



# PROFESSIONAL DRILLING MANAGEMENT ONLINE COURSE TRAINING MANUAL

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Source: Kerstin Danert

2022 COURSE SPONSORED BY:



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# PREFACE

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Dear participants and trainers,

Population growth, agricultural development and increasing living standards are among the many reasons for increased water demands year on year. At the same time climate change affects water availability and presents a risk for crop failure. In many cases, groundwater has the potential to meet additional demands for a comprehensive water supply. Furthermore, aquifers are the perfect climate adaptation infrastructure thanks to their ability to buffer droughts.

In many parts of the world groundwater resources are overused, with a resulting drop in groundwater levels. However, in some regions, especially within Sub Saharan Africa, groundwater resources have not been well developed, and actually have a huge potential to enable socio-economic development. More than 50% of the population in the rural areas on the African continent have currently no safe water supply. For these people, decentralized water supply through shallow wells is likely to be the only source for a safe and affordable domestic water supply. In addition, groundwater can also play an important role for small-scale farming. According to the World Water Development Report 2022 only 3% of Africa's agricultural land is irrigated, of which just 5% is irrigated by groundwater. There is a huge potential for groundwater to play a significant role for agricultural development, poverty reduction alongside, job creation and improved food security.

But how could groundwater resources be developed? Boreholes and wells are central to unlocking the benefits of groundwater for economic development and enhanced livelihoods. Whereas it may appear simple to drill a borehole, experiences show, that they are often not well sited, designed or developed, with an associated loss of productivity after a couple of years or less. Borehole siting, design and construction requires a certain level of expertise. Further, not every borehole is able to successfully provide water, and it is often drillers who bear the full risk of failure. Beyond the technical challenges, groundwater development needs a functioning legal framework that balances risks and costs for the well construction between drillers and those who finance the boreholes.

The training course that is set out in this manual enables drillers, water managers and water users to manage the major challenges associated with the planning and construction of boreholes. Furthermore, the manual provides insights into the enabling environment that is essential to drilling companies to set up their businesses and flourish, and this unlock groundwater for improved livelihoods wider socio-economic benefits.

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The first edition of the course in 2018 was developed within a Project Collaboration Agreement (PCA) between UNICEF and Skat Foundation, while the second edition of the course was made possible thanks to collaboration, financial and in-kind support from Skat Foundation, Lotteriefonds St.Gallen, United Nations High Commission for Refugees (UNHCR), WaterAid UK, Oxfam UK, the Water Integrity Network (WIN), the British Geological Survey (BGS), UNICEF and the Africa Groundwater Network (AGW-Net).

We gratefully acknowledge the contributions of various partners:



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# PURPOSE OF THIS MANUAL

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This manual has been prepared to enable education and training organisations, as well as other entities that would like to improve the skills and knowledge of staff and partners with respect to the professional management of borehole drilling projects and programmes. This manual, and an associated Folder of presentations and associated documents has been placed in the public domain for use, and adaptation as appropriate.

Each course module has a short orientation video and PowerPoint, and contains mandatory reading materials, videos and websites. There are also additional recommended materials given for those who wish to delve deeper into the specific module topics. It is the intention of the partners, that this course continues to run as an online course, and so some aspects of the course, notably quiz questions, and assignments<sup>1</sup>, are not included within this manual. Trainers who use this manual are encouraged to develop their own mechanisms to further support participant learning.

The course presented in this manual was designed for professionals who are already engaged in the management of water well drilling projects or programmes with an emphasis on low- and middle-income countries. They should either be already involved in drilling management or expect to undertake work in this area within one to three years. Target participants include government, NGO, UN and donor organisation staff, as well as those working in the private sector. Participants may be working in development or humanitarian aid/emergency contexts.

Participants were not expected to have an extensive prior knowledge of groundwater or water well drilling. A university degree is not essential for participation if individuals are professionally engaged in the topics or working in a related field, but they should have successfully completed at least 10–13 years of school education.

The folders with the core training materials can be downloaded from <https://ask-for-water.ch>, <http://agw-net.org/> and [www.rural-water-supply.net](http://www.rural-water-supply.net).

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<sup>1</sup> Assignments were included in the 2018 and 2019 facilitator-led courses, but not in the 2022 participant-led course.

## 2022 COURSE

The 2022 Online Course on Professional Drilling Management runs over a 17-week period from 24 June to 29 October, with modules opening as summarised in the GANTT chart below. Once open, each module remained so until the end of the course. The 209 participants were divided into four cohorts, with a lead facilitator and co-facilitators responding to questions in the respective cohorts.

