



**BUSITEMA
UNIVERSITY**
Pursuing Excellence

**FACULTY OF ENGINEERING
DEPARTMENT OF WATER RESOURCES
ENGINEERING**

FINAL YEAR PROJECT REPORT

**DESIGN AND CONSTRUCTION OF A DRILLING
MACHINE FOR SHALLOW WELLS**

(CASE STUDY: SHYAULE VILLAGE, BUSIA DISTRICT)

BY

AFOYORWOTH SHIELLA

BU/UP/2019/1862

ESINGU EZEKIEL

BU/UP/2019/1890

LULE DAVID

BU/UP/2019/2536

SUPERVISORS:

MR. LUBAALE SOLOMON AZARIUS

MR. MASERUKA BENDICTO

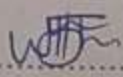
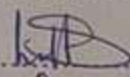

A final year project report submitted to the Department of Water Resources Engineering as a Partial fulfilment of the requirements for the award of a Bachelor of science degree in Water Resources Engineering of Busitema University.

ABSTRACT

Access to safe and portable water remains a major concern in Uganda. The government's limited efforts to provide adequate water supply demands the extensive usage of borehole drilling. However, manual drilling methods including hand digging frequently result in poor water quality. Furthermore, the exorbitant cost of imported drilling rigs makes them prohibitive to domestic drillers. To address this challenge, this project will design and build a drilling machine for shallow wells that will meet the needed drill diameter and depth of up to 20 meters while being economically feasible. The domestically manufactured drilling equipment provides a practical and cost-effective option for improving water accessibility, fostering technological growth in the country, and reducing reliance on costly imports.

DECLARATION

I **ESINGU EZEKIEL, LULE DAVID, AND AFOYORWOTH SHIELLA** declare that all the material portrayed in this project proposal report is ours and has never been submitted for award of any degree, certificate, or diploma to any university or institution of higher learning.

NAME	SIGNATURE	DATE
ESINGU EZEKIEL		06/11/2023.....
LULE DAVID		06/11/2023.....
AFOYORWOTH SHIELLA		06/11/2023.....

APPROVAL

This is to certify that the final year project report was written under the guidance our supervisor on the topic **“DESIGN AND CONSTRUCTION OF A DRILLING MACHINE FOR SHALLOW WELLS”**

Main Supervisor

Name: Mr. Lubaale Solomon Azarius

Busitema University Maritime Institute

Signature: 

Date: 07. NOV. 2023

Co-supervisor

Name: Mr. Maseruka Benedicto

Department: Water Resources Engineering

Signature: 

Date: 20/11/23

ACKNOWLEDGEMENT

We thank GOD the Almighty for the good health, the gift of life HE granted us, and the ability to reseQh and gather the information that is incorporated in this report.

We are deeply grateful to our dear supervisor: MR. LUBAALE SOLOMON AZARIUS and MR. MASERUKA BENDICTO for the guidance, support, time, knowledge, and advice readily provided to us during the preparation of this proposal. May the Almighty God bless you abundantly. More thanks extend to the entire staff of the Water Resources Engineering department and the entire university at large.

It goes without mentioning, the tangible effort our lovely PARENTS have dedicated to us reaching here. May GOD bless you abundantly.

Not forgetting our fellow students in the Water Resources class for their sustained support and corporation.

TABLE OF CONTENTS

Contents

ABSTRACT.....	i
DECLARATION.....	ii
APPROVAL.....	iii
ACKNOWLEDGEMENT	iv
List of tables.....	viii
List of Figures.....	ix
List of acronyms	x
CHAPTER ONE: INTRODUCTION.....	1
1.1 BACKGROUND.....	1
1.2 PROBLEM STATEMENT	3
1.3 JUSTIFICATION	3
1.4 OBJECTIVES	3
1.4.1 Main objective	3
1.4.2 specific objectives.....	3
1.5 SIGNIFICANCE	4
1.6 SCOPE OF THE STUDY	4
2 CHAPTER TWO: LITERATURE REVIEW	5
2.1 Wells.....	5
2.2 Shallow Wells.....	5
2.3 Well construction methods	5
2.3.1 Digging:	6
2.3.2 Boring:.....	6
2.3.3 Driving.....	6
2.3.4 Jetting:	6
2.3.5 Cable tool drilling:.....	7
2.3.6 Direct rotary drilling:.....	7
2.3.7 Reverse rotary drilling:.....	7
2.3.8 RESEQH GAP.....	8
2.4 Groundwater Availability Assessment	8
2.5 DRILLING BITS	9
2.5.1 Drilling Bit Classification.....	9
2.6 DRILLING MACHINE DESIGN STUDIES	13
2.6.1 Reseqh gap:.....	14

