiting the benefits created by operation of dams and reservoirs.

To achieve the highest standards of safety that can reasonably be achieved, measures must be taken to:

1. Control the release of damaging discharges downstream of the dam through controls embedded in the normal operating regime of the dam;

2. Restrict the likelihood of events that might lead to a loss of control over the stored volume and the spillway and other discharges;

3. Mitigate through on-site accident management and/or emergency planning the consequences of such events if they were to occur.

The fundamental safety objective applies to all dams and dam operational activities and to all stages over the lifetime of a dam, including planning, design, construction, commissioning, operation, and either the long term sustainability of the dam or decommissioning of the dam.

The principles presented in Bulletin 154 (ICOLD: 2011a) and reproduced below in the following sections then provide an overarching management framework to support achievement of the fundamental dam safety objective.

"Responsibility for Operational Integrity and Safety

The Dam Owner is ultimately responsible for assuring the safety of the public, property and environment around and downstream of dams. However, since dams are often not owned and operated by a single individual, company or organization, the term Responsible Entity is used in this Bulletin. Usually the dam owner is the Responsible Entity. Sometimes a government institution or agency is responsible for the safety of the dam and the public, either directly or through oversight over the safety management activities of the bodies that operate the dam.

The safety arrangements established by the Responsible Entity must conform to the requirements and expectations of government and the prevailing laws, regardless of how they are established and implemented. Therefore, the Responsible Entity's values and principles that govern safety management reside within the overarching legislative and regulatory value system of the country where the dam is located. In some instances for dams, the Responsible Entity may be a branch of government with significant internal dam engineering and safety management capability, and which is responsible for all aspects of the operational integrity and safety management of the dam over its entire life-cycle. Conversely, the Responsible Entity may have no engineering capability and, in the absence of prescriptive regulatory requirements, it will be the legislative and judicial arms of government where the safety of dams is implied by existing legislation and precedents, with all responsibility for meeting the intent of the law resting with the Responsible Entity.

In order for the Responsible Entity to be confident that it is meeting all obligations in relation to the safety of its dams, a systematic approach to dam safety management activities is needed. This means that the Responsible Entity is responsible, at a minimum, for:

1. *Establishing and maintaining the necessary competencies;*
2. *Providing adequate training and information;*
3. *Establishing procedures and arrangements to maintain safety under all conditions;*
4. *Verifying appropriate design and the adequate quality of facilities and activities and of their associated equipment;*
5. *Ensuring the safe control of all inflows, outflows and stored volumes;*
6. *Ensuring the safe control of all sediments and deleterious materials that arise as a result of the dam.*

Dam safety management covers the full spectrum of hazardous conditions, including dam failure, which can arise from the activities of storing and discharging water. Since dam management can span many human generations, consideration should be given to the fulfillment of the responsibilities of the Responsible Entity and the regulator in relation to both present and future operation. Provision should be made for the continuity of responsibilities and the fulfillment of funding requirements in the long term.

These responsibilities should be fulfilled in accordance with applicable safety objectives and requirements, as established or approved by the regulatory body, and their fulfillment is to be ensured through the implementation of a management system.

Role of Government

The legal and governmental framework for all industrial activities, including operation of dams, provides the overarching structures for operational integrity and safety assurance.

The role of the Government includes defending the general interest of the population and, in order to do so, it writes laws and regulations specific to protection of people, property and the environment. For activities that are hazardous, laws and regulations are often enacted to protect third parties against the harmful effects of mis-operation or failure of the specific activity.

In some cases within the general legal framework, specific laws and regulations may be established to protect against the mis-operation or failure of dams and reservoirs. The legal and governmental framework provides for the governance of dams, reservoirs and operational activities that give rise to dam breach and other inundation risks. The framework typically includes the clear assignment of Responsibility for Operational Integrity and Safety (see Section 2.2). The government is responsible for the adoption of such legislation, regulations, and other standards and measures, within its national legal system, as may be necessary to effectively fulfill all its national responsibilities and any international obligations. In terms of the modern view of safety governance this includes establishment of an independent regulatory body to assure the safety of dams.

Government authorities should ensure that arrangements are made for reduction of risks from dams, including emergency actions, monitoring of high discharges to the environment, and disposing of reservoir silt waste. This does not require that the governments establish and maintain all arrangements, although they may choose to do so. In addition, government authorities have to address the safety of dams for which no other organization has responsibility.

The government body with responsibility for dams should:

1. *Have adequate legal authority, technical and managerial competence, and human and financial resources to fulfill its responsibilities;*

2. *Be effectively independent of the Responsible Entity and of any other body, so that it is free from any undue pressure from interested parties;*

3. *Set up appropriate means of informing parties in the vicinity, the public and other interested parties, and information media, about the safety aspects (including health and environmental aspects) of dams and reservoirs and operational activities, and about regulatory processes;*

4. *Consult parties in the vicinity, the public and other interested parties, as appropriate, in an open and inclusive process."*

Bulletin 154 (ICOLD: 2011a) clearly establishes that governments and regulatory bodies have an important responsibility in establishing standards and establishing the regulatory framework for protecting people, property and the environment against dam safety risks.

In addition Bulletin 154 (ICOLD: 2011a) highlights the role of leadership and management.

"Leadership and Management for Safety

In general, leadership in safety matters should be demonstrated at the highest levels in all organizations. Dam safety is no different. Safety has to be achieved and maintained by means of an effective management system. This system should integrate all elements of management so that requirements for safety are established and applied coherently with other requirements, including those for human performance, quality and security, and so that safety is not compromised by other requirements or demands. The management system also has to ensure the promotion of a safety culture, the regular assessment of safety performance, and the application of lessons learned from experience.

A safety culture that governs the attitudes and behaviour in relation to safety of all organizations and individuals concerned should be integrated in the management system. Safety culture includes:

1. *Individual and collective commitment to safety on the part of the leadership, the management and personnel at all levels;*

2. *Accountability of organizations and of individuals at all levels for safety;*

3. *Measures to encourage a questioning and learning attitude and to discourage complacency with regard to safety.*

An important factor in a management system is recognition of the entire range of interactions of individuals at all levels, with technology and with organizations. To prevent human and organizational failures, human factors must be taken into account, and good performance and good practices supported. Despite all measures that are taken, accidents may occur. Processes should be put in place for the feedback and analysis of operating experience, including initiating events, accident precursors, near misses, accidents and unauthorized acts, so that lessons may be learned, shared and acted upon."

In addition to Bulletins on general principles of dam safety management, ICOLD has also published many bulletins on specific issues including the following.

In 2012 ICOLD published Bulletin 142, *Safe Passage of Extreme Floods,* (ICOLD: 2012a) which addresses two key issues, design floods and effects of climate change.

With regard to selection of the design flood Bulletin 142 (ICOLD: 2012a) states:

"Current practice in the design of dams is to first select the design flood, which is deemed appropriate for the hazard potential for the dam and reservoir and to determine its peak flow rate and/or its entire hydrograph. Then, spillways and outlet works can be designed, or an adequate storage can be allocated in the reservoir, which could safely accommodate the flood without putting the dam and its appurtenant structures at risk and causing loss of life and property damages in areas downstream of the dam.

A survey of existing projects shows that in many modern projects the spillway (or spillways) is designed for a peak flow value based on criteria which usually consider the spillway design flood proper as well as a check flood which is taken as the maximum flood that will not cause the destruction of the dam. This approach is also the standard criterion in most countries where there is an official recommendation for the design of dams.

The selection of the design flood ,which is based on guidelines established by the responsible government agency, the project sponsors and/or the project financing institutions, varies widely from country to country, according to the type of dam and the consequences of dam failure, etc. This process is fully addressed in ICOLD Bulletin 82, "Selection of Design Flood" published in 1992. Intrinsic to the selection process are the methods used to determine the design flood. Again, the used procedures vary greatly among the practitioners, from probabilistic approaches based on previously observed or inferred flood events to the use of precipitation-runoff models based on basin design precipitation events and assumed basin conditions corresponding to the design flood.

One of the current practices is now to use the safety check floods to assess the real safety of the dam."

In addition Bulletin 142 (ICOLD: 2012a) comments on the confidence limits of estimates and the evolution of design criteria for floods as follows:

"Reviewing the evolution of criteria and methods employed by the profession to compute the capacity of spillway facilities in dams, it is apparent that there have been great changes in the design methods and criteria. Experiences in practical applications of the dam regulations clearly indicate the desirability of a dam classification, especially for the large number of small dams, where failures can have consequences ranging from trivial to catastrophic. Design methods and criteria (ICOLD, 1987) should be in conformity with the current state of technological evolution and be compatible with the codes and standards to be used."

With regard to the impacts of climate change Bulletin 142 (ICOLD: 2012a) states:

"Following IPPC 4th (IPCC Fourth Assessment Report: Climate Change 2007), climate change is expected to exacerbate current stresses on water resources. Changes in precipitation and temperature lead to changes in runoff and water availability. Runoff is projected with high confidence to increase by 10 to 40% by mid-century at higher latitudes and in some wet tropical areas, including populous areas in East and South-East Asia, and decrease by 10 to 30% over some dry regions at mid-latitudes and dry tropics, due to decreases in rainfall and higher rates of evapotranspiration."

In 2012 ICOLD published "Bulletin 158: Dam Surveillance Guide" (ICOLD: 2012b) which addresses the key area of visual inspections and provides guidelines for the optimal organization of all components required for dam surveillance and monitoring.

5.1.2. World Bank

The World Bank in its strategic document on the water resources sector (World Bank: 2004) states: "*With regard to dams, the primary challenge is to maintain existing stock in a serviceable and safe manner. The World Bank continues to be involved in working with countries to ensure dam safety….*"

The World Bank study "Regulatory Frameworks for Dam Safety" (World Bank: 2002) provides a comparative analysis of dam safety programs and regulatory frameworks in twenty two countries. The study addresses:

1. A Country study of Regulatory Frameworks for Dam Safety;

2. A Comparative Analysis of Regulatory Frameworks; and

3. Essential Elements, Desirable Elements and Emerging Trends for Dam Safety.

The study highlights three issues that the drafters of a regulatory scheme should consider:

1. The scheme must address the safety of the dam and appurtenant structures and public safety, particularly the safety of the population living in the vicinity of or downstream from the dam;

2. The question of whether the regulations should set different standards for different categories of dam owners. In the case of government ownership there may be questions regarding the liability for dam failure and the independence of the regulatory authorities; and

3. The drafters should decide if the regulations should apply to all dams or only those of a certain size or hazard criteria.

The study recommends the following as essential elements of a regulatory scheme:

- The Form of the Regulation

  The framework should be clearly spelled out in publicly available documents. The precise form of the legal instruments will vary depending on the legal traditions in the country. The regulation may contain:

  - A statute or law passed by the government. It should only contain the objectives and general principles governing the framework. The statute may deal only with dam safety or may deal with other issues such as management of water resources as well;

  - The statute should clearly stipulate the responsibilities of all parties including the authority responsible for dam safety and the authority responsible for handling any emergencies;

  - The details of the regulations should be contained in regulations that are reasonably easy to change; and

  - The regulations may be supplemented by non-binding guidelines. These may take the form of recommended good practice and be developed by professional societies and applied by owners on a case by case basis. (It is noted by this Consultant that such guidelines often become a "de facto" standard and are adopted by designers as they define good practice thereby providing some level of liability protection.)

- The Institutional Arrangements

  These should address:

  - The regulatory authority should be identified and its powers and responsibilities clearly stated. This could be in the statutes. The authority could be limited to dam safety or could be more general; and

- The regulatory authority should be provided with adequate human and financial resources to perform its duties.

It is desirable that:

- The dam safety authority is devoted exclusively to dam safety; and
- The regulatory authority appoints an advisory committee to provide advice on dam safety issues.

There is an emerging trend towards making the owners responsible for monitoring dam safety and for conducting all necessary inspections. The regulatory authorities would be limited to developing standards and monitoring the dam owners' performance.

- The Powers of the Regulating Entity

These should address;

- The power to identify and develop norms, standards and guidelines for dam safety;
- A voice in decisions to grant permits or grant licences for the construction and operation of dams. This means that the entity may have the authority to review and approve dam safety plans of the owner/operator to ensure that they meet applicable dam safety requirements;
- The power to monitor inspections and accept or reject the findings;
- The power to carry out its own inspections when necessary;
- The power to approve the party selected to do the dam safety inspections;
- The responsibility to maintain an inventory or register of all the dams in the country that are covered by the regulations;
- The responsibility to advice owners and other interested parties such as affected communities about dam safety issues;
- The responsibility to make periodic and publicly available reports on dam safety issues to higher authorities in eh executive government and the legislature; and
- The power to enforce the dam safety regulatory framework.

It is desirable that:

- The dam safety authority is empowered, where appropriate, to coordinate dam safety regulation at all levels of government.

There is an emerging trend towards:

- Taking a life cycle approach to dam safety. This means that the dam owner incorporates dam safety into its plans for design, construction, operation, maintenance and decommissioning of the dam;
- The owners are paying more attention to funding the maintenance and rehabilitation of dams;
- Paying more attention to the social implications of dam safety including health and environmental issues; and
- Considering risk analysis methods in dam safety decisions.

- The Content of the Regulatory Scheme

  The regulatory scheme should include:

  - Clear criteria determining which dams are covered by the regulatory scheme. This may be according to size and hazard;
  - Definition of the scope of the regulatory scheme. This should address all stages of the life cycle of a dam including design, construction, first filling, operation, alteration and decommissioning;
  - Clarification that it is the owner that has prime responsibility for dam safety and can be held liable for any damage that results from dam failure;
  - Stipulation of the dam safety standards that an owner is expected to comply with;
  - Establishment of the qualifications of the person who does safety evaluations of the dams for the owner;
  - Stipulation that the owner/operators make periodic reports to the regulators on the results of their reviews, inspections and monitoring of the safety of the dam;
  - Stipulation of the frequency that the owner/operator should conduct safety inspections and reviews;
  - Stipulation that the owner/operator maintain complete records on the dam at a convenient location;
  - Requirement that all dams have an operations, maintenance and supervision manual (OMS Manual) and an adequate budget for operations, maintenance and supervision;
  - Imposition of fees to the regulatory authority; and
  - Requirement that dams with a high hazard potential have an emergency plan that is provided to the regulatory authority and to all relevant

authorities and downstream communities that could be affected by a dam failure.

It is desirable that:

- Stipulation that the regulatory authority may make its own periodic inspections of all high hazard dams;
- Stipulation that the regulatory authority be provided with a copy of the dam's technical records;
- Stipulation that, as part of the process of obtaining a dam license, the prospective owners are required to conduct a failure impact assessment to determine the likely effects of a dam failure on potentially affected downstream communities; and
- The regulatory authority establishes a set of dam safety benchmarks that can be used to assess the safety of all dams.

5.1.3. Development Bank of Southern Africa

The Development Bank of Southern Africa produced a useful *Guide to best practice in the operation, maintenance and safety of dams* (DBSA, 2003). It was prepared for DBSA project teams involved in dam projects and is a useful resource for dam owners and other people involved with dams.

5.2. Trans-boundary Dam Safety

Trans-boundary or regional dam safety is an important aspect of trans-boundary agreements and conventions. An analysis of international trans-boundary agreements reveals that no explicit mention is made of the term "dam safety". Dam safety issues can be inferred from other clauses which relate to emergencies, the obligation not to cause significant harm, various environmental protection clauses and the exchange of information. All of these aspects are covered in the 1997 United Nations (UN) Convention which has recently been ratified and comes into force on 17 August 2014 (UN: 1997). The 1997 UN Convention has formed the framework for many other bi- and multi-lateral trans-boundary agreements.

The legal and institutional aspects for the application of regional dam safety require specific attention and development in an incremental fashion over time. It is fortunate that the Eastern Nile resorts within the framework of the Nile Basin Initiative (NBI) and that ENTRO is an established and functioning entity. Further institutional building should clearly focus on these organisations. In order to implement a regional dam safety framework in the Eastern Nile, a regional agreement needs to be prepared and agreed upon to give effect to the initiative. Provision should be made for future modifications arising from experience and future requirements. These aspects should be a addressed in future implementation projects.

The exchange of information is a powerful building block and evidence of this is already apparent in the Eastern Nile with the various dam safety assessments and the exchange of results at various workshops. Due care should be taken not too make the exchange of information requirements in international agreements to be too onerous and should be limited to information which is really

needed. Joint dam safety inspections is one way of strengthening international ties and raising confidence levels.

The rest of this section reviews examples of international approaches to trans-boundary dam safety issues for comparative purposes.