		One week slots - where we expect the most interaction on the forum discussions										Two week slots - where we expect less interaction				Course ends
		27 Jun - 3 July	4 - 10 July	11 - 17 July	18 - 24 July	25 - 31 July	1 - 7 Aug	8 - 14 Aug	15 - 21 Aug	22 - 28 Aug	29 Aug - 11 Sept	12 - 25 Sept	26 Sept - 9 Oct	10 - 29 Oct	29.Oct	
Module 1	All Cohorts															
	Cohorts 1 & 2															
	Cohorts 3 & 4															
	Cohorts 3 & 4															
Module 2	All Cohorts															
	Cohorts 1 & 2															
	Cohorts 3 & 4															
	Cohorts 3 & 4															
Module 3	All Cohorts															
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	Cohorts 3 & 4															
	Cohorts 3 & 4															
Module 4	All Cohorts															
	Cohorts 1 & 2															
	Cohorts 3 & 4															
	Cohorts 3 & 4															
Module 5	All Cohorts															
	Cohort 1 & 2															
	Cohort 1 & 2															
	Cohorts 3 & 4															

All modules underwent peer review for the 2019 course, and again for this 2022 version.

The 2022 course also benefitted from the establishment of an advisory group, which brought together about 40 key stakeholders from the water and higher education sectors. The members provided expertise for the content, and methodology of the course, raised awareness of the initiative and stimulated interest in building professional capacity and raising 'groundwater literacy'. Thanks to the advisory group, there is broad ownership of this course, and the sister course in 'Groundwater Resources Management', which was also funded by BGR and managed by the same team.



# COURSE SUMMARY

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## Introduction

An estimated 50% of the global and 75% of the African population rely on groundwater for their drinking water supplies. This is likely to increase in the future, especially in the face of climate change, as groundwater resources are often less affected than surface water by climate change impacts.

Drilled water wells are vital to achieving universal clean drinking water, providing safe, affordable, reliable and available water sources. To ensure that the water wells, or boreholes, are built to last, they must be drilled, developed and completed in a professional manner. Key elements of a professional drilling sector are robust procurement, contract management, siting, borehole design, construction, and supervision. Furthermore, management of water resources must also be considered, while long-term maintenance support is key to maintain water supply services. The focus of this course on professional drilling management. Unfortunately, due to a lack of training and mentoring opportunities, in many countries, it is difficult to develop skills in this area.

This manual presents an introductory online course on how to professionally manage water well drilling projects and programmes. It will equip participants with knowledge on: groundwater data, siting, costing and pricing, procurement and contract management, borehole drilling and supervision and how professional water well drilling is affected by the wider legal and institutional environment.

This course has been designed a self-led. Participants have access to presentations, animated films and other educational materials and are expected to take quizzes, as well as engage in online discussion forums with one another. Participants receive limited feedback from facilitators in the online discussion forums. Through these mechanisms, participants learn about good drilling management policies and practices, and have the opportunity to reflect on those of their own contexts.

## Overview

This online course offers participants an introduction to the professional management of water well drilling projects and programmes. It provides an overview of what is required to improve professionalism in the organisations and countries in which they work. The course provides participants with an understanding of the following key elements: groundwater information, siting, costing and pricing, procurement and contract management, borehole drilling and supervision and how professional drilling is affected by the wider institutional environment. Throughout the course, the participants are required to reflect on the pros and cons of practices and policies in their own organisation, organisations that they work with and country. Using state-of-the-art materials, i.e. videos, documents, presentations and websites, the course builds up to the final modules where whereby participants are tasked with exploring actions that could be taken within their own organisations, local authority and/or country to improve borehole drilling professionalism.

## Learning objectives

By the end of the course participants will:

- Have an understanding of the key elements of a **professional** water well drilling sector.
- Understand key reasons for immediate and longer-term **borehole failure**.



- Recognise the value of groundwater **data** and know what constitutes good borehole siting.
- Appreciate the importance of drilling **supervision**.
- Learn about practices, initiatives and challenges to improve drilling professionalism from participants in **other countries**.
- Have improved knowledge to reflect on **procurement** and contract management
- Understand what constitutes a strong **institutional framework** (at national or state level) for borehole drilling, including driller licencing, borehole permits and associations.
- Have signposts for materials that support **further learning** on the topic.

## Course Modules

The five course modules are summarised below:

### Module 1: Introduction, Groundwater Data and Siting

This module provides participants with:

- an appreciation of the importance of groundwater for drinking water supplies in their own country
- an understanding of select key groundwater terms
- recognition of the value of groundwater data
- a basic understanding of what constitutes good borehole siting and how the siting process depends on the hydrogeological environment.

### Module 2: Procurement and Contract Management of Borehole Drilling

Upon completion, participants have a better appreciation of the financial risks of borehole drilling and know that there are different cost components to consider. They are thus able to reflect on the borehole drilling procurement and contract management processes within their own organisation.

### Module 3: Borehole Drilling and Supervision

By the end of this module participants understand some of the key technical reasons for immediate and long-term borehole failure and to appreciate the skills and equipment required to ensure that boreholes are drilled to a high quality. Participants appreciate the importance of drilling supervision; know the responsibilities of the drilling supervisor and the actions to be carried out at each stage to ensure that the driller delivers the borehole as specified in the contract.

