BUSITEMA UNIVERSITY
Pursuing Excellence

FACULTY OF ENGINEERING

DEPARTMENT OF MINING AND WATER RESOURCES ENGINEERING

WATER RESOURCES ENGINEERING PROGRAMME

FINAL YEAR PROJECT PROPOSAL

Simulation and Design of cascade Dams' Hydro Control system

Case Study: River Nile Cascade System.

KADAPAWO GERALD OPOLOT

BU/UP/2013/277

Email: kadahunk@yahoo.com.; Tel.: +256 703843800/ +256 777978746

SUPERVISOR(S): **ENG. OKELLO GEATANO (*PE MASCE MUIPE RE)***

A final year project report submitted to the Department of Mining and Water Resources Engineering as a partial fulfillment of the requirements for the award of a Bachelor of Science degree in Water Resources Engineering

ABSTRUCT

Hydro Power plants utilize mechanical energy provided by water to generate electricity. In Uganda a number of hydro Power Plants have been constructed along the River Nile and even more are yet to be setup along the same valley of the river forming a cascade arrangement. It is because of this arrangement of Dams that the possibilities of hazards resulting from exceedingly excess discharge from one Dam due to either human errors or natural calamity say a Dam break, puts these class iii civil structures at danger. Other than the possibility of Dam breaks which may not be very likely, the natural flow regimes of the river can also easily be disrupted from the same causes resulting in interrupted power generation or destruction of the electro-mechanical and hydro-mechanical equipment.

"You can't make anything perfectly safe when you are dealing with unknown events like water, wind, and earthquakes," says Howard, a French engineer. (Howard, 2015)

It is therefore necessary to design special operation modes for optimum operation of such Hydropower Plants (HPPs) from the point of view of harnessing of hydropower potential of river Hydro Energetic Systems built upon. The various measures to simulate the operations and optimise the management of cascading HPPs have been proposed, including structural and non-structural Best Management Practices (BMPs). Different Computer models (software packages) have become useful tools for the analysis, evaluation and design of these BMPs. There has been development of numerical tools for simulating a wide range of free surface flows and transport phenomena and this one is intended for the specific case in Uganda's cascade dams.

The main objective of this study was to design an improved real time system (tool) that enables the management of water while optimising it for power generation and mitigation of the effects of a calamity especially in upstream Dam(s) with respect to the rest of the other Dams in the same cascade system.

The literature review discusses the historical background, principles of hydropower generation, components and structures of cascade Dams arrangement and their design requirements. It also describes what modelling and simulation entails and their relevance in this designing of the management tool.

This simulation has brought about economically feasible and efficient real time water optimisation and risk management tool that has been designed to improve on the

utilisation of water of River Nile to generate power and reduce the risk of effects that could result from failure in one Hydro Power Plant upon the rest in the same cascade and the environment at large.

Implementation improves the operation and management of Hydro Power Plants in the following ways:

I. Reduce the chances of over topping in any of the dams in the cascade.
II. Reduce chances of over flooding of any one reservoir.
III. Reduce the risk of dam wash away and failure of the structures.
IV. Reduce the chances of unnecessary spilling of water in the reservoirs.
V. Helps to guide decision making during capacity tests.
VI. Gives the required ranges of power on the grid each Dam must be generating at each instant and how much water is available.
VII. enables appropriate technical decision making that safe guard the Dam structure in place at a factor of safety appropriate against failure.

DEDICATION

I would like to dedicate this final year project to my family members (jopo), class mates, my supervisor, the department of Mining and Water resources engineering, Busitema University at large and the almighty Lord, the creator and the provider of knowledge and understanding of earth's complexities.

DECLARATION

I **KADAPAWO GERALD OPOLOT** hereby declare that, this report is a true work of my hands and has never been presented by any person or institution for an academic award

Signature: ....

Date: 29th | May | 2017

APPROVAL

This piece of work has been approved by;

Supervisor

ENG. OKELLO GEATANO

Signature……………………………………………

Date ………………………………………………

ACKNOWLEDGEMENT

In the first place, I would like to thank the almighty Lord, the creator and the provider of knowledge and understanding of earth's complexities.

I wish to extend special thanks to Bujagali Energy Limited for providing me with an opportunity to do my Industrial training from which I developed the idea of this project. Particularly to The General Manager-John Berry, The Technical Manager-Francis Mwangi, the engineers under training- Nankya Prosy & Busingwe Jonathan and all staff of O&M energy limited.

Sincere appreciations go to my Supervisor Eng. Okello Gaetano who ensured that I acquired full knowledge and assistance where I needed.