5.2.1. Southern Africa

There are several examples of international dam safety co-operation in Southern Africa as described briefly below:

- The Lesotho Highlands Water Project is a joint development between South Africa and Lesotho. Several large dams are located in Lesotho and water is transferred to South Africa via a tunnel system. The monitoring of the dams and analyses is partially undertaken by South African experts as part of the co-operative effort;

- The Komati Basin Development is a joint water project between South Africa and Swaziland. A joint implementing and operating body called KOBWA (Komati Basin Water Authority) undertakes the dam safety aspects relating to the dams in terms of the well-developed South African procedures. KOBWA continues to follow the guidelines for the operation and maintenance of the dams as provided in the manuals and regular monitoring of safety indicators. The indicators are measured and recorded daily for analysis by the dam safety engineer. The final report of the First Spilling Inspection at the Maguga Dam in Swaziland confirmed that the dam was performing satisfactorily. During 2007-2008, a second Statutory Dam Safety Inspection for Driekoppies Dam in South Africa was conducted. The initial report also confirmed that the dam is structurally sound but identified some areas for improvement to ensure proper housekeeping. The opportunity was also used for the practical training of the water bailiffs and support staff. KOBWA participated in the Nkomazi Municipality campaigns on Emergency Preparedness. This involved public awareness in various schools and public places. In future, more efforts will be directed to the Swaziland side where the Disaster management legislation and structures have also been put in place; and

- Major regional floods were experienced in the year 2000 in the rivers which rise in South Africa and flow into Swaziland and Mozambique. The three countries have an organisation called the Tripartite Permanent Technical Committee (TPTC) for matters pertaining to these rivers in trans-boundary basins. South Africa transmitted regular hydrological information to the downstream Mozambique during the flood event which assisted the country in their flood forecasting and preparations.

5.2.2. USA/Mexico

The Water Treaty of 3 February 1944 for the "Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande" distributed the waters in the international segment of the Rio Grande from Fort Quitman, Texas to the Gulf of Mexico. This treaty also authorized the two countries to construct operate and maintain dams on the main channel of the Rio Grande. The 1944 treaty also changed the name of the International Boundary Commission (IBC) to the International Boundary and Water Commission (IBWC), and in Article 3 the two governments entrusted the IBWC to give preferential attention to the solution of all border sanitation problems.

The International Boundary and Water Commission (IBWC), composed of a U.S. Section and a Mexican Section, is charged with carrying out the provisions of a number of treaties between the United States and Mexico. Among its responsibilities, the Commission has jurisdiction over two large international storage dams (Amistad and Falcon), and four diversion dams (International, Anzalduas, Retamal, and Morelos) on the Rio Grande and Colorado Rivers. Additionally, the U.S. Section is responsible for the maintenance of American Diversion Dam and five sediment and flood control dams (Broad, Crow, Green, Berrenda, and Jaralosa) owned by the Caballo Soil and Water Conservation District, which are not fully international in nature.

The international dams under IBWC jurisdiction are jointly operated and maintained by the United States and Mexican Sections of IBWC. Due to the international character of the dams under the jurisdiction of the IBWC, the National Dam Inspection Act of 1972 (Public Law 92-367) (USACE: 1972) exempted IBWC dams from inspection by the U.S. Army Corps of Engineers (USACE), but it did not exempt the United States Section from the Act's Dam Safety provisions.

Dam Safety Policy

The policy of the United States Section of the International Boundary and Water Commission is:

1) To carry out the policy and directives of the Congress and the President concerning the Dam Safety provisions; and

2) Maintain an agreement with the Mexican Section for a joint Dam Safety program.

The overall objective of the IBWC dam safety program is to operate and maintain IBWC dams in a safe and efficient manner for compliance with the Federal Emergency Management Agency's (FEMA) Guidelines for Dam Safety (FEMA: 2004), and enhance security of the international dams in accordance with the President's Security and Prosperity Partnership initiative.

Dam Safety Program

The agency has in place a Dam Safety Program that is deemed in compliance with the Federal Guidelines for Dam Safety and supported by the efforts of the USACE, Geotechnical Division, Fort Worth Region. Review of the agency's program, and inspection of the agency's structures, occurs on a 5-year cycle with technical reviews and inspections. These 5-year safety of dams inspections are conducted by a bi-national staff, with review and recommendations being made by the Technical Advisors of both Sections of IBWC (USACE and CONAGUA).

The 5-year safety of dams inspections were performed for the following dams: 1) American and Morelos Diversion Dams in 2006, 2) Amistad, Falcon, Anzalduas, and Retamal dams in 2007, and 3) International Diversion Dam 2008. Weekly or monthly inspections are also performed by field office personnel on all the dams. Monthly and annual inspection reports are prepared for all dams by Area Operations Managers.

Flood and sediment control dams, owned by the Caballo Soil and Water Conservation District, are inspected jointly on an annual basis. Inspection is by engineers of the New Mexico Natural Resource Conservation Service (NRCS) District Office and U.S. Section of the IBWC. Additionally, 5-year Dam Safety inspections are performed by the New Mexico State Engineer Office. The NRCS and the New Mexico State Engineers prepare the annual and the 5-year safety of dams inspection reports for each of these sediment dams.

Color Code

The USACE inspection team applied a risk based action classification rating that will be used for all the IBWC dams. The USACE inspection team place each dam into Dam Safety Action Classes (DSAC) based on their individual dam safety risk considered as probability of failure and potential failure consequences. This rating allows the dam owner to focus, address, and fund the most important dam safety issues.

The five Dam Safety Action Classes (DSAC) and applied color code are as follows:

- Red DSAC I – URGENT AND COMPELLING (Unsafe)
- Orange DSAC II – URGENT (Potentially Unsafe)
- Yellow DSAC III – HIGH PRIORITY (Conditionally Unsafe)
- Blue DSAC IV – PRIORITY (Marginally Safe)
- Green DSAC V – NORMAL (Safe)

5.2.3. USA/Canada

The International Joint Commission was created by Canada and the United States in 1909 because they recognized that each country is affected by the other's actions in lake and river systems along the border. The two countries cooperate to manage these waters wisely and to protect them for the benefit of today's citizens and future generations.

The International Joint Commission (IJC) mission is to prevent and resolves disputes between the United States of America and Canada under the *1909 Boundary Waters Treaty* (IJC: 1909) and pursues the common good of both countries as an independent and objective advisor to the two governments.

In particular, the Commission rules upon applications for approval of projects affecting boundary or trans-boundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the trans-boundary environment, including the implementation of the *Great Lakes Water Quality Agreement* and the improvement of trans-boundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.

The 1909 Boundary Waters Treaty (IJC: 1909) established the Commission, which has six members. Three are appointed by the President of the United States, with the advice and approval of the Senate, and three are appointed by the Governor in Council of Canada, on the advice of the Prime Minister. The Commissioners must follow the Treaty as they try to prevent or resolve disputes. They must act impartially, in reviewing problems and deciding on issues, rather than representing the views of their respective governments.

The Commission has set up more than 20 boards, made up of experts from the United States and Canada, to help it carry out its responsibilities.

The trans-boundary lakes and rivers are used for many purposes. Communities and industries may get fresh water from them, allow waste water to drain into them, or use hydroelectric power

generated by the flow of rivers. Farms may use these waters for irrigation. Recreational boats and commercial ships also travel through the inland waters.

These differing needs conflict from time to time. In some cases the International Joint Commission plays the role of authorizing uses while protecting competing interests in accordance with rules set out by the two governments in the Treaty. For example, the Commission may be called upon to approve applications for dams or canals in these waters. If it approves a project, the Commission can set conditions limiting water levels and flows, for example to protect shore properties and wetlands and the interests of farmers, shippers and others. After the structure is built, the Commission may continue to play a role in how it is operated.

In addition to the Great Lakes-St. Lawrence River system, the International Joint Commission assists governments in managing other waters along the entire border.

The Commission has continuing responsibilities in several areas. In the west, the Commission has established conditions for dams on the Kootenay, Osoyoos and Columbia rivers, which cross through the states of Washington, Idaho and Montana, and the province of British Columbia. The Commission has also helped to set rules for sharing the St. Mary and Milk rivers in Alberta, Saskatchewan and Montana.

In the Midwest the Commission has been involved in how the Souris River is shared among Saskatchewan, Manitoba and North Dakota. It also sets emergency water levels for the Rainy Lake system, which crosses through Minnesota, Manitoba and western Ontario, and has helped protect water quality in the Rainy River.

In the east, the Commission plays a role in regulating dams on the St. Croix River, which flows through New Brunswick and Maine, and in protecting the quality of the river.

In 1998 the IJC published a report on dam safety entitled: "Unsafe Dams? A Report by the IJC" (IJC: 1998) . This report to the governments of the United States and Canada addressed the safety of dams and dykes which are subject to International Joint Commission Orders. (See http://www.ijc.org/php/publications/html/safedam/unsafe.html)

The main findings of the 1998 review (IJC: 1998) of dam safety were:

Maintenance Concerns

Some Regulated Facilities were built early in the century. With aging facilities, maintenance programs are an absolute necessity. Continuing maintenance programs are being implemented in some cases. Monies that owners budget for maintenance work are, however, sometimes not spent. This is, in part, because such expenditures are discretionary and market forces impose other priorities.

Government Oversight

The United States and Canada have very different approaches to oversight of dam safety.

In the United States, recent federal dam safety legislation brings together expertise and resources of the federal and non-federal communities to reduce the hazard. A synopsis of the U.S. National

Dam Safety Program, which was passed in November 1996, is included in Appendix 3. Because this legislation is new, many programs and guidelines are still being developed or revised.

Many of the Regulated Facilities in the United States are either federally owned or are operated and maintained under the supervision of the U.S. Federal Energy Regulatory Commission (FERC), which performs inspections and imposes safety inspection, maintenance and emergency planning requirements.

FERC has agreements with the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission to perform dam safety inspections on a cost-reimbursable basis. Furthermore, the U.S. Army Corps of Engineers or the U.S. Bureau of Reclamation can be retained by any government entity to provide assistance in dam safety activities, including inspections, on a cost-reimbursable basis.

In the United States, states are responsible for the safety of dams not subject to federal oversight. Although 48 states, including all states along the border with Canada, have set up dam safety programs following the guidance of the Model State Dam Program, programs vary between states. In addition, states may participate in the U.S. National Dam Safety Program, which offers assistance for state dam safety programs.

Three privately owned Regulated Facilities that are partly located in the United States are not subject to federal oversight. Two are located in Maine and the other in Minnesota. Both states have dam safety legislation [Minnesota Statutes, Chapter 779 (1978), as amended in Chapter 105 (1979); Maine Revised Statutes Annotated, Title 37B, Chapters 21 and 22]. The Commission learned that these privately owned structures have been inspected by the states infrequently or not at all. Evidence was given at the Commission's hearing that inspections conducted by Maine have been cursory. The Commission understands that Maine is developing and staffing its dam safety program and anticipates substantial progress by the summer of 1998.

The Canadian Government has not enacted a federal dam safety program for Regulated Facilities. Not all facilities are subject to regular provincial inspections.

Many Regulated Facilities straddle the United States-Canadian border, with each side subject to a different government jurisdiction. Given the lack of comprehensive government safety regulation, sometimes only part of a structure is subject to government oversight. Potential problems on either side can, however, pose risks for both sides of the border. This situation highlights the necessity of cross-boundary coordination, both for safety inspections and emergency preparedness.

The Commission has been informed that the United States Federal Energy Regulatory Commission inspects the whole of the Iroquois, Forest City and Vanceboro Dams, including the portions of those structures that are in Canada. The Iroquois Dam straddles the international border in the St. Lawrence River and is owned jointly by the New York Power Authority and Ontario Hydro. It is operated by Ontario Hydro. The Forest City and Vanceboro Dams straddle the international border in the St. Croix River and are owned by Georgia-Pacific Corporation. The Canadian, New Brunswick and Ontario governments do not inspect or oversee the safety of these dams. The Prairie Portage Dam is owned and inspected by the United States Department of Agriculture, Forest Service, on both sides of the border. It is the Commission's view that the Canadian and United States governments should put in place suitable arrangements for joint oversight of these and other similar structures.

The Commission has found that there may not be regular government safety reports for the structures listed.

Dam Safety Associations

Organizations have been formed in both the United States and Canada to promote dam safety. In the United States, the Association of State Dam Safety Officials, in conjunction with the National Dam Safety Program, the Federal Emergency Management Agency, and the Interagency Committee on Dam Safety, provides a forum for exchanging ideas and experiences on dam safety issues, for fostering inter-state and inter-government cooperation in dam safety, and for providing information and assistance to state dam safety programs and officials. The association represents state interests before Congress and federal agencies responsible for dam safety, and works to improve the efficiency and effectiveness of state dam safety programs.

The Canadian Dam Safety Association (CDSA) was founded to advance the implementation of practices that ensure the safe operation of dams in Canada. The Commission understands that the CDSA is joining with the Canadian Committee on Large Dams to form the Canadian Dam Association. This association will continue to provide a forum for the exchange of ideas and experiences with respect to dam safety, foster interprovincial cooperation, promote the adoption of regulatory policies and safety guidelines for dams and reservoirs throughout Canada, and provide information and assistance to dam owners. Safety guidelines developed by the CDSA are influential in Canada with both dam owners and governments. The guidelines are, however, entirely voluntary and cannot take the place of rigorous government oversight. The Commission heard evidence that the guidelines are not standards or specifications but a useful reference for dam owners.

Site Inspections, Maintenance and Repairs

There is considerable variation in the way in which Regulated Facilities are inspected.

Regulated Facilities owned and operated by United States federal agencies are inspected by those agencies. The U.S. Army Corps of Engineers conducts inspections every five years and the U.S. Bureau of Reclamation conducts inspections every three years. The U.S. Forest Service conducts visual inspections annually and safety inspections every five to ten years.

FERC inspects structures subject to its oversight. FERC engineers inspect structures with high and significant hazard potential annually, and those classified as having low hazard potential biennially. During each inspection performed by FERC staff, dam safety and operation and maintenance aspects are evaluated, as well as public safety matters and environmental requirements and conditions covered by FERC dam safety regulations and license requirements. In addition, FERC requires structures subject to its oversight to be inspected by an independent consultant every five years if the dam exceeds certain specified height and impoundment criteria or has a high hazard potential. The independent consultant must be a licensed professional engineer with at least ten years of experience and expertise in dam design and construction and in the investigation of the safety of existing dams. The consultant must also be pre-approved by FERC. FERC regulations specify procedures for inspections, preparing inspection reports and implementing corrective measures.

Water Resources Program engineers from the State of Washington's Department of Ecology inspect the state-owned Osoyoos Lake Control Structure (Zosel Dam) annually. Engineers from the

Dam Safety Section, a separate portion of the Department of Ecology, inspect Zosel Dam every five years.

Regulated Facilities in the United States, owned or operated by government agencies or subject to U.S. federal government oversight, appear to have government programs in place to ensure that repairs recommended in site inspection reports are carried out.

In addition to meeting any government requirements, owners of Regulated Facilities usually have their own self-inspection programs to protect their investments and avoid liability. These inspections are often conducted by consulting engineers and, in Canada, usually follow the CDA guidelines. The Commission has been told that these reports are treated differently by different companies. The reports are not always available to the public and not automatically referred to boards of directors or senior management. External reporting to governments occurs only where there are legislative requirements, which are largely absent in Canada. Self-inspections raise the possibility of conflicts of interest as there is no government oversight of owner-hired engineers. Without government oversight, there is no assurance that owners will follow up on recommendations coming from their own reviews and implement the recommendations of their inspections.

Emergency Action Plans

Information provided to the Commission indicates that emergency action plans do not exist for all Regulated Facilities. Fortunately, there are plans for most high- hazard dams. Considerable variation exists among the plans. Even though failures could in some instances put cities and major highways at risk, the Commission has observed that emergency preparedness training is not always taken seriously by participants, and governments at all levels are not always fully involved. In some cases, such as in the Rainy Lake Basin and in the St. Croix River, there are dams in series. In these situations, the failure of one dam might affect others downstream. Appendix 5 contains information on government oversight, emergency action plans, and inundation mapping for each of the Regulated Facilities.

The Commission is not satisfied that all existing emergency action plans adequately take into account such matters as the effects of potential upstream dam failures, the possibility of earthquakes, the need for on-site personnel, security requirements and the extent of potential trans boundary and domestic loss of life and injury. The Commission believes that emergency preparedness plans which take these factors properly into account should be developed and tested for all Regulated Facilities.

Conclusions and Recommendations:

The conclusions of the review were:

"The Commission agrees with the Canadian Dam Safety Association that "the prime responsibility for public protection" ultimately rests with government.

The existing situation in which some Regulated Facilities are not subject to comprehensive government safety inspections and oversight by governments is unsatisfactory. Throughout the United States it is at least possible for government entities to engage the U.S. Army Corps of Engineers or the U.S. Bureau of Reclamation to perform safety inspections. In Canada, there does

not appear to be any way of obtaining regular government safety inspections for all Regulated Facilities.

Inspections which are initiated and directed by owners without oversight by a government body may not have the same objectives as government inspections which are aimed at protecting the public. There is no assurance that owner-initiated inspections will be carried out with the frequency and scope needed to protect the public interest. The reports of owner-initiated inspections are usually not available to the public. Owners are under no obligation to implement recommendations contained in their reports. The public and governments have no way of ensuring that the inspector's recommendations are followed. There is no way to ensure that emergency action plans exist or are regularly tested or updated. Without government oversight there is no effective means of ensuring accountability for activities that can put the lives and property of Canadian and United States citizens in jeopardy."