3	CHAPTER THREE: METHODOLOGY	15
3.1	Block diagram	16
3.2	Conceptual Diagram.....	17
3.3	Specific objective one: To conduct hydrogeological survey.....	17
3.3.1	Data types and sources	18
3.3.2	Groundwater availability assessment	20
3.3.3	Hydrological measurements	23
3.3.4	Soil sampling	24
3.4	Specific Objective Two: To Design the Components of The Drilling Machine	32
3.4.1	Design Considerations	32
3.4.2	Design Calculations.....	32
3.4.3	Modelling and Simulation	39
3.5	Specific Objective Three: To fabricate and assemble the components of the drilling machine....	40
3.5.1	Components of the drill machine.....	40
3.5.2	Material selection for all components	40
3.5.3	Fabrication of the machine components	41
3.5.4	Assembly of various machine components	41
3.5.5	System Construction.....	42
3.6	Specific Objective Four: To test the performance of the drilling machine.	42
3.6.1	Efficiency.....	42
3.6.2	Tests	42
3.6.3	To perform a cost benefit analysis of the system.....	42
4	CHAPTER FOUR: RESULTS AND DISCUSSIONS	45
4.1	Hydrological measurements.....	45
4.2	Developing thematic maps	45
4.3	GWPZ Delineation.....	49
4.4	Soil Shear Strength.....	50
4.5	Penetration Test	52
4.6	Swivel Leak Test	52
4.7	Winch Test.....	53
4.8	Wear Test.....	53
4.9	Machine Efficiency	54
4.10	To perform a cost-benefit analysis of the drilling machine.....	56
4.10.1	Payback period.....	56
5	CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS.....	57

5.1	CONCLUSIONS:	57
5.2	RECOMMENDATIONS	58
	REFERENCES	59
	APPENDIX	62

List of tables

Table 2-1: Drilling bit types	11
Table 2-2: Drilling Rig Designs	13
Table 3-1; Weighted overlay	23
Table 3-2: Columns' permissible compressive stress to slenderness ratio	36
Table 3-3: BOQ	43

List of Figures

Figure 2-1: Drag Bits	10	
Figure 2-2: Roller Cone Bit	10	
Figure 2-3: Diamond Bits	11	
Figure 3-1: V-shaped approach	15	
Figure 3-2: Engine-Rotary table motion linkage of the drilling machine.....	16	
Figure 3-3: Conceptual Diagram	17	
Figure 3-4: Groundwater Availability Assessment Steps.....	20	
Figure 3-5: Soil Layer one	Figure 3-6: Soil Layer two.....	24
Figure 3-7: Soil Layer Three	Figure 3-8: Soil Layer Four.....	24
Figure 4-1: Sope Map	Figure 4-2: Line Density Map.....	47
Figure 4-3: LULC Map	Figure 4-4: Soil Map.....	47
Figure 4-5: Soil Map	Figure 4-6: Geology Map	48
Figure 4-7: Drainage Density Map		48
Figure 4-8: Groundwater Potential Zones.....		49

List of acronyms

WOB-Weight on Bit

RPM - Rotational speed of revolutions per minute

UCS - unconfined comprehensive strength

SDGs – Sustainable Development Goals

USD – United States Dollar

GWPZ – Ground Water Potential Zones

USGS - United States Geological Survey

MCDM – Multicriteria Decision Making

MCDA – Multicriteria Decision Analysis

NMC- Natural Moisture Content

OMC – Natural Moisture Content

CBR- California Bearing Ratio

PL – Plastic Limit

PI – Plasticity Index

LL – Liquid Limit

LS – Linear Shrinkage

CHAPTER ONE: INTRODUCTION

This chapter is the general overview of the entire research study and it elaborates the background of the study, problem statement and objectives of the study, scope and justification of the study.