### Module 4: Legal and Institutional Considerations

This module introduces participants to the key elements of the legal and institutional framework (at national or state level) that supports borehole drilling professionalism. These include driller licensing; borehole permits and national (or state level) associations.

### Module 5: Actions to Raise Drilling Professionalism

This module equips participants with a wider perspective of the groundwater development sector in the country in which they work. Participants will have opportunities to draw upon and integrate the knowledge developed through the previous modules, and engage in dialogue with others. The final quiz will focus on potential actions that could be taken to improve borehole drilling professionalism in the context in which they work.

## Module Details

### Module 1: Groundwater Data and Siting

<b>Introduction</b>	<p>Groundwater is crucial for domestic water supplies around the world, serving about 50% and 75% of the global and African populations respectively, and its importance continues to grow. In places where it is readily available and of good quality, groundwater can be a reliable resource for a water supply service. However, groundwater varies in terms its quality and of the quantity that can be extracted. A drilled well or borehole needs to be properly located in order to provide a good supply of water, and so reliable information about the groundwater (also referred to as the hydrogeology), coupled with the use of proper siting procedures is very important.</p> <p>Groundwater scarcity, pollution and environmental sustainability are major concerns in some places, while in others, the inadequate understanding of groundwater resources actually undermines its potential to contribute to social and economic development.</p>
<b>Module goal</b>	<p>This module introduces participants to groundwater information and borehole siting. This module sets out to will provide participants with:</p> <ul style="list-style-type: none"> <li>▪ an understanding of key groundwater terms</li> <li>▪ recognition of the value of groundwater data</li> <li>▪ knowledge of what constitutes good borehole siting and how the siting process depends on the hydrogeological environment</li> <li>▪ an appreciation of the importance of groundwater for drinking water supplies in their context.</li> </ul>
<b>Learning objectives</b>	<p>By the end of this module participants are expected to:</p> <ul style="list-style-type: none"> <li>▪ Understand the importance of groundwater data, and see some of the different formats in which it can be presented.</li> <li>▪ Appreciate how groundwater data can be used.</li> <li>▪ Know the steps involved to locate optimum sites for productive boreholes and appreciate that they include technical as well as socio-cultural aspects.</li> </ul>
<b>Orientation video</b>	Module 1 – Orientation ( <i>ZIP-Folder</i> )
<b>Mandatory videos and readings</b>	<ol style="list-style-type: none"> <li>1. UNESCO (2015) <b>Groundwater, the Hidden Resource</b>, <a href="https://www.youtube.com/watch?v=5wb-CgQdG6o&amp;t=112s">https://www.youtube.com/watch?v=5wb-CgQdG6o&amp;t=112s</a></li> <li>2. UNICEF/Skat Foundation (2016) <b>Value Groundwater data and use groundwater information in</b> UNICEF/Skat Foundation (2016) Professional Water Well Drilling: A UNICEF Guidance Note (pp 17 to 21) <a href="https://www.rural-water-supply.net/en/resources/details/775">https://www.rural-water-supply.net/en/resources/details/775</a></li> <li>3. RWSN (2015) <b>Drilling, the importance of good borehole siting</b> <a href="https://vimeo.com/126795160">https://vimeo.com/126795160</a></li> <li>4. CARTER, CHILTON, DANERT AND OLSCHESKI (2010) <b>Siting of Drilled Water Wells. A Guide for Project Managers</b> <a href="http://www.rural-water-supply.net/en/resources/details/187">http://www.rural-water-supply.net/en/resources/details/187</a></li> </ol>
<b>Learning videos (optional)</b>	For participants fairly new to the topic of groundwater, here are three SHORT introductory videos:

	<ul style="list-style-type: none"> <li>▪ KQED QUEST (2017) <b>What is Groundwater?</b> <a href="https://www.youtube.com/watch?v=oNWAerr_xEE">https://www.youtube.com/watch?v=oNWAerr_xEE</a></li> <li>▪ UPGRO (2020) <b>Introducing groundwater</b> <a href="https://www.youtube.com/watch?v=ai7KuzOwgcc">https://www.youtube.com/watch?v=ai7KuzOwgcc</a></li> <li>▪ GeoScience Videos (2016) <b>What is an Aquifer (USA context)?</b> <a href="https://www.youtube.com/watch?v=g7R0yLX0V9E">https://www.youtube.com/watch?v=g7R0yLX0V9E</a></li> </ul>
<b>Recommended readings</b>	<ul style="list-style-type: none"> <li>▪ MACDONALD, A. DAVIES, J., CALOW R and CHILTON (2005) '<b>Chapter 9 – Learning lessons</b>' in <i>Developing Groundwater, A guide for rural water supply</i>, Intermediate Technology Group Publishing (free e-book) <a href="https://practicalactionpublishing.com/book/489/developing-groundwater">https://practicalactionpublishing.com/book/489/developing-groundwater</a></li> <li>▪ MACDONALD, A. DAVIES, J., CALOW R and CHILTON, J (2005) '<b>Chapter 5 - Finding groundwater</b>' in <i>Developing Groundwater: A guide for rural water supply</i>, Intermediate Technology Group Publishing, (free e-book) <a href="https://practicalactionpublishing.com/book/489/developing-groundwater">https://practicalactionpublishing.com/book/489/developing-groundwater</a></li> <li>▪ UNICEF/SKAT FOUNDATION (2018) '<b>Module 3: Borehole Siting and Drilling Supervision Consultancy</b>' in <i>Borehole Drilling – Planning, Contracting &amp; Management: A UNICEF Toolkit</i>, by UNICEF and Skat Foundation <a href="https://www.rural-water-supply.net/en/resources/details/826">https://www.rural-water-supply.net/en/resources/details/826</a></li> </ul>
<b>Recommended web sites</b>	<ul style="list-style-type: none"> <li>▪ <b>BGS Africa Groundwater Atlas Home</b> [Online] <a href="http://earthwise.bgs.ac.uk/index.php/Africa_Groundwater_Atlas_Home">http://earthwise.bgs.ac.uk/index.php/Africa_Groundwater_Atlas_Home</a></li> <li>▪ BGR and UNESCO (2016) <b>World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP)</b> [Online] <a href="https://www.whymap.org/whymap/EN/Home/whymap_node.html">https://www.whymap.org/whymap/EN/Home/whymap_node.html</a>; choose Map applications/services; choose WHYMAP viewer; choose WHYMIS in bottom left menu; and then tick the box to left of the word 'WHYMIS' that appears mid-bottom of screen (also 'Countries' below this is ticked) – a yellow overlay map appears; Click on any country – a pop up box appears with a list of hydrogeological maps available for that country and the scanned map &amp; scanned legend</li> </ul>
<b>Recommended videos</b>	<p><b>For participants who want to learn more about different types of groundwater</b></p> <ul style="list-style-type: none"> <li>▪ Aquifer Characteristics (video of module 1 of the groundwater resources management course 2022 – in ZIP Folder)</li> </ul>
<b>Take home messages</b>	<p>The key points to note from this first module are that:</p> <ul style="list-style-type: none"> <li>▪ Groundwater is crucial for domestic water supplies and can be a reliable resource.</li> <li>▪ Groundwater quantity and quality varies.</li> <li>▪ Groundwater scarcity, pollution and environmental sustainability are concerns.</li> <li>▪ Poor understanding undermines the potential of groundwater to contribute to development.</li> <li>▪ Successful boreholes require reliable information and professional siting.</li> <li>▪ If properly located, a borehole can provide a good water supply.</li> </ul>

<b>Module discussion forum (sample questions)</b>	<ul style="list-style-type: none"> <li>▪ Is there a groundwater database in your country, and if so, which institution manages it? How is it used, and do you have experience of accessing the information?</li> <li>▪ Who is responsible for undertaking borehole siting in your organisation, or in organisations that you know? Does your organisation (or other organisations that you know) follow a logical approach to well siting as illustrated in Figure 2 of the RWSN Siting Publication (mandatory reading).</li> </ul>
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## Module 2: Procurement and Contract Management

<b>Introduction</b>	<p>The proper design, planning and management of drilling projects and programmes is an essential, but time-consuming process. Most of the construction is underground and much can go wrong, even for experienced drillers. As mentioned in Module 1, figuring out what lies underground is actually detective work.</p> <p>Borehole drilling is generally riskier than other civil works such as building construction. Uncertainties include not knowing what the formation is, or if good quality water of sufficient quantity will be found. Estimating drilling costs, and determining an appropriate price to charge requires consideration of many aspects, including risk.</p> <p>The foundation of long-term sustainable boreholes is adherence to all four key stages of the drilling procurement and contract management process, i.e.: (i) preparing a procurement plan, (ii) a systematic contract award process, (iii) professional contract management (including regular communication, supervision and timely payment) and (iv) monitoring and reporting after construction.</p>
<b>Module goal</b>	<p>Upon completion of this module, participants will better appreciate the financial risks of borehole drilling and be familiar with the various cost components. They will also be able to reflect on the borehole drilling procurement and contract management processes within their own organisation.</p> <p>The training materials and forum will introduce the participants to borehole costing and pricing methods alongside the importance of preparing engineers estimates. The participants should also have an appreciation of the realities faced by private sector drillers including the effects of non-payment for dry boreholes by clients.</p>
<b>Learning objectives</b>	<p>By the end of this module participants are expected to:</p> <ol style="list-style-type: none"> <li>1. Understand the cost components of borehole drilling.</li> <li>2. Appreciate the need for accurate engineers' estimates before tendering.</li> <li>3. Know the stages of the procurement and contract management process for borehole construction.</li> <li>4. Appreciate the importance of transparency in procurement.</li> <li>5. Be aware of different contract and payment arrangements alongside the risks of not paying drilling contractors for dry boreholes</li> </ol>
<b>Orientation video</b>	Module 2 – Orientation ( <i>ZIP-Folder</i> )