The recommendations were:

"The Commission recommends that governments oversee the safety of Regulated Facilities. This government oversight should include requirements for:

- *regular, periodic, complete and independent on-site inspections by qualified experts;*
- *a reasonable timetable for implementation of all inspection report recommendations;*
- *establishment and regular testing of emergency action plans which take account of eventualities and include detailed notification procedures, identification of responsibilities, provision for trans-boundary coordination, and inundation maps; and*
- *public access to all reports and documentation relating to safety issues.*

The Commission also recommends that the Canadian and United States governments put in place suitable arrangements for joint oversight of structures that extend across the border.

If the Commission does not receive a substantive response from the Canadian and United States governments by June 1, 1998, about how they are going to deal with the issues raised in this report, the Commission may consider amending its Orders to require the owner of each Regulated Facility to provide the Commission periodically with a certified copy of a safety inspection report prepared by a government official for the structure. These reports would have to be provided on a periodic basis commensurate with the hazard posed by a particular structure. The level of hazard would be established according to rules prescribed by Canadian and United States agencies. Owners would also be required to confirm that all maintenance and repairs recommended in the government's safety report are being undertaken within a reasonable time. Furthermore, owners would be required to develop and provide the Commission with copies of an emergency action plan developed in concert with governments.

Until the Commission's recommendations are accepted by governments, the Commission recognizes that there may be structures for which regular government safety reports are still not available. The Commission will consider possible means of addressing public safety in the interim.

The Commission attaches great importance to public safety and would welcome any views which the governments or others may have about how best to ensure that Regulated Facilities are maintained and operated safely."

5.3. Other National Approaches

ICOLD has devoted a lot of effort into disseminating information on dam safety practices and has produced a number of publications on the topic which is an important source of current best practice. The international experience provides a "baseline" of "best international practice" from which conclusions may be drawn of the effectiveness of the current dam safety programs in the EN Basin.

There is a wealth of examples of this topic in the literature and it was considered that it would be useful to quote some cases from developed and developing countries such as:

- Australia;
- Canada;
- South Africa;
- UK;
- USA.

5.3.1. Australia

In Australia dam safety regulation is done on a state level. Currently only three states (New South Wales, Queensland and Victoria) out of the six states and two mainland territories have dam safety regulations in place. In 2003 the Australian National Committee on Large Dams (ANCOLD) (www.ancold.org.au) published a "Guideline on Dam Safety Management" (ANCOLD: 2003) which is developed from earlier versions (1976 & 1994) ANCOLD guidelines and sets out general considerations for dam safety programs. The Guidelines can be obtained in hard copy form from ANCOLD.

The guideline stresses that dam safety management can be achieved by:

- Identifying the responsibilities of owners, governments and dams personnel;
- Ensuring adequate funding and resources for dam safety management;
- Creation of public awareness on dams safety issues;
- Responsible management of risks;
- Implementing appropriate dam operation and maintenance practices;
- Educating and training of dams personnel in emergency procedures and responses;
- Adopting quality management programmes.

The guideline indicates that the level of effort and resources to be employed to ensure proper dam safety management is influenced by the dam hazard/risk level. ANCOLD developed hazard categories provided below based on the severity of damage/loss and the size of population at risk.

Table 5-1: ANCOLD hazard categories

<table>
<tr><th rowspan="2">Population at Risk</th><th colspan="4">Severity of Damage and Loss</th></tr>
<tr><th>Negligible</th><th>Minor</th><th>Medium</th><th>Major</th></tr>
<tr><td>0</td><td>Very low</td><td>Very low</td><td>Low</td><td>Significant</td></tr>
<tr><td>1 to 10</td><td>Low
(1 & 4)</td><td>Low
(4 & 5)</td><td>Significant
(5)</td><td>High C
(6)</td></tr>
<tr><td>11 to 100</td><td rowspan="3">(1)</td><td>Significant
(2 & 5)</td><td>High C
(6)</td><td>High B
(6)</td></tr>
<tr><td>101 to 1000</td><td rowspan="2">(2)</td><td>High A
(6)</td><td>High A
(6)</td></tr>
<tr><td>>1000</td><td>(3)</td><td>Extreme
(6)</td></tr>
</table>

Notes :

(1) With a Population at Risk (PAR) of 5 or more people, it is unlikely that the severity of damage and loss will be “negligible”

(2) “Minor” damage and loss would be unlikely when the PAR exceeds 10

(3) “Medium” damage and loss would be unlikely when the PAR exceeds 1000

(4) Change to “significant” where the potential for one life being lost is recognized

(5) Change to “high” where there is the potential for one or more lives being lost

(6) See ANCOLD Guidelines (2000) for explanation of high hazard categories.

ANCOLD guideline for dam safety management then provides an overview of investigation, design, construction and commissioning in the context of dam safety. These include:

- Highlights of issues concerning dam owners;
- Identified issues to be addressed by dam engineers;
- Guidelines to the type and extent of investigations to be conducted;
- Design related issues;
- Construction guidelines;

- Commissioning procedures.

Further, ANCOLD provides guidelines for the following:

- Operating procedures;
- Maintenance procedures;
- Dam safety inspections and frequency of inspection;
- Dam monitoring;
- Dam safety reviews;
- Remedial actions to be taken;
- Dam safety emergency planning.

The ANCOLD Guidelines have no force of regulation but are used extensively as a guide by many owners and engineering organizations. They are the sole or major source of guidance in all non-regulated jurisdictions in Australia.

5.3.2. Canada

There are Over 14,000 dams in Canada with 933 classified as Large Dams by ICOLD.

A summary of the Canadian Regulatory Framework is as follows:

- Dams are Provincially Regulated (except for Boundary Waters). In other words Provincial Responsibility for Licensing Dams and Regulating Water Use.
- For Boundary Waters there are either an International Joint Commission and/or River Treaties for example Columbia River, etc.
- Dam Safety has historically been managed by Large Dam Owners' due diligence.

Within this framework there are four Provinces with Dam Safety Regulations:

- Alberta,
- Quebec,
- British Columbia
- Ontario – Draft Regulations Proposed

There are still a number of Provinces without Dam Safety Regulations. Newfoundland, Nova Scotia, New Brunswick, Manitoba, Saskatchewan and the Yukon have acknowledged that they would direct dam owners and consultants to CDA Guidelines for practice.

<u>Role of Canadian Dam Association (CDA):</u>

CDA is the Canadian national committee of ICOLD [www.cda.ca]. CDA Dam Safety Guidelines were initially published in 1995 and updated in 1999 and 2007 (CDA: 2007). Most recently a review of three sections was published (CDA: 2013). The Guidelines have no force of regulation but are used extensively as a valuable guide by many owners and engineering organizations. They are the sole or major source of guidance in all non-regulated jurisdictions in Canada.

There are no federal dam safety regulations in Canada; they are the responsibility of the Provinces. The Provinces with regulations generally keep them limited to the following:

- Dam Hazard Classification System (4 to 6 classes depending on Province);
- Specific Design Criteria (IDF, Seismic) in some cases:
- A schedule of Dam Safety Reviews is mandated for certain situations:
    - Hazardous conditions
    - Suspension of operation
    - Expert opinion
- Frequency of Inspections and Reviews.

The 2007 CDA Guidelines (CDA: 2007) are very comprehensive and are "user friendly" and contain the following major sections:

- Guidelines
- Principles
- Dam Safety Management
- Operation, Maintenance and Surveillance
- Emergency Preparedness
- Dam Safety Review
- Analysis and Assessment
- 9 Technical Bulletins on Dam Safety Analysis and Assessment

In summary, the main approach remains the traditional criteria based approach using "Hazard Classifications" but there is a recognition and endorsement of more advanced risk-based approaches to assessing safety of dams and to decision-making by CDA. Consideration for dual approach (traditional and risk based) to regulation of dam safety in Ontario, including potential failure modes approaches, with some inclusion of risk-informed arguments in regulation of dam safety in British Columbia.

5.3.3. South Africa

Formalized dam safety regulation was implemented in the Republic of South Africa (RSA) in 1986 by means of regulations in terms of the then National Water Act (RSA: 1986). The impetus for this initiative was the exposure that engineers of the Department of Water and Sanitation (previously known as the Department of Water Affairs or the Department of Water Affairs and Forestry) had in the activities of the International Commission on Large Dams (ICOLD) in matters related to dam safety as discussed above. ICOLD finalized its Bulletin 59: *Dam Safety Guidelines* during this period (ICOLD: 1987). The Department of Water and Sanitation is the National Authority for the management and regulation of the water resources of South Africa. The Department is also an owner of a significant number of the large dams in South Africa.

The South African National Committee on Large Dams (SANCOLD) played a leading role in the implementation of these regulations over the years. A Symposium was held shortly after the promulgation of the regulations, (SANCOLD: 1986). Over the years, SANCOLD developed several guidelines related to the safety of dams. Some of these have been or are in the process of being updated [See SANCOLD website].

A new National Water Act (RSA: 1998) was promulgated in 1998 and this also contained provision for dam safety regulation. An update of the regulations was promulgated in 2012 (RSA: 2012). The updated regulations are very similar to the original ones which have functioned effectively for some 26 years. Refinements were incorporated into the new regulations based on past experience and also aligning the Regulations with the new National Water Act.

The framework for dam safety regulation in South Africa is set out below and is more fully described in by Nortje (2011) and the regulations itself (RSA: 2012).

The Dam Safety Office (DSO) of the Department of Water Affairs is responsible to facilitate the implementation of the dam safety legislation. The DSO is a relatively small unit of engineers (3), technicians (3) and administrative personnel (11). Details of the unit are given on the website of the Department of Water and Sanitation.

Dam owners are required in terms of the legislation to register "dams with a safety risk" with the DSO. A "dam with a safety risk" means any dam which can store more than 50 000 m^3 and which has a wall height of more than five metres. Only dams with a safety risk are subject to dam safety legislation. Such dams include tailings dams and municipal water storage reservoirs if the capacity exceeds 50 000 m^3. This definition of height differs from the ICOLD definition – the height is measured from the lowest natural bed level at the downstream toe of the dam wall to the non-overspill crest. The distribution of registered dams in 2014 according to size class is given in **Table 2** below.

Table 5-2: Distribution of registered dams according to size class (2014)

Size class	Number	%
Small (5m – 12m)	4 000	83.4%
Medium (12m – 30m)	627	13.1%
Large (30m and higher)	169	3.5%

Total	4 796	100%

Details of these dams are on the website of the Department of Water and Sanitation (RSA: 2014). The SANCOLD website contains the South African Register of Large Dams where "large" follows the ICOLD definition and generally has a height greater than 15 m.

The purpose of dam safety legislation as stated in the National Water Act (RSA, 1998) is to improve the safety of new and existing dams with a safety risk so as to reduce the potential for harm to the public, damage to property or to resource quality. The provisions of the Act and Regulations are in addition to dam owner's common law responsibility to ensure the safety of their dams.

The most important features of the dam safety legislation are:

- Provision for different categories of dams that determine the required level of control. Only dams of a defined size or dams which have been declared to be dams with a safety risk are subject to the dam safety legislation.

- Requirement that a licence must be obtained before constructing a new or altering an existing dam with a safety risk. A separate licence is also required for impoundment.

- Requirement of regular dam safety evaluations including inspections.

- Systematic upgrading of existing dams to appropriate dam safety standards.

- Requiring involvement of approved professional persons for certain tasks at category II and III dams, ensuring that the necessary expertise is involved during design, construction and dam safety evaluation/inspection. In the case of category III dams, the approved professional person must be assisted by a professional team. (See later discussion on the classification system).

- The Engineering Council of South Africa (ECSA) assists in the approval of suitably qualified and experienced professional persons for dams.

- Dams are classified in three classes denoted as Categories with Category I having the lowest hazard potential and Category III the highest. Category II is an intermediate class.

- Appointment of one approved professional person for a task at a category II or III dam, ensuring that one person takes responsibility for all important decisions and actions, thereby improving coordination and eliminating any misunderstandings regarding responsibility.

- Requirement that an operation and maintenance manual including emergency preparedness plan must be available at Category II and III dams.

The classification of dams (see **Table 5**) is defined in the Dam Safety Regulations (RSA: 2012) and is based on a matrix of dam size (see **Table 3**) and hazard potential (see **Table 4**). The hazard potential includes factors such as potential loss of life, potential economic loss and potential

adverse impact on resource quality. The resource quality relates to the water quality of the water resources and includes problems associated with sediment.

Table 5-3: Size classification

Size class	Maximum wall height in metres (m)
Small	Less than 12 m
Medium	Equal to or more than 12m but less than 30m.
Large	Equal to or more than 30m

Table 5-4: Hazard potential classification

Hazard potential rating	Potential loss of life	Potential economic loss	Potential adverse impact on resource quality
Low	None	Minimal	Low
Significant	Not more than ten	Significant	Significant
High	More than ten	Great	Severe

Table 5-5: Category classification of dams with a safety risk

Size class	Hazard potential rating		
	Low	Significant	High
Small	Category I	Category II	Category II
Medium	Category II	Category II	Category III
Large	Category III	Category III	Category III

The status of classification of existing dams in 2014 is given in **Table 6** below.

Table 5-6: Category classification of existing dams (2014)

Category classification	Number of dams	%
Category I	2 694	56.2%
Category II	1 813	37.8%
Category III	289	6.0%
Total	4 796	100%

It has been found that on-going training and education of all role players is necessary to improve efficiency. Regular SANCOLD courses and conferences as well as publications are an essential feature of this training initiative. In this respect the SANCOLD Guidelines have been an invaluable asset for the dam safety sector.

The Dam Safety Rehabilitation Programme was initiated in 2005 to address dam safety related deficiencies at Department of Water Affairs' dams. The Department is not exempted from the provisions of the Dam Safety Regulations. The Department owns 316 large dams which are located countrywide. To date, 30 dams have been successfully rehabilitated. A further 6 dams are currently undergoing construction and another 32 dams are in various stages of design or tender stages. The expenditure to date is in excess of 200 million USD, spent on consulting engineering services and construction work at DWA dams.

It is concluded that dam safety regulation has been most effective in South Africa. Not a single new category II or III dam, for which a licence to construct has been issued, has failed since 1987 (Hattingh et al, 2012).

5.3.4. United Kingdom

The Reservoirs Act 1975 (UK: 1975) provides the legal framework to ensure the safety of UK reservoirs that hold at least 25,000 cu m of water above natural ground level. Approximately 2,500 reservoirs are covered by the Act: some 80% of these are formed by embankment dams with the remainder being concrete or masonry dams or service reservoirs. The Act is applicable in England, Wales and Scotland: it does not apply to Northern Ireland, although some reservoir owners and operators there comply with the spirit of the Act.

The Act identifies four key persons or organizations with distinct functions and responsibilities as follows:

1. Undertakers

   The Undertakers are generally the owners or operators of the reservoir, and have ultimate responsibility for the safety of the reservoir.

2. Enforcement Authorities

   The Enforcement Authority is responsible for ensuring that the Undertakers observe and comply with the requirements of the Act.

   Since 1 October 2004 the Environment Agency has been the Enforcement Authority for England and Wales. Further information on the Act and the Environment Agency's responsibilities can be found on http://www.environment-agency.gov.uk/business/sectors/64246.aspx. The Enforcement Authorities in Scotland are the Local Authorities.

3. Qualified Civil Engineers (also referred to as Panel Engineers)

Qualified civil engineers are experienced reservoir engineers appointed to one of the panels under the Act by the Secretary of State in consultation with the Institution of Civil Engineers. They are responsible for the design and supervision of construction, the supervision of measures in the interests of safety, inspection of reservoirs and the ongoing supervision of reservoirs. There are currently four panels of engineers:

- All Reservoirs Panel
- Non-impounding Reservoirs Panel
- Service Reservoirs Panel
- Supervising Engineers Panel

Further details of these panels and a list of currently appointed panel engineers can be found on http://www.environment-agency.gov.uk/business/sectors/64253.aspx

4. Secretary of State

The Secretary of State is responsible for overseeing the activities of the Enforcement Authorities, appointment of qualified civil engineers and making statutory instruments to prescribe regulations.

Current responsibility for the Act in England lies with the Secretary of State for Environment, Food and Rural Affairs. Since 1 July 1999, the Scottish Parliament and the National Assembly for Wales have had the powers to make specific regulations for Scotland and Wales respectively, but these have not yet been used.

The Reservoirs Act 1975 is in the process of being updated by the Flood and Water Management Act 2010 (UK: 2010). The Flood and Water Management Act (UK: 2010) reflects a more risk-based approach to reservoir regulation through:

- Reducing the capacity at which a reservoir will be regulated from 25,000m^3 to 10,000m^3; and
- Ensuring that only those reservoirs assessed as a higher risk are subject to regulation
- All undertakers with reservoirs over 10,000m^3must register their reservoirs with the Environment Agency
- Inspecting engineers must provide a report on their inspection within 6 months
- All undertakers must prepare a reservoir flood plan
- All incidents at reservoirs must be reported

The reservoir sections of the Act are dependent upon on the development of secondary legislation (regulations and orders) before the law can be fully implemented, so it is likely that many of the provisions in the Act will not come into force for some time yet. (Link to the Flood and Water Management Act 2010: http://www.opsi.gov.uk/acts/acts2010/pdf/ukpga_20100029_en.pdf).