I would like to thank the stuff in the department of Mining and Water Resources engineering Busitema university especially Eng. Okello Geatano and other department lecturers for his guidance and assistance during proposal development.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF EQUATIONS

LIST OF TABLES

ACRONYMS

HPP - Hydropower Plant

BMPs - Best Management Practices

SCADA- Supervisory Control and Data Acquisition

MNL -Maximum Normal Level of the reservoir

PFL -Project Flood Level

IPB -Isolated Phase Bus B

EFL -Extreme Flood Level

PPE -Personal Protective Equipment

(H) -Head

UEGCL -Uganda Electricity Generation Company

UETCL -Uganda Electricity Transmission Company Limited

R -Hydraulic radius

1.0 CHAPTER 1

1.1 INTRODUCTION

This chapter gives an introduction and overview of the problems relating to Cascade arrangement of Dam system management. The introduction also gives the main and specific objectives of the designed simulation tool system. Furthermore, the aim and scope of the study as well as the outline of the thesis are presented.

1.2 BACKGROUND

Water is our most common natural resource and necessary for provision of hydraulic energy that is used in generation of Hydropower. It is therefore important to manage it well without letting it to be a catastrophe to the surrounding environment and affecting power generation.

A number of catastrophes have been registered in the world regarding cascade dam failures and water losses due to errors in operation caused by upstream dams in cascade. For example, the 1975 Banqiao and Shimantan cascade Dams catastrophe . (Alley, 2003)

This explains how critical it is to improvise remedies before catastrophe regarding dam failure or errors associated with operation need to be put in place.

The present situation of Reservoirs, channel systems management in Ugandan Dams along the river Nile is not very reliable in case of emergencies such as Dam breaks or exceedingly excess flows. The existing measures include loses in water in the reservoirs and in extreme cases may lead to halt in generation. In general, these HPPs need extra simulated real time systems that can be based on to either reduce or eliminate the effect of failure in operation of one dam on to others in Uganda.

Dams (or reservoirs) are just one of the many human activities that have significant influence on the world's water resources. Researchers are collectively turning their attentions to the River Nile because of the rapid development of hydropower projects that is currently taking place.

In addition, its noted that dams may work fine for many years, but they require proper design and maintenance, notes France. They fail quickly if they are overtopped by rising

6.0 REFERENCES

Alley, T. W. S. V. &. T., 2003. The Catastrophic Dam Failures in China in August 1975. *The Catastrophic Dam Failures in China in August 1975*, p. 20.

Anon., 1997. *Design and Analysis of Experiments, Third Edition, John Wiley..* Montgomery, D.C: s.n.

Anon., 2006. *"Low Water Levels Observed On Lake Victoria". USDA, (Washington, DC)..* s.l., s.n.

Anon., 2006. *BASICS OF HEC RAS RIVER ANALYSIS SYSTEM.* s.l.:s.n.

Anon., 2016. "Isimba Hydropower Project, Uganda".. *Power-technology.com (PTC)..*

Anon., 2016. (From Wikipedia, the free encyclopaedia) Bujagali Hydropower Plant.

Anon., 2016. (From Wikipedia, the free encyclopaedia) Bujagali Hydropower Station.

Anon., 2016. Busitema Lecture notes for Hydropower Development & Planning. In: s.l.:s.n., p. 56.

Anon., s.d. *: European Small Hydropower Association).* s.l.:s.n.

Anon., s.d. From Wikipedia, the free encyclopaedia.

Anon., s.d. From Wikipedia, the free encyclopaedia Nalubaale power station.

Anon., s.d. Main article: Kiira Hydroelectric Power Station.

Association, E. S. H., s.d. s.l.:s.n.

Howard, B. C., 2015. 4 Hidden Causes of Dam Failures.

Howard, B. C., 2015. 4 Hidden Causes Of Dam Failures.

http://www.hec.usace.army.mil/software), s.d.

maps, g., 2015. "Location of Bujagali Hydropower Station At Google Maps".

Maria, A., s.d. INTRODUCTION TO MODELLING AND SIMULATION.

Musingo, D., 2011. "Government plans to build power dam in Kamuli District".New Vision..

Mwangi S. Kimenyi and John Mukum Mbaku, 2015. *Governing the Nile River Basin: The Search for a New Legal Regime.* s.l., s.n.

O&M, 2009. *principles of hydropower generation.* s.l., s.n., p. 50.

paish, 2002. *Small hydro power: technology and current status).* s.l.:s.n.

Paish, 2002. *Small hydro power: technology and current status).* s.l.:s.n.

Technology, P., 2014. Bujagali Falls Hydropower Dam, Jinja, Uganda.

The Observer, m. y., 2016. "Isimba hydro plant to start power generation in 2016". The Observer (Uganda).

Tribune, i. H., 2006. *Britain had secret to cut flow of Nile River- newly opened official file.* s.l., s.n.

v.sundararajan, s.d. what is modelling and simulation engineering. *pune 411007.*

Vision, N., 2012. Owen Falls Dam. *Powering Uganda for Five Decades.*