<p><b>Mandatory videos and readings</b></p>	<ol style="list-style-type: none"> <li>1. RWSN (2016) <b>Four steps to better drilling contracts</b> [Online], Rural Water Supply Network, Available at <a href="https://vimeo.com/171751215">https://vimeo.com/171751215</a></li> <li>2. ADEKILE, D. (2014) <b>Procurement and Contract Management of Drilled Well Construction. A Guide for Supervisors and Project Managers</b>, Rural Water Supply Network, Switzerland, Available at <a href="http://www.rural-water-supply.net/en/resources/details/431">http://www.rural-water-supply.net/en/resources/details/431</a></li> <li>3. DANERT, K., LUUTU, A., CARTER, R., &amp; OLSCHESKI, A. (2014) <b>Costing and Pricing – A Guide for Water Well Drilling Enterprises. RWSN Publication 2014-12</b>, Rural Water Supply Network, Switzerland, <a href="http://www.rural-water-supply.net/en/resources/details/146">http://www.rural-water-supply.net/en/resources/details/146</a></li> </ol>
<p><b>Learning videos (optional)</b></p>	<ul style="list-style-type: none"> <li>• UNICEF-RWSN <b>Effective Procurement &amp; Contract Management of Borehole Construction</b> (<i>Presentation 04:40-22:07</i>) (<i>Presentation on payment arrangements 17:22-19:10</i>) <a href="https://vimeo.com/123310467">https://vimeo.com/123310467</a></li> </ul>
<p><b>Recommended readings</b></p>	<ol style="list-style-type: none"> <li>1. HEATH, T, TIBENDERANA, P, CARTER, R, DANERT K &amp; BERHE, E. (2009) <b>Borehole Costing Model V2.8 BETA</b>, Cranfield University, UNICEF, SDC, Skat, RWSN <a href="http://www.rural-water-supply.net/en/resources/details/361">http://www.rural-water-supply.net/en/resources/details/361</a> and HEATH, T. (2009) <b>Borehole Costing Model v2.8: Quick Start Guide</b></li> <li>2. UNICEF (2018) <b>Toolkit Module 1: Principles for the Planning, Contracting and Management of Borehole Drilling Projects</b> <u>in</u> UNICEF/Skat Foundation (2018) <b>Borehole Drilling – Planning, Contracting &amp; Management: A UNICEF Toolkit</b>, UNICEF and Skat Foundation <a href="https://www.rural-water-supply.net/ressources/documents/default/1-826-4-1544004634.pdf">https://www.rural-water-supply.net/ressources/documents/default/1-826-4-1544004634.pdf</a> and <a href="https://www.rural-water-supply.net/en/resources/details/826">https://www.rural-water-supply.net/en/resources/details/826</a></li> <li>3. UNICEF (2018) <b>Toolkit Module 2: Procurement Considerations for Borehole Drilling Works</b> <u>in</u> UNICEF/Skat Foundation (2018) <b>Borehole Drilling – Planning, Contracting &amp; Management: A UNICEF Toolkit</b>, UNICEF and Skat Foundation <a href="https://www.rural-water-supply.net/ressources/documents/default/1-826-4-1544004696.pdf">https://www.rural-water-supply.net/ressources/documents/default/1-826-4-1544004696.pdf</a></li> <li>4. <b>Toolkit Module 4: Template Terms of Reference for Borehole Drilling Works and Pump Supply and Installation (pdf &amp; Word)</b> <u>in</u> UNICEF/Skat Foundation (2018) <b>Borehole Drilling – Planning, Contracting &amp; Management: A UNICEF Toolkit</b>, UNICEF and Skat Foundation <a href="https://www.rural-water-supply.net/ressources/documents/default/1-826-4-1544004783.pdf">https://www.rural-water-supply.net/ressources/documents/default/1-826-4-1544004783.pdf</a> and <a href="https://www.rural-water-supply.net/en/resources/details/826">https://www.rural-water-supply.net/en/resources/details/826</a></li> </ol>