In fulfilment of a commitment made in response to the Pitt Review, The Government has completed inundation (flood) mapping of every reservoir under the Reservoirs Act, in England and Wales.

- Further information in relation to reservoir flooding can be found on the Environment Agency website at: www.environment-agency.gov.uk/homeandleisure/floods/114481.aspx

- Advice on what to do and how to prepare for a reservoir emergency can be found at: www.environment-agency.gov.uk/homeandleisure/floods/114476.aspx

Reservoir owners will in due course be required to prepare on-site emergency plans. On-site emergency plans detail how reservoir owners or those responsible for the operation of a reservoir will respond to a potential or real reservoir failure. It is good practice for all reservoirs to have on-site plans and all reservoir owners are recommended to prepare one.

The following link leads to further information on on-site plans: http://www.defra.gov.uk/environment/flooding/reservoir/flood-plans.htm

The Reservoirs (Scotland) Act 2011 (Scotland: 2011) introduces a risk-based approach to the regulation of reservoirs which aims to increase reservoir safety in Scotland. Key features of the Reservoirs (Scotland) Act 2011 are:

- The Scottish Environment Protection Agency (SEPA) will become the enforcement authority (anticipated to commence in 2015) taking over responsibility from local authorities;

- The capacity threshold for regulated reservoirs will be reduced from 25,000m3 to 10,000m3;

- The introduction of a risk based and proportionate approach to the management of reservoir safety;

- Reservoir Managers will be required to register their reservoir with SEPA.

The Reservoirs (Scotland) Act 2011 (Scotland: 2011) will repeal and replace the Reservoirs Act 1975 (UK: 1975) which is currently enforced by Scotland's 32 local authorities.

The Reservoirs (Scotland) Act 2011 is available at: http://www.legislation.gov.uk/asp/2011/9/pdfs/asp_20110009_en.pdf

Information relating to the implementation of the Reservoirs (Scotland) Act 2011 is available from the Scottish Government website: http://www.scotland.gov.uk/Topics/Environment/Water/16922

A list of UK guidance documents covering a range of topics is provided at the British Dam Society website: http://www.britishdams.org/reservoir_safety/default.htm

5.3.5. United States of America

The Federal Energy Regulatory Commission's (FERC's) Division of Dam Safety and Inspections (D2SI) is responsible for approximately 2,500 dams including 1,100 high and significant hazard

dams that form a significant part of the hydroelectric infrastructure for the United States. As the regulator of these facilities, D2SI is committed to providing the public and the environment with adequate protection from the risks which are inherent to collecting and storing large volumes of water or subsequent release.

D2SI has historically utilized a criteria-based decision-making framework in its dam safety program. The failure of Teton Dam in 1976 demonstrated a need for a more comprehensive approach to evaluating and addressing dam safety issues.

In 1979, a committee of Federal agency representatives commissioned by the President developed the Federal Guidelines for Dam Safety to promote prudent and reasonable dam safety practices among Federal agencies. The Federal Guidelines recognized that:

"Risk-based analytical techniques and methodologies are a relatively recent addition to the tools available for assessing dam safety. With further refinement and improvement, risk-based analyses will probably gain wider acceptance in the engineering profession and realize potential as a major aid to decision-making in the interest of public safety."

The Federal Guidelines cautioned:

"However, even when fully developed, risk analyses cannot be used as a substitute for sound professional judgment of engineers, contractors, or review boards."

D2SI has followed the development of risk analysis techniques and methodologies for use in dam safety decision-making.

In 2002 D2SI added Potential Failure Mode Analysis (PFMA) as a tool to its dam safety program. PFMAs are the initial step in a risk analysis. The introduction of PFMAs to D2SI's dam safety program allowed qualitative assessment of failure modes that were not amenable to numerical analysis or criteria and allowed surveillance and monitoring programs and emergency action plans to be focused on specific failure modes. It is included in the latest revision of the FERC Dam safety guidelines (FERC: 2004).

After ten years of experience with PFMA D2SI believes that the practice of risk analysis in dam safety has been refined and improved and now has the potential to be a major aid to decision-making in the interest of public safety.

The Commission's 2009-2014 Strategic Plan has a stated objective to minimize risk to the public. One strategy to achieve this goal has been identified as incorporating risk-informed decision-making (RIDM) into the Commission's dam safety program administered by the Office of Energy Projects – Division of Dam Safety and Inspections (D2SI).

5.3.6. Uganda

Uganda has large hydropower development in the Upper Nile, which is critical to its socio economic development, and its failure would not only have serious possibility of considerable loss of life but would cripple major industry for several years. Moreover, there are small storage dams in the country, in which their safety records have not been good. Many have failed due to poor workmanship or inadequate spillways. Many have also lost their function due to uncontrolled erosion in the upper catchments causing them to fill with silt. Recognizing these facts, the country

has developed its dam safety Regulatory Framework and Guideline in 2006. The Directorate of Water Development was recommended to have the responsibility of implementing the legislation and the associated regulations and be accountable to the Ministry of Energy and Mineral Development for all decisions in respect of dam safety. It is important to note that this guideline was developed by consultants and based extensively on the ANCOLD Guideline on Dam Safety Management (ANCOLD: 2003) with substantial additions from various other sources.

The dam safety Regulatory Framework is organized in 8 chapters and 12 appendixes. The Dam safety guideline, emphasizes on large dams, is one of the appendixes. In addition to this, supplementary appendixes such as Draft Guidelines for Managing Small Dams; Inspection manual, International examples of regulatory frameworks; Legal aspects and institutional aspects of dam safety are contained in the framework.

As it is stated in the guideline, rather than developing very prescriptive standards, minimum standards of design, construction, operation and maintenance general guidelines was recommended. In line with this, a dam safety guideline was adapted from the Australian Dam Safety Management Guideline. It is composed of the following main dam safety elements.

- Responsibility & accountability of dam owner, regulatory authorities, dams engineers and operators
- Quality management, education and public consultation
- Investigation, design, construction & commissioning
- Surveillance
- Safety reviews
- Dam safety emergency planning
- Operations and maintenance
- Dam surveillance

The guideline outlines the role and responsibility of dam owner, regulatory authorities, dam engineers, operators and the need to develop a national dam safety program.

Based on loss of life, environmental, social and economic risks, Potential Impact classification (PTC) or dam hazard classification is provided in the guideline.

An overview of investigation, design, construction and commissioning in the context of dam safety is also broadly described in the guideline. It recommends using additional references for detail analysis and assessment.

It recommends development of operating and maintenance procedures and manuals by the dam owner for the safe operation of a dam under adverse (even worst case) scenarios as well as normal conditions, including coordination of releases with other dams, communication security, liaison with counter disaster and other agencies and discharge or flood warning to downstream areas.

The guideline discusses the need of surveillance programs of dams commencing as early as possible in the life of the dam (preferably during the construction phase), to detect the development of any problem or unsafe trends and to provide full background information on the dam's performance. It recommends the scope of the surveillance program should be based on the consequences of dam failure, the level of risk at the dam, the type and size of the dam, and the value of the dam to the dam owner.

Frequency and regular inspection requirement for abnormalities in conditions and for deterioration of dams are highlighted and four general levels of dam safety inspection program, discussed in the guideline. The frequency of inspections, taking into account the consequences of dam failure, the level of risk at the dam, the type and size of the dam and the value of the dam to the dam owner and the community is elaborated. As part of the monitoring program, some of the items to be monitored are listed in the guideline.

A Safety Review procedure for assessing the safety of a dam, and comprises where relevant, a detailed study of structural, hydraulic, hydrologic and geotechnical design aspects and of the records and reports from surveillance activities is recommended. A generic procedure to undertake a safety review is also included in the guideline

The following aspects are recommended to be undertaken in the dam safety review process:

(a) Determination of Likelihood of Dam Failure

(b) Consequence Assessment

(c) Risk Evaluation

Remedial action (i.e. risk reduction) is required at a dam when it no longer meets an acceptable level of safety. The remedial action evaluation process should select a timely and cost effective course of action, which could include interim or long-term remedial works, maintenance, changes to operating procedures, or decommissioning. The guideline provides an outline, which could be used in the remedial action evaluation for a dam and recommended to be adopted or adapted as necessary for particular situations. In line with this, the following risk reduction options are discussed in the document.

- Interim Remedial Actions
- Long-Term Remedial Works
- Decommissioning
- Disuse
- Abandonment
- Site Rehabilitation

Risk of dam failure can be reduced using standards for design, construction, operation, maintenance, surveillance of dams and emergency plans. Taking this into account, the guideline has adequately addressed the following two types of emergency plans.

- A Dam Safety Emergency Plan developed by the dam owner; and
- A separate Disaster Plan developed by appropriate State or local emergency management agencies to provide protection for downstream communities in the event of a dam safety emergency.

One of the appendixes, Guideline for Small Dam, is intended for use only as a guide to owners and operators of small dams. It outlines prudent approaches to normal dam surveillance and maintenance practice with a view to enhancing the long-term safety and operation of small dams in Uganda.

The Ugandan dam safety guideline is more appropriate for countries that have adequate and experienced professionals in the design, construction and operation of large dams. It is broader and doesn't adequately address some of the dam safety elements to be considered during planning and design phases. Some of these are:

- Dam safety management coordination on dams constructed on trans-boundary rivers
- Dam site identification, Topographical survey and map preparation (dam site area, inundation area, flood prone area, etc.)
- Hydrological studies (river flow requirement, rainfall-runoff analysis, flood frequency analysis, selection of design flood, etc.);
- Geology (geological formation, Earth quake and reservoir induced seismicity, foundation, construction material, etc.);
- Hydraulic assessment of spillways and other outlet structures
- Structural integrity and stability of dam and appurtenant structures
- Reservoir filling and operating strategies
- Construction Contract management,
- Environmental and social issues

To conclude, as it is mentioned before, the guideline is very broad and substantially adapted from the Australian Dam Safety Guideline. It lacks addressing some basic dam safety elements. More in-depth assessment and analysis are left to highly qualified professionals and it focuses on existing dam safety management. Additional reference materials and guideline are needed to augment the information contained in the guideline..

5.3.7. Malaysia

The Malaysian Department of Irrigation and Drainage (DID) presently operates 15 dams of which serves for flood control, irrigation, municipal and industrial water supply. Thirteen of these dams are earth fill dams, one concrete faced rock fill dam and one rock fill dam.

The department has published a technical manual consisting of eleven separate volumes covering Flood Management; River Management; Coastal Management; Hydrology and Water Resources;

Irrigation and Agricultural Drainage; Geotechnical, Site Investigation and Engineering Survey; Engineering Modelling; Mechanical and Electrical Services; Dam Safety, Inspections and Monitoring; Contract Administration; and Construction Management. The first edition of the Manual was published in 1960 and updated in 2009 (Malaysia: 2009).

The dam safety guideline is one of these eleven volumes. It is adapted from Federal Emergency Management Agency (FEMA) guideline (2004), United States Bureau of Reclamation (USBR) manuals and New Zealand dam safety guideline (NZSOLD: 2000). The Guideline is organized in 7 chapters and 4 appendixes and it is composed of the following main dam safety elements.

- Planning
- Design
- Construction
- Operation
- Maintenance
- Inspection
- Surveillance
- Abandonment

The four appendixes are:

- Instrumentation Data
- Routine Inspection Reports
- Periodic Inspection Report
- Safety Inspections

The Planning section provides hazard classification of dams as per FEMA classification. It discusses the roles and responsibilities of dam owner and consultants during design, construction, first reservoir filling, Operation and Maintenance (O&M), aging and decommission of dams. A very brief description of water resource development planning process is given in the guideline.

The geotechnical factors and investigation to be considered during the design phase are outlined in the guideline. In addition, hydrological analysis, selection of design flood parameters as per the risk classification of dams is also discussed in the document.

The guideline recommends a dam break analysis during design phase and suggested a remedial action need to be taken for existing dams, particularly related to spillway inadequacy.

All factors to be considered during the design of dams (Physical, geotechnical, hydrological, structural, operational and environmental) are listed.

It also recommends the criteria set forth by US Corps of Engineers to design embankment and gravity dams, spillways, outlet works and hydro-mechanical equipment.

It describes safety concerns of stake holders, roles and responsibilities of the owner and contractor during construction. It briefly describes the design-build contract system, quality assurance and contract administration during construction period.

Development of operation instructions and some procedures of operation of the typical gates found to be most in use, reservoir operation, and safety of access, environment and working conditions and Emergency operations are discussed briefly. The following operating manuals are recommended to be developed as part of the operation guideline.

- Hydraulic structures and equipment including gates and valves and other types of controls, if any; and related mechanical and electrical equipment.
- Reservoir operation
- General security arrangements
- Public safety measures

Where there is substantial change in demand and supply of water for irrigation, and municipal, industrial uses, it suggests applying optimized reservoir operation taking the following points into consideration.

- Review details of availability of water and demands as differentiated from those worked out at the earlier stages
- Review the technology and data used to maximize benefits and minimize adverse effects
- Consider adaptation of operations in case of the changes that have been recognized
- Study the risks posed consequent to the changes and the management of such risks
- Minimized downstream damage as constraint, limiting upstream flood damages to those determined previously and minimizing number of spillway gate operation changes.

The guideline discusses the following two types of dam maintenance procedures:

- Preventive Maintenance, also called Regular Maintenance, Routine Maintenance or Periodic Maintenance.
- Extraordinary Maintenance, also called Unscheduled Maintenance

Maintenance procedures and timing are also described in the guideline. A check list of actions to be taken and frequency of maintenance for preventive maintenance of embankment, concrete gravity dams and appurtenant structures is attached. Safety Monitoring and Safety Inspections surveillance process, Frequency of Monitoring, use of Instrumentation Data, Interpretation of Data, Catchment Area Monitoring, and Reservoir Sedimentation Monitoring are discussed in detail.

In addition to the Checklist for Periodic Inspection, the following five types of inspections are also elaborated in the guideline.

- Routine Inspections
- Periodic Inspections
- Formal Inspections
- Emergency Inspections
- Special Inspections

A dam should not be abandoned until sufficient of the dam structure has been removed or otherwise modified to make it incapable of impounding a storage, either temporarily or permanently, to a degree which constitutes a risk to life or property. The guideline describes the process and requirements for abandonment. It highlights the dam operation is ceased or abandoned because of any of the following cases are realized.

- The dam is no more useful i.e. when it does not serve the purpose for which it was designed or any other purpose.
- The operation and maintenance costs exceed the benefits being derived from it by keeping it running
- Rehabilitation works required for the safety of the dam including downstream life and property are not technically feasible, e.g. need of additional spillway or increasing the spillway discharge capacity.
- The dam safety works required to be incurred become unaffordable, e.g. cost of provision of addition spillway or increasing the capacity of the spillway.

The Malaysian Dam Safety Guideline is relatively more detail and descriptive than the Ugandan and Canadian guidelines (CDA: 2007). However, it lacks adequately addressing the following critical dam safety elements.

- Dam safety management coordination on dams constructed on trans-boundary rivers
- Topographical survey and map preparation (dam site area, inundation area, flood prone area, etc)
- Construction monitoring and inspection standards and procedures
- Earth quake and reservoir induced seismicity, Geo technical investigation and foundation treatment
- Dam safety assessment techniques

6. ENVIRONMENTAL AND SOCIAL ISSUES IN DAM SAFETY

6.1. Basin wide Policy, Legal, Technical and Institutional Aspects

At the Nile Basin Initiative and the Eastern Nile Subsidiary Action Program levels various policies and strategies have been put in place and institutional and technical capacities are being built within the temporary basin and sub-basin wide institutions (NBI and SAPs).

The following paragraphs provide brief outline of existing basin-wide policies and strategies including available knowledge products in order to show that there are enabling environment and supporting policies to put in place a dam safety program that integrates environment and social issues at sub-basin and country levels.

Nile Basin Sustainability Framework (NBSF)

The Nile Basin Sustainability Framework (NBSF) (NBI: 2011) is a strategic planning tool that seeks to (a) ensure that all relevant guiding policies and strategies needed to support the Subsidiary Action Programs (SAP) investment projects are available in a timely manner, (b) promote the consideration of the trans-boundary dimension in riparian states' approaches to water resources management, and (c) provide direction in some aspects of the cooperative management and development of the river basin until a permanent Basin Organization (RBO) is established.

NBI Environmental and Social Policy (ESP)

The NBI Environmental and Social Policy (ESP) (NBI: 2013a) was developed as stipulated by NBI's Nile Basin Sustainability Framework under its Key Strategic Direction 3 (KSD 3): "Environmental and water-related natural resources management". The ESP forms an integral part of the existing landscape of NBI policies, strategies and guidelines, complements national efforts of NBI member states and is in line with international standards. The scope of this policy covers strategies and guidelines under KSD 3 and provides overall guidance for the other three KSDs (Water-related socio-economic development; water resources planning and management; and climate change adaptation and mitigation).The ESP (NBI: 2013a) intends to provide coherence for the NBI's activities by covering the environmental and social dimensions of sustainable development in line with international best practice. Its overarching goal is to ensure social and environmental sustainability of NBI program outcomes.