1.1 BACKGROUND

Water is one of the necessities of mankind hence both local governments, states, and nationals in every country work towards making portable water available for their populations(Dienagha *et al.*, 2013). Groundwater is critical for sustaining ecosystems and ensuring human adaptation to extreme and unexpected global environmental changes, particularly as surface water systems become increasingly unsustainable in the face of rapid population growth and climate change (Scanlon *et al.*, 2023). Globally, groundwater meets the domestic needs of approximately half of the world's population and its abstraction accounts for 33% of total withdrawals and provides water for agricultural (42%), domestic(36%), and industrial(27%)needs(Dangar, Asoka and Mishra, 2021). At least 20 countries have globally installed millions of pumps mounted on tube wells (drilled wells with pipe casing) to access shallow groundwater resources for machinated farming. More than 8 million hand-drilled wells in Bangladesh have been constructed, largely by small private businesses(Rural and Supply, 2017)

In Africa, the major source of water for agricultural and domestic use are surface and subsurface water sources. For most rural populations, surface water is readily available and water from this sources is not reliable for an all year round availability most times and could constitute health hazards(Babalola *et al.*, 2018). Ground water sources with exception of shallow wells however are for long term sustainable water supply because of their unique characteristics of all year around availability(Factors *et al.*, 2018). Accessing groundwater for domestic use includes digging a hand well, manually drilling a well, or using mechanized well drilling. In order to reach shallow groundwater resources, manual effort is required for both hand digging and manual drilling of wells. In specific geophysical circumstances, manual well drilling is the most suitable low-cost alternative available for individual small households to access groundwater resources(Weight, Yoder and Keller, 2013).

REFERENCES

- Adamu, F.A. and Stanley, I.O. (2012) ‘Development and performance evaluation of a mechanized hand borehole drilling rig in submerged areas of Nigeria’, *Journal of Emerging Trends in Engineering and Applied Sciences*, 3(4), pp. 708–710.
- Al-naft, O., The, B.C. and Drake, C. (1859) ‘Introduction , wellbores types and drilling methods’, pp. 1–16.
- Arnø, M. *et al.* (2019) ‘Design and Implementation of a Miniature Autonomous Drilling Rig for Drillbotics 2018’, *SPE/IADC International Drilling Conference and Exhibition*, p. D021S007R006. Available at: <https://doi.org/10.2118/194226-MS>.
- Authority, P.N. (2016) ‘1 . Introduction to Drilling Methods’.
- Babalola, A. *et al.* (2018) ‘Design of an Agricultural Tractor Mounted Prototype of a Water Drilling Rig’.
- Bowman, I. (2001) ‘Well-drilling Methods’, *United States Geological Survey*, pp. 7–135.
- Dangar, S., Asoka, A. and Mishra, V. (2021) ‘Causes and implications of groundwater depletion in India: A review’, *Journal of Hydrology*, 596, p. 126103.
- Dienagha, A.R.S. *et al.* (2013) ‘Design of A Portable Hydraulic Water Borehole Drilling Rig’, 4(14), pp. 18–27.
- Drill, K. (no date) ‘Drill String Design’, pp. 1–12.
- Factors, C. *et al.* (2018) ‘Makerere university’, (April).
- ‘FLOOD IMPACTS ASSESSMENT IN GALIRAAAYA AND BBAALE SUBCOUNTIES-KAYUNGA DISTRICTS ; AND PROBALE INTERVENTIONS DWRM November 2021 Prepared by ; Monitoring and Assessment Department List of Figures’ (2021), (November).
- Gebrie, T. and Getachew, G. (2019) ‘Journal of Hydrology : Regional Studies Groundwater potential assessment using GIS and remote sensing : A case study of Guna tana landscape , upper blue Nile Basin , Ethiopia’, *Journal of Hydrology: Regional Studies*, 24(April), p. 100610. Available at: <https://doi.org/10.1016/j.ejrh.2019.100610>.

Ghiselin, D. (1998) 'Drill bit technology--Still at the cutting edge', *Petroleum Engineer International*, 71(2).

Gobet, K.E., Lucas, S.G. and Lerner, A.J. (2006) 'Lungfish Burrows of Varying Morphology From the Upper Triassic Redonda Formation , Chinle Group , Eastern New Mexico', 2. *The Triassic-Jurassic Terrestrial Transition - I. Bulletin of the New Mexico Museum of Natural History and Science*, (October 2019), pp. 140–146.