	<p>5. <b>Toolkit Module 5: Template Request for Proposal for Services (RFPS) (pdf &amp; Word)</b> in UNICEF/Skat Foundation (2018) Borehole Drilling – Planning, Contracting &amp; Management: A UNICEF Toolkit, UNICEF and Skat Foundation. Available at <a href="https://www.rural-water-supply.net/ressources/documents/default/1-826-4-1544004847.pdf">https://www.rural-water-supply.net/ressources/documents/default/1-826-4-1544004847.pdf</a> and <a href="https://www.rural-water-supply.net/en/resources/details/826">https://www.rural-water-supply.net/en/resources/details/826</a></p> <p>6. <b>F-301/2017a UNHCR Sample Drilling Contract and Technical Specification (Word)</b> (2017) <a href="https://wash.unhcr.org/download/drilling-contract-and-specification/">https://wash.unhcr.org/download/drilling-contract-and-specification/</a></p>
<b>Recommended web sites</b>	<ol style="list-style-type: none"> <li>1. RWSN Thematic Page: <b>Professional Water Well Drilling</b> <a href="https://www.rural-water-supply.net/en/sustainable-groundwater-management/professionnal-water-well-drilling">https://www.rural-water-supply.net/en/sustainable-groundwater-management/professionnal-water-well-drilling</a></li> <li>2. GIACC (2008) <b>Anti-Corruption Tools Procurement procedures</b> [Online], Global Infrastructure Anti-Corruption Centre <a href="http://www.giaccentre.org/procurement.php">http://www.giaccentre.org/procurement.php</a></li> <li>3. GIACC (2008) <b>Contract Terms</b> [Online], Global Infrastructure Anti-Corruption Centre <a href="http://www.giaccentre.org/contract_terms.php">http://www.giaccentre.org/contract_terms.php</a></li> <li>4. WIN (2019) <b>Descriptions of common integrity risks and applicable tools for water organizations &amp; projects</b> [Online] <a href="https://www.waterintegritynetwork.net/imtoolbox/integrity-risks-tools/">https://www.waterintegritynetwork.net/imtoolbox/integrity-risks-tools/</a> (check the categories procurement &amp; project execution).</li> </ol>
<b>Recommended videos</b>	<ul style="list-style-type: none"> <li>• Liddle, E and Fenner, R. <b>Professional Borehole Drilling: Learning from Uganda</b> (0-6:40) <a href="https://www.youtube.com/watch?v=RGVWmIRcxzE">https://www.youtube.com/watch?v=RGVWmIRcxzE</a></li> <li>• UNICEF Mali. <b>Learning from the management of borehole construction for schools in Mali.</b> <a href="https://vimeo.com/142475788">https://vimeo.com/142475788</a> (Lessons on tender documents from minute 17:39-31:39)</li> </ul>
<b>Take home messages</b>	<ol style="list-style-type: none"> <li>1. Good design, planning and management of drilling projects and programmes is time-consuming.</li> <li>2. To ensure quality, all four stages of the drilling procurement and contract management process are essential: <ol style="list-style-type: none"> <li>i. preparing a procurement plan,</li> <li>ii. a systematic contract award process,</li> <li>iii. professional contract management (including regular communication, supervision and timely payment) and</li> <li>iv. monitoring and reporting after construction</li> </ol> </li> <li>3. Borehole drilling is riskier than many other civil works such as building construction.</li> <li>4. Drilling cost and drilling price estimated need to consider risk.</li> <li>5. Even if «turn-key» or «no water no pay» contracts are used, the cost of failed boreholes will be paid somehow.</li> </ol>
<b>Module discussion</b>	<ul style="list-style-type: none"> <li>• To run a successful borehole drilling business, there is need for the enterprise to have a business plan, sufficient cash flow, competent staff and to</li> </ul>



forum (sample questions)	<p>understand the market. Tell us what other challenges you think that a private sector drilling businesses may face and how you think that these challenges could be overcome.</p> <ul style="list-style-type: none"> <li>How are each of the four steps to better drilling contracts in the film and RWSN publication, followed (or not) within your organisation (or for another organisation with which you are familiar), and what could be improved?</li> </ul>
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## Module 3: Borehole Drilling and Supervision

Introduction	<p>A drilled water well, or borehole should have a design life of more than 25 years. The lifespan of the installed lifting device tends to be shorter. A pump can be replaced entirely or component by component as various parts wear, but still using the same borehole. Drilling cost-effectiveness is "optimum value for money invested over the long term". Thus, the cheapest borehole is not always the most cost-effective, particularly if construction quality is compromised to save money.</p> <p>Poor borehole construction is a key contributor to low functionality. To ensure cost effectiveness, the drilling itself needs to be of high quality, with the entire process supervised by a competent supervisor working in a highly professional manner. The supervisor represents the client and is expected to act with honesty, impartiality and fairness in any dispute over the contract. New supervisors need support and mentoring by those with more experience.</p>
Module goal	<p>The goal of this module is to enable participants to understand some of the key technical reasons for immediate and long-term borehole failure and to appreciate the skills and equipment required to ensure that boreholes are drilled to a high quality. Upon completion of the module, the participants will appreciate the importance of drilling supervision; know the responsibilities of the drilling supervisor and the actions to be carried out at each stage to ensure that the driller delivers the borehole as specified in the contract. Through the discussion forum, participants will reflect on the supervision practices of their own organisation.</p>
Learning objectives	<p>By the end of this module participants are expected to:</p> <ol style="list-style-type: none"> <li>1. Appreciate some of the technical reasons for borehole failure.</li> <li>2. Understand the importance of effective supervision in borehole construction for sustainability.</li> <li>3. Understand the steps and detailed actions required in full time and part time/milestone borehole supervision.</li> <li>4. Be in a position to critically reflect on the borehole supervision practices carried out by their organisation.</li> </ol>
Orientation video	Module 3 – Orientation ( <i>ZIP-Folder</i> )
Mandatory videos and readings	<ol style="list-style-type: none"> <li>1. RWSN (2016b) <b>Why are some boreholes better than others?</b> [Online], Rural Water Supply Network, <a href="https://vimeo.com/185289895">https://vimeo.com/185289895</a></li> </ol>