The ESP (NBI: 2013a) was devised with the following four objectives in mind, which are based on NBI's recognized mandate:

- Objective 1: To provide a set of principles and fields of action for the integration of environmental and social concerns in NBI programs.
- Objective 2: To provide guidance for managing trans-boundary environmental and social impacts of national activities.
- Objective 3: To provide support to Nile Basin countries for the protection and conservation of critical Nile Basin environmental resources.

- Objective 4: To demonstrate commitment of the NBI and Nile countries to international best practices with regard to environmental and social management of development activities.

NBI Wetland Management Strategy

The NBI Wetland Management Strategy (NBI: 2013b) was developed as stipulated in the Nile Basin Sustainability Framework under its Key Strategic Direction 3: Environmental and water-related natural resources management". The Wetland Management Strategy (NBI: 2013b) forms an integral part of the existing landscape of NBI policies, strategies and guidelines and complements the national efforts of NBI member countries. The strategy focuses on the trans-boundary management of Nile Basin wetlands to guide their sustainable utilization and enhance their greatest possible contribution towards the common benefit for the Nile Basin.

In view of the pressing threats and challenges for Nile Basin wetlands, the overarching goal of this Wetland Management Strategy is to foster the sustainable management and utilization of the Nile Basin's wetlands.

This strategy has the following five strategic objectives that govern NBI's Wetland Management Strategy.

- Objective 1: Strengthen the knowledge base on wetlands of transboundary importance in the Nile Basin to support basin-wide conservation, management, planning and restoration efforts.

- Objective 2: Raise awareness and undertake advocacy efforts to build consciousness around the important role of wetlands and their ecosystem functions for the basin's development.

- Objective 3: Develop and promote a basin-wide approach for the sustainable and cooperative management of wetlands taking into account the full variety of wetland uses.

- Objective 4: Strengthen national policies and institutional capacities for the effective management of wetlands with basin-wide importance.

- Objective 5: Strengthen basin-wide access to finance for wetland management and the capacity for development of feasible projects in the Nile Basin.

NBI Climate Change Strategy

The NBI Climate Change Strategy (NBI: 2013c) was developed as stipulated in the Nile Basin Sustainability Framework under its Key Strategic Direction 4: "Climate Change Adaptation & Mitigation". The Climate Change Strategy forms an integral part of the landscape of NBI policies, strategies and guidelines and complements national efforts of NBI member countries. It focuses on trans-boundary water resources management as a strategic element of climate adaptation and low carbon development in the region. It integrates key strategic plans and activities of the NBI sub-programmes and provides a roader framework for action.

The overall goal of this strategy is to strengthen basin-wide resilience to climate change and ensure climate compatible water resource management and development.

There are five strategic objectives that govern NBI's climate change strategy. These are based on the NBI's recognized and mandated role as well as the climate specific guiding principles:

- Objective 1: Strengthen the knowledge base to enhance common understanding of climate change risks and its impacts on water resources, ecosystems and the socio-economic system of the Nile Basin.

- Objective 2: Strengthen long-term capacities for addressing climate risks and uncertainty in the Nile Basin at national and trans-boundary levels.

- Objective 3: Support climate resilient planning and implementation addressing climate risks and uncertainty in NBI's programs.

- Objective 4: Promote scalable low carbon development through enhanced trans-boundary cooperation in areas such as protection of wetlands as well as clean energy use and development.

- Objective 5: Strengthen basin-wide climate finance access and the capacity for development of feasible projects in the Nile Basin.

In addition to the above basin wide policies and strategies, there are a number of core studies that include Eastern Nile Joint Multipurpose Program (JMP) -Scoping study; Strategic Perspectives and Options Assessment on Blue Nile Multipurpose Development, Working Paper 1, Environmental and Social Perspectives on Blue Nile Multipurpose Project Development ; Strategic Perspectives and Options Assessment on Blue Nile Multipurpose Development, Working Paper 2,Strategic Options Assessment of Blue Nile Multipurpose Project Development; Cooperative Regional Assessment for watershed management, irrigation and drainage and power trade program.

The above discourse shows that at basin and sub-basin levels appropriate policies and strategies including useful knowledge products are available to support a dam safety program that incorporates environment and social considerations.

At National level all the four countries of the Eastern Nile have water sector policies, environment policies and a number of legislation and guidelines exist in all countries except in South Sudan. However policies, legislation and institutional arrangements specific to dam safety do not exist in any of the Eastern Nile countries. In Ethiopia the Ministry of Water, Irrigation and Energy conducts dam safety inspections on a regular basis and now is working on a national dam safety guidelines in collaboration with the Ethiopian Committee on Large Dams (ETCOLD).

6.2. Key environmental and social issues

The following environmental and social issues should be recognized in the management of dams in the Eastern Nile countries.

6.2.1. Water security

- Cascade development is likely to have wide-ranging impacts on water security in the Eastern Nile Basin in both the short and longer term, depending on hydrological conditions and operation of dams. In the long term downstream countries may benefit from obvious and lasting benefits such as increased water security, dependable flood and sedimentation control;

- Filling strategy of dams should consider water security of downstream users. the filling strategy should also consider fulfilling the primary objective of the project such as early generation of power to achieve socioeconomic benefits to the owner of the dam; and

- In the longer term, after new reservoirs have been filled, there may be benefits from increased water security.

6.2.2. Access to water and livelihoods

- The presence of construction workers and job seekers during the construction of dams may pose a potential risk to family structures and social networks in the project affected areas;

- Cascade development will create employment, skills development and business opportunities and create an opportunity to up-grade and improve the existing infrastructure, provide an opportunity to provide a reliable and secure source of energy;

- Cascade development will affect recession agriculture. however the regulated water from cascade development will ensure sustainable irrigation for all involved in recession agriculture;

- The raising of dry season flows by regulation will ensure that water supplies are available for abstraction throughout the year; and offers protection from floods;

- Pumped irrigation will enable farmers to plant two crops per year, compared with one crop from flood recession; and

- Cascade developments upstream may impact on water level in the downstream dams during filling, reduce sediment, and regulate flow in the long term.

6.2.3. Water Quality

- Reservoirs may stratify during certain periods of the year resulting in the creation of an anoxic layer and may impact on aquatic species and human usage;

- Cascade development will trap the majority of the sediment generated in the upstream regions and increase flow levels during the low flow season;

- Water quality in downstream dams may decrease during filling and operation of the cascade development due to the decrease in water volume and reduced ability to dilute fertilizer runoff. However in the long run with the river flows regulated will increase the volume of water in downstream dams that may improve the quality of water.

6.2.4. Hydropower development

- The cascade development will create a major source of revenue through the sale of energy to users in the region;

- The reduction in sediment will enable downstream hydropower schemes to increase energy production; and

- The cascade development has the potential to reduce the energy produced by some downstream dams due to the lower reservoir levels during both the filling and operational phase.

6.2.5. Erosion and sedimentation

- Increasing population pressure in the upstream highlands will result in increasing erosion in the catchment of upper river basins;
- The release of water from reservoirs upstream associated with peak energy generation will result in bank and river bed erosion; and
- The combined impact of the cascade developments upstream are likely to reduce sediment inflows into downstream dams and will result in increasing the useful life of dams downstream.

6.2.6. Critical habitats, ecosystem functions and biodiversity

- The cascade development will change rivers from natural, fast flowing river to lake type habitat with increase in fish resources;
- Changes in flow regimes may negatively impact wetlands, increase fish resources, increase ground water recharges; and
- Change in flow regime during filling up and operation of dams upstream may negatively impact water quality, fish resources and increasing the lives of dams through reduction of sedimentation in downstream regions.

6.2.7. Vulnerable groups

- Cascade development will require resettlement of project affected populations;
- The cascade development will affect pastoralists in downstream regions due to impacts on wetlands, also result in higher flow levels during the low flow period which will impact on the ability of pastoralists to cross rivers and tributaries.

6.2.8. Dam safety

- The daily operation of upstream dams to produce peaking energy will have impacts on the river regime in the river channel immediately downstream;
- Catastrophic dam failure of the cascade development in upstream regions would pose risks to populations in downstream regions;
- A Dam Safety Monitoring and Emergency Response Plan should be prepared in consultation between the countries of Eastern Nile; and
- The downstream population should be informed of the emergency response plan and the required action in the event of a dam break.

6.2.9. Climate change

- Climate change and variations in annual rainfall events could affect reservoir filling; and

- For downstream countries the potential for improved water security during the operational phase of the cascade development has the potential to mitigate increased climate variability in both countries.

7. EASTERN NILE REGULATORY ASSESSMENTS

7.1. Dam Safety Legislation in the EN Countries

Dam owners normally have the prime responsibility to ensure that the capital asset is maintained in good condition and to minimize (within reasonable limits) any risk of damage to the asset and third parties. A dam safety program is intended to assist in achieving this goal via legislation, regulation and the dam owner's dam safety program.

In this section, comments on the existence of relevant dam safety legislation and institutional structures are presented for each EN country. In cases where dam safety is not mentioned *per se* in the existing legislation, it can sometimes be inferred in general terms from clauses which deal with:

- Obligation not to cause significant harm;
- Emergency situations.

At this stage, with the limited information available no comments are possible on the effectiveness of any dam safety regulatory authority can be given or whether there are specific dam safety guidelines which are applied.

7.1.1. Egypt

Four laws support the activities related to the water sector in Egypt. The legislation is clearly focussed on the major water use sector of irrigation as well as water quality matters.

Current policies of water resources management looks at the whole set of technical, institutional, managerial, legal, and operational activities required to plan, develop, operate, and manage the water resources system on both the national and local scales while considering all the sectors of the economy which depend on water.

However no mention was found on the issue of dam safety in any of the legislation and this need to be confirmed in further consultations.

Responsibilities for establishing, operating and maintaining dams appears to be defined primarily at the Ministry of Water Resources and Irrigation (MWRI) with the Ministry of Electricity and Energy (MoEE) responsible for hydroelectric projects.

The High and Aswan Dams Authority (HADA) drafted a project proposal for updating the monitoring systems of the High Aswan Dam focusing on rehabilitation of dam instruments and installing new monitoring instruments. Among the proposed project activities establishing guidelines and the methods of evaluation of regular dam safety program for the two dams has been proposed. Unfortunately the status of this proposed project could not be determined during this assessment.

7.1.2. Ethiopia

There is a relevant legislation in Ethiopia that states the responsibility of dam safety lies with the Ministry of Water, Irrigation and Energy. At the present there is no clear dam safety regulation or guideline to be followed in design, construction and operation of dams.

Several dams are currently under construction for hydropower, irrigation and water supply purposes by various owners and it appears that the dam safety requirements are therefore dependent on the owner or designer. No specific guidelines are used in the country to assure dam safety. In some cases ICOLD Bulletins may be referred to for design purposes.

The Ministry of Water, Irrigation and Energy of Ethiopia which is the federal organization established to undertake the management of water and energy resources of Ethiopia.

7.1.3. South Sudan

The Ministry of Electricity Dams, Irrigation and Water Resources (MEDIWR).MEDWIR is responsible for the development of vital water infrastructure investments, including rural water supply systems (boreholes) and small water distribution systems (SWDSs). It also oversees construction of Hafirs, dams, weirs, irrigation networks, flood management facilities such as dikes and gates, and river training and regulation works. The Ministry is also responsible for trans-boundary water resources management.

Apart from small dams for water supply, there are no major dams constructed in South Sudan due to the civil strife that continued for decades. This explains the lack of dam safety regulations development. But after the Comprehensive Peace Agreement (2005) several studies were done to establish the feasibility of generating hydropower from sites on Bahr el-Jebel, and multipurpose use on Bahr el-Ghazal and the Sobat. These projects were all under the Dams Implementation Unit at the national level in Khartoum. The greatest hydropower potential was found in Fula 1 on Bahr el-Jebel, with installed capacity of 900 MW. The Government of South Sudan, and MEDWIR for that matter, has prioritized this site to be considered under the current East Africa Northern Corridor Infrastructure Project established by Head of States Summit.

7.1.4. Sudan

"The National Water Policy Draft of 2000" (Sudan: 2000) has a hydropower section in which dam safety issues are addressed in the "Disaster Management and Public Safety" section of the policy. The section states that:

- A national "Disaster Management Plan" will be developed to enable both avoidance of disasters and effective response to disasters (which include floods and droughts which threaten the public safety and major structures such as dams and reservoirs).

- International cooperation is critical for proper and adequate response to natural and other disasters. The Sudan will seek to participate in and contribute to international efforts.

- In order to ensure adequate public protection, regulatory and administrative instruments which balance the cost of safety measures with an acceptable level of risk to public safety will be developed and implemented at national and federal level as appropriate.

The above mentioned disaster management and public safety matters are not yet in place and not formulated in a separate legislation addressing public safety in connection to dam safety. The dam safety is addressed only in the context of securing the structure itself and facilities contained therein. The dam operators therefore struggle to maintain the functionality of the dam and they are mandatorily obliged to report to the undersecretary of the MWRE about the day to day activities in relation to gate maintenance and water releases.

The Ministry of Water Resources and Electricity (MWRE) is responsible for planning, implementation, operation and management of water resources projects including projects with dams, hydropower and other hydraulic structures. The Ministry has also established major development projects unit such as "Merowe Dam Electricity Company" www.mdec-sd.com currently responsible for operation and maintenance of Merowe Power Station and Merowe Dam, and "Sudanese Hydro Generation Company Ltd." www.shgco-sd.com responsible for all hydro power generation plants in other dams in Sudan (Roseires, Sennar, Kashim el Girba and Jebel Aulia Dams) and there are plans to include the Dams housing these plants within their operation and maintenance responsibilities. These two companies are operating directly under the Ministry to operate and manage the hydropower stations and dams.

7.2. Dam Safety Programs in EN Countries

In addition to identifying and /or establishing suitable institutions, capacity building in dam safety management methods and practices is essential in all of the countries of the region. In addition to normal dam safety management issues, it is important in the EN situation that trans-boundary issues are considered in all programs and trainings in dam safety. In addition, environmental and social factors should be incorporated. In addition, it will be beneficial to be particular and selective in the individuals and institutions that are participating in the dam safety consultations and training activities making sure that they are relevant and dedicated persons and institutions that will continue in dam safety management in their respective countries.

7.2.1. Egypt

Literature review of Egyptian policies, legal framework and institutions shows that there are no policies and legislation directly referring to dam safety and there is no one institution responsible for dam safety. However, some elements of safety for the water structures (e.g. dams, barrages) have been considered in the Egyptian Code for Water Resources and Irrigation Works (Egypt: 2003).

There are well-established institutions in the field of water resources and irrigation, environment, water supply and sanitation. This also includes a number of government and non-governmental organizations dealing with environment and social aspects of water resources development. There are adequate legislations, decrees and guidelines addressing environmental and social issues of development projects.

The High and Aswan Dams Authority (HADA) drafted a project proposal for updating the monitoring systems of the High Aswan Dam focusing on rehabilitation of dam instruments and installing new monitoring instruments. Among the proposed project activities establishing guidelines and the methods of evaluation of regular dam safety program for the two dams has been proposed. Unfortunately the status of this proposed project could not be traced.

Some elements of safety for the water structures (e.g. dams, barrages) have been considered in the Egyptian Code for Water Resources and Irrigation Works (Egypt: 2003). It deals with detailed design requirements for each element in the barrages, including the various types of gates and deals with earthfill, rockfill, gravity and arch dams. It provides design guidelines and indicated in general the possible failure modes for earthfill and rockfill dams and addresses the settlement of rockfill dams. It focuses mainly on the design and construction stages. However, there are no guidelines on the operation and maintenance stages.

In practice, the design and implementation of the dam and barrages on the main Nile in Egypt are carried out by foreign international consultancy firms and international construction firms respectively. Both firms usually apply an international standard. However the Egyptian code is used to guide the design and construction of some small dams built for rainwater harvesting and torrential flood protection.

It is concluded that in Egypt there is substantial institutional capacity in the water resources arena, and several elements of a dam safety program are in operation with supportive policies and legal framework. However, it would be beneficial if more generally applicable dam safety regulations and guidelines were in place which were applied uniformly for all projects.

7.2.2. Ethiopia

There is a relevant legislation in Ethiopia that states the responsibility of dam safety lies with the Ministry of Water, Irrigation and Energy. At the present there is no clear dam safety regulation or guideline to be followed in design, construction and operation of dams.

Several dams are currently under construction for hydropower, irrigation and water supply purposes by various owners and it appears that the dam safety requirements are therefore dependent on the owner or designer. No specific guidelines are used in the country to assure dam safety. In some cases ICOLD Bulletins may be referred to for design purposes.

It is evident that there are policies and legal frameworks and readiness on the part of government institutions in Ethiopia to work towards a comprehensive dam safety program that integrates environment and social aspects of dam safety. There is capacity to establish an appropriate dam safety unit, with supportive policies and legal framework, to put in place a national dam safety program.

7.2.3. South Sudan

South Sudan is a new nation and has suffered over two decades of war and destruction and has been going through a post conflict recovery program and development.

It may seem premature for South Sudan to immediately launch a dam safety program. However a number of preparatory activities can be done in order to create an enabling environment for launching a national dam safety program.