Inyang, H.I. (2002) 'Developments in drag bit cutting of rocks for energy infrastructure', *International Journal of Surface Mining, Reclamation and Environment*, 16(4), pp. 248–260. Available at: <https://doi.org/10.1076/ijsm.16.4.248.8630>.

Jibrin, M.U. *et al.* (2013) 'Design and development of a crop residue crushing machine', *International Journal of Engineering Inventions*, 2(8), pp. 28–34.

Journal, I. *et al.* (2015) 'International journal of engineering sciences & reseQh technology study of the cracking energy dynamics with nominal diameter and masses of palm kernel nut during cracking', 4(1), pp. 405–412.

Khurmi, R.S. and Gupta, J.K. (2005) *A textbook of machine design*. S. Chand publishing.

Liu, R. *et al.* (2021) 'Design and ReseQh of Micro Pile Drilling Rig for UHV Transmission Line in Mountainous Area Design and ReseQh of Micro Pile Drilling Rig for UHV Transmission Line in Mountainous Area'. Available at: <https://doi.org/10.1088/1755-1315/668/1/012056>.

Methods, D. and Drilling, W. (2020) 'Details of Lecture Note (Lesson Plan) of Course No . IDE-302 1 . Degree Programme : B . Tech . (Ag . Engg .) 4 . Course Name : Ground Water Wells and Pumps 5 . Course code : IDE-302 6 . Topic Name : Lecture 12 . Different Methods of Well Drilling 7 . E'.

Missteat, B., Banks, D. and Clark, L. (2017) *Water wells and boreholes*. John Wiley & Sons.

Miyazaki, K. *et al.* (2019) 'Performance of polycrystalline diamond compact bit based on laboratory tests assuming geothermal well drilling', *Geothermics*, 80, pp. 185–194. Available at: <https://doi.org/https://doi.org/10.1016/j.geothermics.2019.03.006>.

richard oliver (dalam Zeithml., dkk 2018) (2021) '濟無No Title No Title No Title',

Angewandte Chemie International Edition, 6(11), 951–952., pp. 2013–2015.

Ross, C., Bird, J. and Little, A. (2021) *Mechanics of Solids, Mechanics of Solids*. Available at: <https://doi.org/10.1201/9781003128021>.

Rural, T. and Supply, W. (2017) ‘Rural Water Supply Network (RWSN)’, (November 2014).

Scanlon, B.R. *et al.* (2023) ‘Global water resources and the role of groundwater in a resilient water future’, *Nature Reviews Earth & Environment*, pp. 1–15.

Selvaraj, T. *et al.* (2022) ‘A Comprehensive Review of the Potential of Stepwells as Sustainable Water Management Structures’, *Water*, 14, p. 2665. Available at: <https://doi.org/10.3390/w14172665>.

Sharipovich, S.A. (2020) ‘Well drilling and drilling methods’, 7(7), pp. 82–83.

‘Soils for civil engineering purposes —’ (1990), (1).

Sun, P. *et al.* (2023) ‘Design and Implementation of a Chain-Type Direct Push Drilling Rig for Contaminated Sites’, *International Journal of Environmental ReseQh and Public Health*, 20(4). Available at: <https://doi.org/10.3390/ijerph20043757>.

UNICEF (2016) ‘Strategy for Water, Sanitation and Hygiene 2016-2030’, *UNICEF Website*, 20(2), pp. 1–60. Available at: https://www.unicef.org/wash/files/UNICEF_Strategy_for_WASH_2016_2030.PDF.

USGS (2019) ‘Drilling Methods Used by the Western Region ReseQh Drilling Program’.

Weight, E., Yoder, R. and Keller, A. (2013) ‘Manual well drilling investment opportunity in Ethiopia’, *IWMI Working Papers*, 155. Available at: <https://doi.org/10.5337/2013.210>.

Wells, W. *et al.* (2022) ‘Water Wells and Boreholes (second edition)’, (August 2011). Available at: <https://doi.org/10.1007/s10040-011-0729-y>.

Zacny, K. (2007a) ‘Coring basalt under Mars low pressure conditions’, *The Mars Journal*, 3(January 2007), pp. 1–11. Available at: <https://doi.org/10.1555/mars.2007.0001>.

Zacny, K. (2007b) ‘Methods for cuttings removal from holes drilled on Mars’, *The Mars Journal*, 3, pp. 42–56. Available at: <https://doi.org/10.1555/mars.2007.0004>.