	<ol style="list-style-type: none"> <li>2. RWSN (2015) <b>A borehole that lasts for a lifetime</b> [Online], Rural Water Supply Network <a href="https://vimeo.com/128478995">https://vimeo.com/128478995</a></li> <li>3. ADEKILE, D. (2014) <b>Supervising Water Well Drilling. A guide for supervisors</b>, Rural Water Supply Network <a href="http://www.rural-water-supply.net/en/resources/details/392">http://www.rural-water-supply.net/en/resources/details/392</a></li> </ol>
Learning videos (optional)	<ul style="list-style-type: none"> <li>• <a href="#">From well Construction to Pumping Tests</a></li> <li>• <a href="#">Pumping Test Equipment</a></li> </ul>
Recommended readings	<ol style="list-style-type: none"> <li>1. SCHNEIDER, S. J. (2014) <b>Water Well Guidelines for use in Developing Countries, Third Edition</b>, <a href="http://www.rural-water-supply.net/en/resources/details/411">http://www.rural-water-supply.net/en/resources/details/411</a></li> <li>2. BALL, P (2001) <b>Drilled Wells, Series of Manuals on Drinking Water Supply, Volume 6</b>, Skat, <a href="http://skat.ch/book/drilled-wells/">http://skat.ch/book/drilled-wells/</a></li> <li>3. DANERT, K, ADEKILE, D and GESTI CANUTO, J (2014) <b>Manually Drilled Boreholes: Providing water in Nigeria's Megacity of Lagos and beyond</b>, Skat Foundation, Switzerland, Available at <a href="http://www.rural-water-supply.net/en/resources/details/618">http://www.rural-water-supply.net/en/resources/details/618</a></li> <li>4. MacAllister, D.J. ; Fallas, H.; MacDonald, A.M. ; Kebede, S.; Mkandawire, T.; Mwathunga, E.; Owor, M.; Whaley, L.. (2021) <b>Determinants of hand-pumped borehole functionality: preliminary evidence from Ethiopia, Malawi and Uganda</b>, <a href="https://nora.nerc.ac.uk/id/eprint/531048/">https://nora.nerc.ac.uk/id/eprint/531048/</a></li> </ol>
Recommended web sites	<ul style="list-style-type: none"> <li>• RWSN: Professional water well drilling <ol style="list-style-type: none"> <li>a. ENGLISH- <a href="https://www.rural-water-supply.net/en/sustainable-groundwater-management/professionnal-water-well-drilling">https://www.rural-water-supply.net/en/sustainable-groundwater-management/professionnal-water-well-drilling</a></li> <li>b. FRENCH <a href="https://www.rural-water-supply.net/fr/developpement-durable-des-eaux-souterraines/la-professionnalisation-du-secteur-des-forages">https://www.rural-water-supply.net/fr/developpement-durable-des-eaux-souterraines/la-professionnalisation-du-secteur-des-forages</a></li> </ol> </li> <li>• RWSN: Manual Drilling <ol style="list-style-type: none"> <li>a. ENGLISH <b>Error! Hyperlink reference not valid.</b><a href="http://www.rural-water-supply.net/en/sustainable-groundwater-management/manual-drilling">www.rural-water-supply.net/en/sustainable-groundwater-management/manual-drilling</a></li> <li>b. FRENCH <a href="https://www.rural-water-supply.net/fr/implementation-french/drilling-wells-and-boreholes-french/355-le-forage-manuel">https://www.rural-water-supply.net/fr/implementation-french/drilling-wells-and-boreholes-french/355-le-forage-manuel</a></li> </ol> </li> </ul>
Recommended videos	<ul style="list-style-type: none"> <li>• Dunne, A. (2009) <b>Borehole for water well, CCTV Camera</b> [Online] <a href="https://www.youtube.com/watch?v=N5fwgSgqatw">https://www.youtube.com/watch?v=N5fwgSgqatw</a></li> <li>• DANDO (2016) <b>Dando Watertec 50, Tanzania, Dando Drilling</b>, <a href="https://www.youtube.com/watch?v=2AW-J48ZkBM">https://www.youtube.com/watch?v=2AW-J48ZkBM</a></li> </ul>