1. Train a dedicated cadre of dam safety experts including provision of practical experience in order to develop in-house capacity for dam safety management;

2. Establish a dam safety unit in the Ministry of Electricity, Dams, Irrigation and Water Resources;

3. Adopt dam safety guidelines and conduct comprehensive training programs for the design and construction of new dams.

4. Develop frameworks for environment and social assessment and resettlement action plan in the context of the proposed dam sites and influence areas; and

5. Participate actively in the ENTRO dam safety program.

7.2.4. Sudan

The Ministry of Water Resources and Electricity (MWRE) is responsible for planning, implementation, operation and management of water resources projects including projects with dams, hydropower and other hydraulic structures. However, at this time, dam safety regulations have not been implemented.

There are numerous and relevant legislations, directives and acts with regards to dam safety as well as environmental and social aspects. There are also policies and legal frameworks and readiness on the part of government institutions in Sudan to work towards a comprehensive dam safety program that integrates environment and social aspects of dam safety.

It is concluded that in Sudan there is adequate institutional capacity, with supportive policies and legal framework, to put in place a national dam safety program

7.3. Environmental and Social Policies for Dams in EN Countries

The results of a literature review of Egyptian policies, legal frameworks and government and non-governmental organizations that deal with environment and social aspects of water resources development is presented for each EN country.

See **Appendixes C, D** and **E** for summaries of Policies, Laws and Articles, Legislation and Implementation Responsibilities, and List of Institutions with Responsibilities Related to Environment and Social Management, respectively.

7.3.1. Egypt

There are a number of government and non-governmental organizations that deal with environment and social aspects of water resources development in Egypt. There are legislations, decrees and guidelines addressing environmental and social issues of development projects. There are also well established institutions in the field of water resources and irrigation, environment, water supply and sanitation. Relevant institutions and policies are briefly outlined below.

Egyptian Environmental Affairs Agency (EEAA)

The central organization for environmental protection is the EEAA. This agency has an advisory task to the Prime Minister and has prepared the National Environmental Action Plan of Egypt 2002/17 (Egypt: 2002). According to Law 4 of 1994 (Egypt: 1994b), it has the enforcing authority with respect to environmental pollution except for fresh water resources. Law 4 of 1994 and its Executive Regulations (amended by Law 9 of 2009 – Egypt: 2009) is the framework environmental legislation in Egypt and provide the legal requirement for Environmental Impact Assessment.

The National Environmental Action Plan (Egypt: 2002) and the National Water Resources Plan (Egypt: 2005b) are the major policy documents affecting Environment and Social Management (ESM) in Egypt.

Ministry of Health and Population (MOHP)

The MOHP is the main organization charged with safeguarding drinking water quality and is responsible for public health in general. Within the framework of Law 48 of 1982 (Egypt: 1982b), this Ministry is involved in standard setting and compliance monitoring of wastewater discharges.

Ministry of Housing, Utilities and New Communities (MHUNC)

Within the Ministry of Housing, Utilities and New Communities, the National Organization for Potable Water and Sanitary Drainage (NOPWASD) has the responsibility for planning, design and construction of municipal drinking water purification plants, distribution systems, sewage collection systems, and municipal wastewater treatment plants.

Ministry of Water Resources and Irrigation (MWRI)

The Ministry of Water Resources and Irrigation (MWRI) has prepared a National Water Resources Plan till 2017 (Egypt: 2005b) including three main themes:

- optimal use of available water resources;
- development of water resources; and
- protection of water quality and pollution abatement.

Responsibilities for establishing, operating and maintaining dams appears to be defined primarily at the Ministry of Water Resources and Irrigation (MWRI) with the Ministry of Electricity and Energy (MoEE) responsible for hydroelectric projects.

7.3.2. Ethiopia

The Ethiopian Water Sector Policy (Ethiopia: 2001) includes the following with regards to environmental and social issues for Dams and Reservoirs Management and Operation:

1. Provide guidelines concerning dams and reservoirs operations and safety procedures as well as promote community participation in the development and management of such schemes."
2. Ensure and promote the safety of water retaining, transmission and diversion structures like weirs, barrages, dams, reservoirs and pipelines, against natural and manmade disasters for the:-
    - protection and conservation of the available water, the structures and all systems and equipment;
    - Protection of the environment, human settlements, flora and fauna, socio-economic infrastructures.
3. Establish preparedness and contingency plans for disasters and emergencies, in terms of :-
    - provision and continuation of services during and after emergencies,
    - plans for rehabilitation and repair of water systems,
    - protection of water bodies and water systems from pollution and depletion.
4. Provide corrective measures at the lowest practical cost while retaining project and environmental benefits.

5. Incorporate environmental studies as a component of the studies to be carried out for water resources development projects.

6. Adopt Environmental Impact Assessment (EIA) to serve as part of the major criteria in the evaluation and selection water resources development projects

In addition to the above policy and strategy provisions that have direct bearing on dam safety, Ethiopia has put in place a number of policies and legal framework with regards to environment and social aspects of water resources development.

These include the Environmental Policy of Ethiopia (Ethiopia: 1997), Environmental and Social Impact Assessment Guidelines for Dams and Reservoirs (Ethiopia: 2000b), Energy Policy issued in 1994, The Ethiopian Water Resources Management Policy (1999), Water Sector Strategy, Water Sector Development Program (2006-2016), National Proclamation on Water Resources Management (Ethiopia: 2000a), Water Resources Management Regulation (Ethiopia: 2005), Basin Organization Proclamation, Environmental Impact Assessment Proclamation (2002a) , Environmental Pollution Control Proclamation (2002b), Conservation of Wildlife Proclamation, Policy on Biodiversity Conservation and Research, Environmental Guidelines, National Biodiversity Strategy and Action Plan, Wildlife Policy.

7.3.3. South Sudan

The Ministry of Housing, Physical Planning, and Environment (MHPPE) is responsible for environmental protection and management, planning, development of action plans for policy implementation, and monitoring and evaluation of policy implementation programs. In this role it has prepared the draft South Sudan National Environment Policy (SSNEP) (South Sudan: 2011).

The following are important excerpts from the draft SSNEP:

"The goals of the draft SSNEP are to ensure protection and conservation of South Sudan's environment and ensure sustainable management of its natural resources to meet the needs of its present and future generations. The corresponding policy objectives include:

- *Improve livelihoods of Southern Sudanese through sustainable management of the environment and utilization of natural resources;*
- *Build capacity of the government at all levels of governance and other stakeholders for better management of the environment;*
- *Integrate environmental considerations into the development policies, plans, and programs at the community, government, and private sector levels; and*
- *Promote effective, widespread, and public participation in the conservation and management of the environment.*

Environment Impact Assessment (EIA):

- *Make the EIA process legally binding to all proposed projects;*
- *Develop capacity to monitor the state of the environment in South Sudan;*

- *Ensure that EIA guidelines for all sectors are developed; and*
- *Ensure stakeholder participation during the EIA process right from the begining to all proposed projects."*

It is commendable that South Sudan is able to put in place an environment policy given the challenges it has faced in the near past. .

7.3.4. Sudan

The relevant organizations with regards to dam safety, environment and social issues include the Higher Council for Environment and Natural Resources (under the Ministry of Environment and Physical Development, the Ministry of Water Resources, the Ministry of Agriculture and Irrigation; and the Dams Implementation Unit of the Ministry of Electricity and Water Resources.

There are numerous and relevant legislations, directives and acts with regards to dam safety that include: the Public Health Act (Sudan: 1975), Criminal Act (Sudan: 1991), Water Resources Act (Sudan: 1995a), National Water Corporation Act (Sudan: 1995), Environmental Health Act (Sudan: 1997a), Groundwater Act (Sudan: 1997b), Environment Protection Act (Sudan: 2001), Wildlife Protection and National Parks Act (Sudan: 1986), Forestry Act (Sudan: 1989), Forests and Renewable Natural Resources Act (Sudan: 2002).

8. DAM SAFETY ASSESSMENTS

As part of the situational analysis of dam safety in the Eastern Nile (EN), the Potential Failure Mode Analyses (PFMA) methodology was used as an assessment tool and analyses were conducted at a number of dams in Ethiopia and Sudan.

This process started with a training workshop on PFMAs and risk-informed decision making for Eastern Nile countries conducted during 27 January-1 February 2014 in Bahr-Dar, Ethiopia (Workshop No. 2). Koga Dam in Ethiopia was used as a practical example during the workshop and the dam was also visited. Then six dams were assessed by national teams, four in Ethiopia and two in Sudan using the PFMA methodology.

8.1. PFMA Key Concepts

As discussed during the training workshop the following key concepts are important when conducting a PFMAs:

- Perform the PFMA with a diverse team with appropriate knowledge and experience for all the components of the dam;
- Each time take a fresh look. Never assume that a dam is safe based on previous evaluations. Check the validity of previous analysis. Don't just accept the results on face value;
- Review background material diligently (by more than one qualified engineer). The appropriate time should be taken when doing the review;
- Involve operating personnel in the potential failure modes discussions. This will be invaluable training as well as an opportunity to tap their operational experience;

- Think beyond traditional analyses to potential failure modes;
- It is essential to understand all the possible failure modes (including the step by step progression to eventual failure) of all the components of a dam. It is usually helpful to separate the project into major components such as left embankment dam, spillway, buttress section, intake and powerhouse, right embankment dam etc.;
- Typically it is helpful to seek the potential failure modes of an existing dam in the following broad categories as suggested in the PFMA Template:
    1. Normal conditions and operations events - normal water level, structural instability, etc.;
    2. Ageing and/or deterioration initiated events – alkali-aggregate reactions, corrosion, internal erosion, etc.;
    3. Flood condition events – high water levels, spillway discharge, overtopping, etc.;
    4. Earthquake initiated events – during and after an earthquake event; and
    5. Other significant conditions – e.g. debris accumulation, siltation, human factors.
- For a dam that is under construction the above categories should be extended to address:
    6. Construction conditions; and
    7. First filling of the reservoir and commissioning of the project.
- For dams in planning or in design the same potential failure modes and broad categories used for existing dams should be used;
- The PFMA document should contain enough information to be a standalone document that could be used in future to understand the rationale behind the results, conclusions and recommendations. To satisfy this requirement it is essential to reference all results and conclusions especially when deciding not to consider particular PFMs. It is also important when referring to an analysis results in the Appendixes to provide a summary description of the scope, the assumptions, the methodology, the scenarios considered, the results and a high level assessment if the results is still applicable.

8.2. PFMA Training at Workshop No. 2

Workshop #2 of the ENTRO Dam Safety Project was held at Bhar Dar in Ethiopia in Jaunary 2014 and provided technical training and capacity building in the area of dam safety potential failure mode analysis (PFMA) and risk-informed decision making. The workshop was lead by Gregg Scott, from Denver, USA, who has been centrally involved in the development and application of PFMA and risk assessment methods at the U.S. Bureau of Reclamation (USBR). Participating engineers and scientists represented the countries of Egypt, Ethiopia, South Sudan, and Sudan.

The first day of the training focused on presentations dealing with potential failure mode analysis and semi-quantitative risk assessment. These included the following: (1) overview of the PFMA process, (2) assessing consequences of dam failure, (3) operational failure modes, (4) structural

failure modes, (5) internal erosion failure modes, (6) hydrologic failure modes, and (7) seismic failure modes. The day ended with a hands-on exercise using the Evans Creek Dam example. The participants were given a brief data package to review. Potential failure modes were identified in a group exercise. The participants were then divided into small groups to practice describing a potential failure mode. Finally, Gregg Scott facilitated the entire group through an analysis of one of the identified potential failure modes to illustrate the process.

The second day of the training began the three-day application of the PFMA process to Koga Dam, a nearby dam selected for the training, leading to a model report on day 5 for reference in subsequent PFMAs.

The initial phase of the Koga Dam PFMA focused on a review of background material for the dam. Several reports had been obtained describing project design and completion details. Due to the large number of participants at the workshop, they were divided into teams to research various aspects of the project including; (1) the dam, (2) the saddle dam, (3) the spillway and hydrology, (4) the intake tower and outlet, (5) project operations, and (6) downstream conditions and potential consequences.

The morning of day 3 was spent travelling to and from Koga Dam, and performing a brief examination of the dam, spillway, outlets, and related equipment and features.

The afternoon of day 3 was spent in the workshop meeting room identifying and screening potential failure modes for Koga Dam in a “brainstorming" session based on potential vulnerabilities determined from the data review and field examination. A total of 26 potential failure modes were identified. However, after discussion, this list was narrowed down to 5 potential failure modes for failure mode analysis. These were: (1) internal erosion through the right embankment foundation under normal operations, (2) sliding of the spillway crest structure under high pool or flood loading and subsequent erosion of the underlying soil, (3) internal erosion along the outlet conduit under normal operations, (4) stagnation pressure slab jacking during spillway releases and subsequent erosion of the underlying soil, and (5) embankment overtopping erosion under flood conditions.

Day 4 was spent conducting the potential failure mode analyses for the 5 potential failure modes identified the previous day. Gregg Scott facilitated the first potential failure mode analysis according to the procedures described during the day 1 presentations. Then each of the National Dam Engineering experts from Ethiopia, Sudan, and South Sudan facilitated a potential failure mode analysis with their national contingent. Gregg Scott provided some coaching and input, as did others in the room, and then facilitated the last potential failure mode analysis.

The first part of Day 5 was spent reviewing the PFMA results and identifying major findings and understandings. Then, while the PFMA report for Koga Dam was being prepared, Gregg Scott presented some additional material to the workshop participants. This included: (1) using the results of a PFMA to plan and execute instrumentation, surveillance, and monitoring program, (2) a framework for risk-informed decision making, and (3) assessing risks for certain potential failure modes (i.e. multiple spillway gates).

The morning of day 6 was spent reviewing the draft report for Koga Dam. Additional discussions were held concerning the PFMA process, potential failure modes, and report preparation.

The group was asked to identify key areas where further training on best practices would be beneficial to EN countries. These included:

- Application of dam safety assessment procedures to dams in the early planning, design and construction phases;
- Training for dam operators;
- Treatment of ageing processes in dams including such topics as material deterioration, loss of efficiencies in drains, etc;
- Seismic design and analysis;
- Bottom outlets;
- Roller Compacted Concrete (RCC) dams

The workshop was an intensive 5-1/2 days of presentations, group exercises, and practical applications of the PFMA methodology. In general, all participants were attentive, enthusiastic and focused throughout the workshop. Comments from the attendees during and at the end of the workshop indicated that the material was well received and valuable for future dam safety assessments. It was particularly pleasing to see the National Dam Engineering experts each successfully facilitate a potential failure mode for Koga Dam.

In the next stage of the Dam Safety Project national groups performed Potential Failure Modes Analyses on dams in their country. Workshop No. 2 was designed to provide a good foundation for this work. It was emphasized that successful outcomes will depend to a large extent on the facilitator and the dam engineering expertise of the core team for each dam.

Future PFMA participants were provided with the Koga Dam PFMA report (ENTRO, 2014a) as a model and a template for recording and reporting. Dr. Robin Charlwood and Mr. Louis Hattingh performed a home office review of the PFMA reports for consistency and technical content. In the future, the Eastern Nile Basin countries may wish to form a similar review group from the national PFMA teams. It will also be helpful if it will be possible to allow participants across national boundaries in the PFMA sessions. This should improve the results, improve consistency, and allow for learning from each other.

8.3. Initial Country PFMA Program

Following Training Workshop No.2, PFMAs were performed on six dams (4 dams in Ethiopia and 2 dams in Sudan) representing the range of different dam options in use in the EN sub-basin. PFMA reports were prepared by National Dam Experts for ENTRO for all six dams as referenced below, (ENTRO 2014b, c, d and e). The report for Finchaa, Amerti and Neshe Dams were combined into one report. These PFMA reports were then reviewed by the International Dam Specialists in a series of summary reports (ENTRO, 2014f, g, h and i).

These included existing dams as well as dams under construction:

- Ethiopia:
    - Tekeze Dam, a 188 m high concrete arch dam with a controlled spillway (ENTRO, 2014b and f);
    - Finchaa Dam, a 42 m high rockfill embankment with a central clay core and uncontrolled concrete ogee spillway (ENTRO, 2014c and g);

  - Amerti Dam, a 15 m high homogeneous earthfill embankment with a by-wash spillway (ENTRO, 2014c and g) ; and

  - Neshe Dam, a 38 m high homogeneous earthfill embankment with an uncontrolled morning glory spillway (ENTRO, 2014c and g).

- Sudan:

  - Roseires Dam, a 78 m high composite dam with a central controlled concrete buttress spillway section and earthfill embankment flanks. It is also important to note that this dam was recently raised to its current height (the raising was completed in 2012) (ENTRO, 2014d and h).

  - The Dam Complex of Upper Atbara which is currently under construction. This dam complex with a maximum height of 55 m consists of controlled concrete gravity spillway sections in the river sections with earthfill embankment flanks. Planned completion of the dam complex is 2015 (ENTRO, 2014e and i).

The following are summaries of the PFMA process followed in the different countries:

- In Ethiopia, basically the same PFMA team attended all the PFMAs. The majority of the PFMA team attended the PFMA training in Workshop No. 2. The PFMA workshop at Tekeze Dam was held over 4 days. At Finchaa, Amerti and Neshe Dams the PFMA workshop was combined for all three dams and was held for 3 and a half days. The PFMA reports for these 3 dams were also combined into a single report. It is clearly evident that the times spent on the PFMAs of the 3 dams were not sufficient and each dam should have its own PFMA report;

- In Sudan a completely different team attended each of the PFMAs. None of the PFMA participants attended the Workshop No. 2 training. The process outlined in the PFMA Report template was used generally but only a single day was used for the each PFMA process. The PFMA workshops were considered as an introductory training exercise into dam safety and the PFMA process in particular. As a result not all the components of the dams were considered during the PFMA processes; and

- No trans-boundary involvement took place during any of these PFMAs.

The following shortcomings with regards to the PFMA results were identified:

- In a lot of cases the Potential Failure Mode (PFM) descriptions was not sufficiently specific and also do not describe the potential failure mode but rather observations or causes of PFMs;

- Some of the PFMAs did not contain step by step descriptions of the failure progression. Insufficient time was spend in the PFMA process especially in Sudan where it was used as an introductory training exercise;

- Generalised statements are used rather than the preferred referencing;

- Not all the components of some of the dams were considered especially for the Sudanese dams (especially the concrete structures and the gated spillways); and
- For most of the dams insufficient technical information was available.

8.4. Conclusions from the Initial PFMA Program

The following important general conclusions were made from the results of the PFMAs:

- There was generally a lack of available technical information at the dams where the PFMA workshops were conducted;
- For the PFMAs to be effect tive, it is necessary to fully understand the failure mode in terms of its step by step progression from initiation to failure and its conequences;
- Structural and operational failure modes need to be identified and addressed thoroughly;
- It was noted that there is insufficient monitoring and surveillance at all the dams;
- There were a number of issues regarding operational staff, and
- Operational and Maintenance Manuals, Surveillance and Monitoring Plans and Emergency Action Plans need to be developed; and
- In general the PFMA reports lack the required detail and therefore should at this stage be considered to be preliminary but provide a good starting point for the proposed follow-up assessment programs.

However, it is noted that the issues with regards to quality and consistency of the end products during the initial implementation of the PFMA process are not unique to the this program. Experience has shown that it takes time and effort to successfully implement the process and the first products invariably is not as good as those produced after more experienced is gained.

Ultimately, many organizations/agencies (e.g. USBR, FERC, United States Army Corps of Engineers) that use PFMA and risk-informed decision making (RIDM) approaches to dam safety evaluations have decided that it is necessary to have a group of trained and approved facilitators who facilitate the evaluations to help ensure the quality and consistency of the products. The EN countries should consider a training and certification program to establish such a group of facilitators.

Both the USBR and Corps of Engineers have established groups or teams to perform high level quality and consistency reviews. Items reviewed by such groups or teams include whether the approved process was followed, whether the failure modes are adequately described, whether the results make sense and the case is adequately built, whether the recommendations are appropriate given the results, etc. This role is being filled to a limited extent by the International Consultants for the first round, but the EN countries should consider establishing such an oversight group.

The following important site specific conclusions were evident:

- Tekeze Dam:
    - The most likely PFM is sliding in the dam foundation. The failure likelihood is moderate (in the light of the opening up of the foundation on the upstream side shown by the extensometers and the possibility of increase of uplift as a consequence) and the consequences is very high;
    - The importance of monitoring and continuous proper interpretation of the monitoring results is also highlighted.
- Finchaa Dam:
    - The most likely PFM from the PFMA was overtopping failure of the embankment due to blocking of the spillway by the floating islands prevalent in reservoir. The failure likelihood is moderate and the consequences are very high. No detail information is available on the hydrology of the catchment or the capacity of the spillway; and
    - The failure likelihood of the piping failure through the central core of the embankment was only considered to be low even though a significant increase in seepage has been reported by the operational personnel. This PFM could be considered moderate to high in view of the reported increase in seepage and should be given its due consideration in future.
- Amerti Dam:
    - The most likely PFM from the PFMA was overtopping failure of the embankment due to blocking of the spillway by the floating islands prevalent in reservoir. The failure likelihood is moderate and the consequences are very high. No detail information is available on the hydrology of the catchment or the capacity of the spillway;
- Neshe Dam:
    - The most likely PFM from the PFMA was overtopping failure of the embankment due to blocking of the morning glory spillway by the floating islands prevalent in reservoir. The failure likelihood is high (could even be very high in light of the small spillway capacity relative to the un-routed PMF flood peak) and the consequences are very high; and
    - The failure likelihood of the piping failure through the embankment was only considered to be low to moderate even though no proper filter drain system exist and no monitoring is taking place at the dam. This PFM could be considered moderate to high.

- Roseires Dam:
    - PFMs for the concrete buttress dam or the spillway system were not considered for this report; and
    - The most likely PFMs from the PFMA for the earthfill embankments was piping failure through the sand layer in the foundation and overtopping failure of the embankments due to gate failure/malfunction. The failure likelihood is moderate and the consequences are very high.
- Dam Complex of Upper Atbara:
    - This PFMA was conducted on a dam complex under construction;
    - PFMs for the concrete gravity dam or the spillway system were not considered for this report; and
    - The most likely PFM from the PFMA for the earthfill embankments was piping failure through the sand layer in the foundation. The failure likelihood is moderate and the consequences are very high. One would have expected that for any new dam with very high failure consequences that the highest failure likelihood should be low or remote. In this case a failure likelihood of moderate was identified indicating a potential serious flaw in the design of the dam. The outcome also clearly illustrates the importance of using the PFMA concepts even during design and construction of new dams.

8.5. Recommendations for future EN PFMA Programs

The following recommendations are made:

- General PFMA and dam safety principles:
    - Collection and archiving design and construction information both at the owners project offices and at a national level;
    - The scope of the PFMA should include: detailed review of the design basis and selected basic calculations, construction records and photographs, proper review and interpretation of monitoring data especially where there is no technical information available. Also summarize the results of previous analyses in the PFMA report;
    - Surveillance and Monitoring Plans (SMPs) establishing appropriate surveillance of dams and reporting;
    - Operational and Maintenance (O & M) manuals to be compiled and implemented; and
    - Emergency Action Plans (EAP) to be compiled, implemented and tested.
- PFMA process capacity building in EN countries:

- A core group of dam safety experts as well as trained and approved facilitators is needed in the EN sub-basin. The EN countries should therefore consider a training and certification program to establish such a group of facilitators.

- Additional training should also be provided with regards to the PFMA process for the core group of dam safety experts especially refreshing of the key concepts, detail structural and operational failure modes and dam break and inundation mapping as well as for operational staff in appropriate operation, maintenance and monitoring;

- Establish groups or teams to perform high level quality and consistency reviews. Items reviewed by such groups or teams include whether the approved process was followed, whether the failure modes are adequately described, whether the results make sense and the case is adequately built, whether the recommendations are appropriate given the results, etc.

9. CONCLUDING REMARKS

The water resources infrastructure of the EN Basin countries comprises many existing dams with large water storage reservoirs. In addition to these major new dams are under construction and there are also additional development plans to be implemented in the basin. Many of these structures are located on the Abay/Blue Nile and Main Nile (a trans-boundary watercourse) and generate electricity, control flood, and supply water for agriculture, municipalities, industries, livestock, etc. It is important to note that for the large majority of these structures the consequences of a dam failure would be extremely high as they are all situated upstream of populated areas as well as large irrigation schemes.

Developments of large scale water infrastructure on trans-boundary rivers require careful coordination of dam safety-related planning and management. Proper operations and maintenance of these large water infrastructure coupled with recognition of impacts of climate change (intensive rainfall and flooding), is vital to minimise the risks of a catastrophic disaster affecting populations residing downstream of the dams.

Despite the growing number of water resource infrastructures in the EN countries, there is only limited regulation in each EN country. It is clear that comprehensive dam safety management programs are required for all existing and new large dams in all the EN countries, coupled with the necessary transfer of technological know-how to protect the assets and the public from dam failure.

In addition, there is no regional framework or institute responsible for dam safety management addressing the potential trans-boundary impacts of dam mis-operation or other safety incidents. It is therefore necessary to establish such a regional framework to increase the functionality and safety of the structures, the service they provide, and protect downstream communities who may be at risk if dam safety is compromised. This could be achieved through coordinated regional regulatory dam safety framework, which encompasses the technical, institutional and legal framework, and capacitated human resources.

Therefore, to reduce the risk of dam failure and accidents caused by uncoordinated operations and varying dam safety criteria and operational strategy in the Eastern Nile, it is important that ENTRO supports the implementation of a comprehensive dam safety framework, dam safety guidelines and implementation strategies and capacity building activities.

Guidelines on dam safety can be adapted from those that are available in the literature and guidelines for each of the Eastern Nile countries can be developed and implemented. These EN guidelines should address local conditions and incorporate trans-boundary issues that are particularly important in this area.

Safe design, construction and operation of dams in the EN also require a major program of capacity building. This should include ongoing training programs for all levels of personnel from management to field operators and maintenance staff.

A program to address these needs is outlined in the associated report to ENTRO, “A Roadmap for Preparation of a Regional Dam Safety Framework”.

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11. USEFUL WEBSITES

Websites used in the gathering of information for this Report are given below.

Australian National Committee on Large Dams (ANCOLD) www.ancold.org.au/

Canadian Dams Association (CDA) www.cda.ca

Department of Water and Sanitation, South Africa www.dwa.gov.za. For detailed information on dam safety and the activities of the Dan Safety Office go to www.dwa.gov.za/DSO/

Federal Energy Regulatory Commission (FERC) for Hydropower Projects http://www.ferc.gov/industries/hydropower.asp

Ethiopian Electrical Power Corporation (EEPCO) www.eepco.gov.et

Global Water Partnership www.gwp.org

International Commission on Large Dams (ICOLD) www.icold-cigb.net

International Law Association (ILA), www.ila-hq.org

International Network of Basin Organizations www.inbonews.org

Ministry of Water, Irrigation and Energy, Ethiopia www.mowr.gov.et

Ministry of Electricity Dams, Irrigation and Water Resources, South Sudan www.goss.org

Ministry of Water Resources and Irrigation, Egypt, www.mwri.gov.eg

South African National Committee on Large Dams (SANCOLD) www.sancold.org.za

Water Research Commission, South Africa www.wrc.org.za

World Bank www.worldbank.org

Appendix A

List of dams

Country name	Name of Dam	Year of Completion	Year of change 1	Change type 1	Year of change 2	Change type 2	Year of change 3	Change type 3	Planned year of completion	Design or construction	River	Basin	Dam Type	Detailed type	Sealing	Height of Dam (m)	Length of Dam wall	Reservoir Capacity (103 m3)	Purpose	Catchment area (km2)	Potential Consequences Classification
EGYPT	Assiut Barrage	1902									Nile	Main Nile	BM	Masonry	fm	16.0	800	NA	IHN	-	HIGH
EGYPT	Delta Barrages	1862									Nile	Main Nile	BM	Masonry				NA	IC	-	
EGYPT	High Aswan Dam	1970									Nile	Main Nile	ER/PG	Rockfill		111.0	3 830	162 000 000	IHC	2 200 000	VERY HIGH
EGYPT	Esna Barrage	1908									Nile	Main Nile	BM	Masonry	fm	16.0	865	NA	IC	-	
EGYPT	Damietta Barrage	1950									Damietta branch	Main Nile	TE/BM			15.0	360	NA	IC	-	
EGYPT	Rosetta Barrage	1985									Rosetta branch	Main Nile	BM			15.0	483	NA	IC	-	
EGYPT	Nag-Hamady Barrage	1930									Nile	Main Nile	BM	Masonry	fm	16.0	825	NA	IC	-	
EGYPT	New Esna Barrage	1994									Nile	Main Nile	ER/BM	Concrete		17.5	532	NA	ICNH	-	HIGH
EGYPT	New Nag-Hamady Barrage	2008									Nile	Main Nile	TE/BM/TE	Concrete		17.0	330	NA	ICNH	-	HIGH
EGYPT	Old Aswan Dam	1902	1912		1933						Nile	Main Nile	CB	Masonry	fc	36.0	1 950	5 000 000	IHC	2 200 000	
EGYPT	Zifta Barrage	1902	1954								Damietta branch	Main Nile	BM	Masonry				NA	IC	-	
EGYPT	Farascour Barrage	1989									Damietta branch	Main Nile	ER/BM	Concrete				NA	INX	-	
EGYPT	Edfina Barrage	1951									Rosetta branch	Main Nile	BM	Masonry				NA	NX	-	
ETHIOPIA	Alwero Dam	1996										Baro-Akobo-Soba	TE	Homogenous	he	14.0	4 100	75 000	I		HIGH
ETHIOPIA	Amerti Dam	1984									Amerti	Blue Nile	TE	Homogenous	he	15.8	740	110 000	IH		VERY HIGH
ETHIOPIA	Angereb Dam	1996									Angereb	Tekezze-Atbara	TE		he	34.0	420	6 000	S		VERY HIGH
ETHIOPIA	Arjo Dedessa									C		Abay	TE	Zoned	he	47.0	502	2 000 000	I		
ETHIOPIA	Chara Chara Weir	1997									Tana	Blue Nile	PG		hc	4.6	670		H		VERY HIGH
ETHIOPIA	Finchaa Dam	1973									Finochaa	Blue Nile	ER	Rockfill with central cla	ie	22.2	543	650 000	IH	2 500	VERY HIGH
ETHIOPIA	Grand Ethiopian Renaissance Dam									C	Blue Nile	Blue Nile	PG	RCC	hc	145.0	1 780	74 000 000	H		
ETHIOPIA	Koga Dam	2006									Koga	Blue Nile	TE	Zoned	ie	21.5	1 855	77 000	I		VERY HIGH
ETHIOPIA	Megech									C	Megech	Abay	TE	Zoned	ie	76.0	890	1 800 000	I		
ETHIOPIA	Midimar Dam	1999									Maria Shewito	Tekezze-Atbara	TE	Zoned	ie	33.0	380	10 000	S		VERY HIGH
ETHIOPIA	Nekempte Dam	2008										Blue Nile	PG	Masonry	hx				S		
ETHIOPIA	Neshe Dam	2010										Blue Nile	TE	Homogenous	he	38.0	1 010	448 000	IH	330	VERY HIGH
ETHIOPIA	Ribb Dam											Abay	TE	Zoned	ie	73.2	800	234 000	I		
ETHIOPIA	Tekeze Dam	2009									Tekeze	Tekezze-Atbara	VA	Double curvature arch	hc	188.0	420	9 310 000	H	30 390	VERY HIGH
SUDAN	Jebel Aulia Dam	1937									White Nile	White Nile	PG/TE	Zoned+Masonry+Zoned	he	39.0	5 000	2 540	HC		VERY HIGH
SUDAN	Khashim el Girba Dam	1964									Atbara River	Tekezze-Upper At	TE/CB/TE	Zoned+RCB+Zoned	he	50.0	3 850	600	IH		VERY HIGH
SUDAN	Merowe Dam	2009									Nile River	Main Nile	TE/ER/PG/TE/ER	Zoned+CFRD+RCPG+EC	he/fc/ie/fc/h	67.0	9 300	12 400	H		VERY HIGH
SUDAN	Roseires Dam	1966	2012	H							Blue Nile	Blue Nile	TE/CB/TE	Zoned+RCB+Zoned	ie	78.0	25 125	6 000	IH	250 000	VERY HIGH
SUDAN	Dam Complex of Upper Atbara								2015	C	Setit, Upper Atbar	Tekezze-Upper At	TE/CB/TE	Zoned+RCB+Zoned	ie	54.0	13 000	3 700	IH	100 000	VERY HIGH
SUDAN	Sennar Dam	1926									Blue Nile	Blue Nile	TE/PG/TE	Zoned+Masonry+Zoned	he	39.0	3 025	375	IH		VERY HIGH
SUDAN	Kajbar Dam									D	Nile River	Main Nile	ER/PG/ER	Zoned+RCPG+Zoned	ie	31.0	2 930	678	H		
SUDAN	Sheraik									D	Nile River	Main Nile	ER/PG/ER	Zoned+RCPG+Zoned	ie	44.0	3 065	2 687	H		

The following ICOLD terminology is used to describe details in the table above.

DESIGN OR CONSTRUCTION

- C : under construction
- D : in design but not yet under construction

DAM TYPE

- CB: buttress dam
- BM: barrage
- ER: rockfill dam
- MV: multiple arch
- PG: gravity in masonry or concrete
- TE: earth
- VA: arch
- XX: unlisted

When a dam is composed of several types of structures, they are described from the right bank to the left bank with various types separated by a slash. For example TE/PG/TE is a dam with a central part as a gravity dam and two wings in earth.

PURPOSE

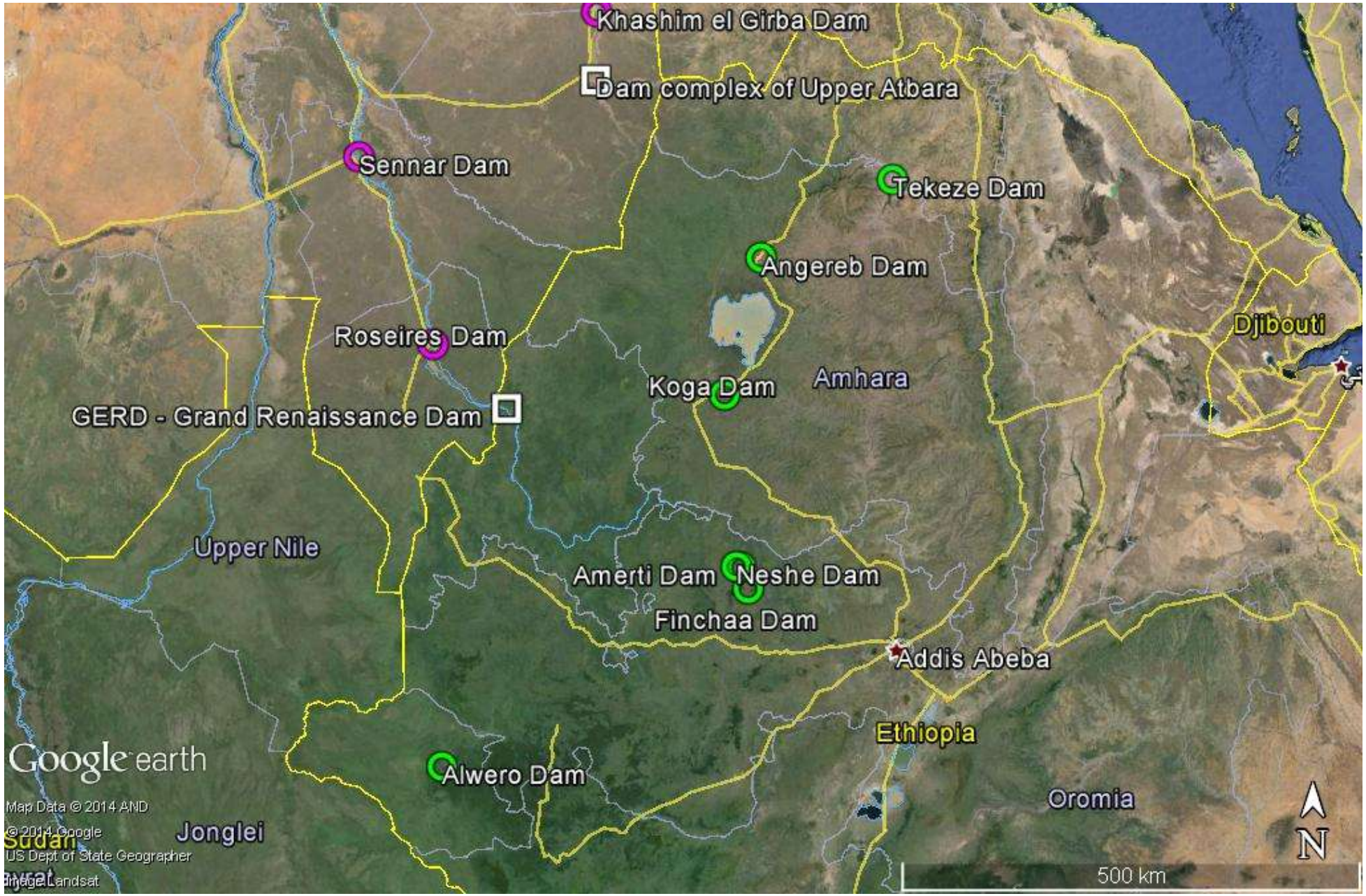
- C: flood control
- I: irrigation
- H: hydroelectric
- F: fish farming
- N: navigation
- R: recreation
- S: water supply
- X: others or unlisted

When a dam has several purposes, these purposes are indicated with a combination of these letters without any separator, beginning with the most important purpose of the dam and ending with the least important purpose. For example “HIS” is for a dam used for hydropower and secondary purposes in irrigation and water supply.

Appendix B

Location of dams


Edfina Barrage
Farascour Barrage
Gaza Strip
Israel
Jordan
Alexandria
Zifta Barrage
Delta Barrages
Rosetta Barrage
Al Jowf
Giza
Tabuk
Assiut Barrage
Egypt
New Nag-Hamady Barrage
Nag-Hamady Barrage
New Esna Barrage
Esna Barrage
Al Madinah
New Valley
Old Aswan Dam
High Aswan Dam
Google earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2014 ORION-ME
US Dept of State Geographer
Image Landsat
N
600 km


Khashim el Girba Dam
Dam complex of Upper Atbara
Sennar Dam
Tekeze Dam
Angereb Dam
Roseires Dam
Djibouti
Amhara
Koga Dam
GERD - Grand Renaissance Dam
Upper Nile
Amerti Dam
Neshe Dam
Finchaa Dam
Addis Abeba
Ethiopia
Alwero Dam
Oromia
Jonglei
Google earth
Map Data © 2014 AND
© 2014 Google
US Dept of State Geographer
Image Landsat
N
500 km


Kajbar Dam
Merowe Dam
Sheraik Dam
Eritrea
الخرطوم
أسمرة
Jebel Aulia Dam
Khashim el Girba Dam
Sudan
Dam complex of Upper Atbara
Sennar Dam
Tekeze Dam
Angereb Dam
Roseires Dam
Koga Dam
GERD - Grand Renaissance Dam
Google earth
Map Data © 2014 AND
Image Landsat
US Dept of State Geographer
© 2014 ORION-ME
700 km
N

Appendix C

Summary of Articles, Policies, and Laws Related to Environmental and Social Management

Type	Egypt	Ethiopia	Republic of the Sudan	Republic of South Sudan
Relevant Constitutional Articles	Provisional Constitution of the Arab Republic of Egypt, 2011 (based on Constitution of 1971) Article 4 – economic development, social justice, and rights to property Article 8 – equality of opportunity for citizens Article 23 – fair distribution of wealth and higher living standards Article 27 – participation Article 29 – ownership Article 34 – expropriation Article 40 – equality before the law Article 59 – safeguarding the environment Article 151 – international treaties	The Constitution of Federal Democratic Republic of Ethiopia, 1995 Article 25 – Right to Equality Article 26 – Right to Privacy Article 40 – Right to Property Article 41 – Economic, Social and Cultural Rights Article 42 – Rights of Labour Article 43 – Right to Development Article 44 – Environmental Rights Article 86 – Principles for External Relations Article 89 – Economic Objectives Article 90 – Social Objectives Article 91 – Cultural Objectives Article 92 – Environmental Objectives	Comprehensive Peace Agreement, 2005 (including Machakos Protocol, 2002) Interim National Constitution of the Republic of Sudan, 2005 Article 7 – equality of citizens Article 10 – economic development, eradication of poverty, equitable distribution of wealth Article 11 – clean and diverse environmental, sustainable utilization of natural resources Article 12 – social justice Article 17 – promote international cooperation and economic integration Article 23 – duties to preserve natural environment Article 43 – right to own property, expropriation Article 185 – principles for equitable sharing of resources and common wealth Article 186 – land regulation	Interim Constitution of Southern Sudan, 2005
Policies, Plans, and Strategies	National Environmental Action Plan (2002-2017) National Water Resources Plan (2005)	Environmental Policy of Ethiopia, 1997 Water Resources Policy, 1999	National Plan for Environmental Management 2007 Forest Policy, 1986, updated	Forest Policy, 2007 Official circular, 2006 Ministerial Decree, 2006

Type	Egypt	Ethiopia	Republic of the Sudan	Republic of South Sudan
		Water Sector Strategy, 2001 Water Sector development Programme, 2000 Sustainable Development and Poverty Reduction Program	Statement in 2006 National Water Policy (1992) National Water Policy (Draft) of 2000	
Main EIA Requirement/Environmental Management Law	Law No. 4/1994 for the Protection of the Environment, amended by Law No. 9/2009)	Proclamation No. 300/2002 Environmental Pollution Control Proclamation No. 299/2002 Environmental Impact Assessment Proclamation Proclamation No. 295/2002 Establishment of Environmental Protection Organs	Environmental Protection Act, 2001	Investment Act, 2004
EIA Guidelines	Guidelines of Principles and Procedures for Environmental Impact Assessment, 2009	Environmental Impact Assessment Guideline Document, 2000		
Other Environmental Laws, Regulations, and Decrees	Law No. 117/1983 on Cultural Heritage Law No. 102/1983 on Natural Protectorates Law No. 124/1983 on Fisheries Law No. 48/1982 on Protection of Nile and its Waterways Law No. 137/1981 on Labor Law No. 27/1978 on Public Water Sources	Proclamation No. 513/2007 Solid Waste Management Proclamation No. 9/1995 Proclamation No. 94/1994 Forestry Conservation, Development, and Utilization Proclamation No. 92/1994 Water Resources Utilization Penal Code Proclamation 1957	Forests and Renewable Natural Resources Act, 2002 Seeds Law 1990 Forests Act No. 14, 1989 Environmental Health Act, 1975 Law No. 37/1974 on Pesticides Law No. 18/1974 on Quarantines	Forestry Commission Act, 2004 Forestry Training Centre Act, 2004 Timber Utilization and Management Act, 2003 Customary law

Type	Egypt	Ethiopia	Republic of the Sudan	Republic of South Sudan
	Law No. 31/1976 on Public Cleanliness Law No. 66/1973 on Transport Air Pollution Law No. 38/1967 on Public Cleanliness Law No. 53/1966 on Agriculture Law No. 93/1962 on Wastewater and Drainage		Freshwater Fisheries Act, 1954	
Social/Resettlement Laws, Regulations, and Decrees	Egyptian Civil Code Law No. 3/1993 Physical Planning Law Prime Ministerial Decree No. 160/1991 Prime Ministerial Decree No. 2166/1994 Law No. 27/1956 Law No. 557/1954 Law No. 10/1990 for the Expropriation of Ownership for Public Interest Decree No. 358/2008	Civil Code of Ethiopia Proclamation No. 455/2005 on Expropriation of Land Holdings for Public Purposes and Payment of Compensation Council of Ministers Regulation No. 135/2007 on Expropriation and Compensation Proclamation No. 456/2005 on Rural Land Administration and Land Use Plan for Accelerated and Sustained Development to Eradicate Poverty	Land Registration and Settlement Act, 1925 Land Acquisition Act, 1930 Unregistered Land Act, 1970 The Civil Transactions Act, 1984 Urban Planning and Land Disposal Act, 1994 Central Forest Act, 1932 Provincial Forest Act, 1932	
			Various land laws and land tenure arrangements at national and Southern Sudan levels	

Appendix D

National Environmental Legislation and Implementation Responsibilities

Principal Environmental Laws, Decrees, and Regulations - Egypt

Environmental Law	Date	Authority	Decress/Regulations	Implementing Agency
Law No. 4 on Environment	1994	Establishment of EEAA and Environmental Trust Fund; requirement of ESIA, regulation of air pollution, hazardous waste management, and marine pollution	Decres No. 338 of 1995 (Executive Regulations)	MoEA, EEAA
Law No. 117 on Cultural Heritage	1983	Preservation and management of cultural heritage	Presidential Decree No. 2828 of 1971 (cultural heritage)	Ministry of Culture, SCA
Law No. 102 on Natural Protectorates	1983	Designation and management of natural protectorates	Decrees designating sites	MoEA, EEAA
Law No. 124 on Fisheries	1983	Management and protection of fisheries and marine animals		Ministry of Agriculture and Land Reclamation
Law No. 48 on Protection of Nile and its Waterways	1982	Control of pollution of surface waters	Decree No. 8 of 1983 (standards for wastewater discharges to surface waters)	Ministry of Public works and Water Resources
Law No. 137 on Labor	1981	Control of work place safety and environment		Ministry of Manpower and immigration
Law No. 27 on Public Water Sources	1978	Protection of public water sources for drinking and domestic purposes	Decree No. 27 of 1966 (Supreme Com. for Water) Annex IV of 1975 (Standards for potable water)	Ministry of Health and Population Supreme Committee for Water
Law no. 31 on Public Cleanliness	1976	Control of solid waste management (amends Law No. 38 of 1967)		Ministry of Housing, Utilities, and Urban Communities
Law No. 66 on Transport Air Pollution	1973	Control of air pollution from transportation sources	Decress No. 864 of 1969 (Supreme Committee) Decree No. 470 of 1971 (ambient air standards)	Ministry of Health and Population Supreme Committee for Protection of Air

Environmental Law	Date	Authority	Decress/Regulations	Implementing Agency
Law No. 38 on Public Cleanliness	1967	Control of solid waste management (including hazardous waste)	Decress No. 134 of 1968 (waste from domestic and industrial sources)	Ministry of Housing, Utilities, and Urban Communities
Law No. 53 on Agriculture	1966	Regulation of purchase, importation, and handling of pesticides	Decree No. 50 of 1966 (registration and licensing requirements)	Ministry of Agriculture and Land Reclamation
Law No. 93 on Wastewater and Drainage	1962	Control of wastewater discharges and drainage to public sewers	Decree No. 643 of 1962 (standards for wastewater discharges to public sewers)	Ministry of Housing, Utilities, and Urban Communities

Principal Environmental Laws, Decrees, and Regulations - Ethiopia

Environmental Law	Date	Authority	Implementing Agency
Proclamation No. 513 Solid Waste Management	2007	Stipulates planning and movement of solid waste, standards for specific materials	EPA
Proclamation No. 300 Environmental Pollution Control	2002	General control of waste and pollution sources, state necessity for sectoral pollution standards	EPA
Proclamation No. 299 Environmental Impact Assessment Proclamation	2002	Requirement of EIA for development projects and public instruments	EPA
Proclamation No. 295 Establishment of Environmental Protection Organs	2002	Establishment of EPA and Environmental Council, designation of objectives, powers, and duties	
Water Resources Management Policy	1998	Environmental protection of water resources, appropriate water allocation	MoWRI
Environmental Policy of Ethiopia	1997	Definition of environment and natural resource base, sectoral policy guidelines	
Proclamation No. 9	1995	Definition of the Environment	
Proclamation No. 94 Forestry Conservation, Development, and Utilization	1994	Designation of forests, rules for conservation, management, and use	Ministry of Natural Resources Development and Environmental Protection

Environmental Law	Date	Authority	Implementing Agency
Proclamation No. 92 Water Resources Utilization	1994	Introduction of water permits	
Penal Code Proclamation	1957	Regulation of waste, water, and soil pollution	

Principal Environmental Laws, Decrees, and Regulations - Sudan

Environmental Law	Date	Authority	Implementing Agency
Forestry Commission Act	2003	Established forest commission for regulation, management, and utilization of forests	Forestry Commission
Environmental Protection Act	2001	Framework environmental law, compliance with international conventions	HCENR
Seeds Law	1990		Ministry of Agriculture
Forests Act No. 14	1989		
Environmental Health Act	1975	Measures for water pollution control and drinking water safety	By Locality
Law No. 37 on Pesticides	1974		Ministry of Agriculture
Law No. 18 on Quarantines	1974		Ministry of Agriculture
Freshwater Fisheries Act	1954	Regulate introduction of species, use of chemicals and equipment, licensing issues	Ministry of Agriculture, Food, and Natural Resources

Appendix E

Summary list of institutions with responsibilities related to Environmental and Social Management

Type	Egypt	Ethiopia	Republic of the Sudan	Republic of South Sudan
Potentially Relevant Institutions	Ministry of State for Envrionmental Affairs Egyptian Environmental Affairs Agency (EEAA) Ministry of Health and Population Ministry of water Resources and Irrigation Ministry of Electricity and Energy Ministry of Local Development Ministry of Tourism Ministry of Industry Ministry of Housing Utilities and Urban Communities Ministry of Interior Ministry of Manpower Ministry of Agriculture & Land Reclamation Ministry of Petroleum Ministry of Foreign Affairs Egyptian General Authority for Land Survey	Environmental Protection Authority (EPA) Ministry of Water Resources Development Ministry of Agriculture and Rural Development Ministry of Finance and Economic Development Ministry of Health Institute of Biodiversity Conservation Ethiopian Electric Power Corporation Water Supply and Sewerage Services Abbay River Basin Authority Regional Governments Woreda Administration & Agriculture and Rural Development Offices Municipalities Kebele Administrations Ministry of Capacity Building	Ministry of Environment, Forestry, and Physical Development Higher Council for Environmental and Natural Resources (HCENR) Ministry of Water Resources Ministry of Agriculture and Irrigation Forests National Corporation Ministry of Environment and Physical Development Ministry of Tourism and Wildlife Ministry of International Cooperation Ministry of Social Welfare, Women and Child Affairs State Council for Environment and Natural Resources Wildlife Conservation General Administration Antiquities and Museums National Corporation Dams Implementation Unit National Land Commission Institute of Environmental Studies	Ministry of Environment, Wildlife Conservation and Tourism (MEWCT) Directorate of Environmental Affairs Directorate of Wildlife Conservation Directorate of Tourism State-level Institutions

Type	Egypt	Ethiopia	Republic of the Sudan	Republic of South Sudan
			Sudanese Association for Combating Desertification Wildlife Society Environmentalist Society Sudan Environmental Conservation Society Civil Society	