	<ul style="list-style-type: none"> <li>• Practica Foundation (2017) <b>Practica Found_Professionalizing Manual Drilling in Africa</b> [online]  <a href="https://vimeo.com/178460626">https://vimeo.com/178460626</a></li> </ul>
<b>Take home messages</b>	<ol style="list-style-type: none"> <li>1. There are numerous technical reasons for borehole failure.</li> <li>2. Borehole failure can be due to poor siting, borehole design and construction in the first place.</li> <li>3. Professional drilling supervision can assure construction quality.</li> <li>4. Supervision can be full-time, or part time (i.e. milestone).</li> <li>5. As a drilling programme manager, you should be able to critically reflect on the borehole supervision process that is undertaken by your organisation</li> </ol>
<b>Module discussion forum (sample questions)</b>	<ul style="list-style-type: none"> <li>• Based on your experience, or that of your colleagues, what are the main reasons for low yielding boreholes, poor quality water or mechanical failure just a few months after construction?</li> <li>• How could a borehole camera be used to ensure drilling quality?</li> </ul>

## Module 4: Legal and Institutional Frameworks for Borehole Drilling Professionalism

<b>Introduction</b>	<p>The legal and institutional framework is a broad concept covering the functions of governments, private enterprises, political jurisdictions, judicial systems, legislative bodies, and regulatory agencies. The legal framework incorporates laws, amendments, treaties, acts, ordinances, mandates, regulations, and their enforcement mechanisms. It is important to know, that not only written rules and formal institutions may be important, since in some contexts informal customs and norms also govern the construction of wells. Some countries have only recently introduced formal legal and institutional frameworks. In many countries, the laws, regulations and procedures as well as responsibilities for groundwater development and management of the resources are not clear or are contradictory. Responsibilities may fall between or be divided among ministries and between national and provincial or district administrations. Some countries lack technical guidelines for borehole construction and rehabilitation. The combination of these weaknesses can undermine the professionalism of groundwater development, or water well drilling.</p> <p>However, in several countries, government and private enterprises (through associations) are trying to improve the legal and institutional framework.</p>
<b>Module goal</b>	<p>The goal of this module is to introduce participants to the key elements of the legal and institutional framework (at national or state level) that support (or undermine) borehole drilling professionalism. These include driller licencing; borehole permits and national (or state level) professional associations. Through the discussion forum, participants will have the opportunity to reflect on the institutional framework in the county (or state) in which they work.</p>
<b>Learning objectives</b>	<p>By the end of this module participants are expected to:</p> <ol style="list-style-type: none"> <li>1. Learn about mechanisms that ensure that siting, drilling and supervision is undertaken by professionals e.g., through licencing of drillers and consultants, or associations</li> </ol>

	<ol style="list-style-type: none"> <li>Understand the different aspects of the institutional framework for borehole drilling (formal and informal)</li> <li>Identify some strengths and weaknesses of the institutional framework for borehole drilling in your country, or state</li> </ol>
Orientation video	Module 4 – Orientation ( <i>ZIP-Folder</i> )
Mandatory videos and readings	<ol style="list-style-type: none"> <li><b>Five areas to Explore Module 4 – Legal and Institutional Frameworks for Borehole Professionalism</b> (separate video to be embedded)</li> <li>RWSN (2010) <b>Code of Practice for Cost-effective Boreholes</b>, Rural Water Supply Network  <a href="http://www.rural-water-supply.net/en/resources/details/128">http://www.rural-water-supply.net/en/resources/details/128</a></li> <li>Achievements and Lessons Learned in the Implementation of Groundwater Regulation in Zambia  <a href="https://www.rural-water-supply.net/en/resources/details/1040">https://www.rural-water-supply.net/en/resources/details/1040</a></li> </ol>
Learning videos (optional)	NONE
Recommended readings	<ol style="list-style-type: none"> <li>ADITC (2012) <b>Minimum Construction Requirements for Water Bores in Australia</b> [Online], Australian Drilling Industry Training Committee,  <a href="https://www.dnrme.qld.gov.au/data/assets/pdf_file/0009/99765/minimum-construction-req-au.pdf">https://www.dnrme.qld.gov.au/data/assets/pdf_file/0009/99765/minimum-construction-req-au.pdf</a></li> <li>DANERT, K and GESTI, J (2016) <b>Summary of E-discussion on Groundwater Regulation</b>, Rural Water Supply Network  <a href="https://rwsnblog.files.wordpress.com/2018/02/summary-groundwater-regulation_0005.pdf">https://rwsnblog.files.wordpress.com/2018/02/summary-groundwater-regulation_0005.pdf</a></li> <li><b>Legal and other institutional aspects of groundwater governance (Chapter 2 of the World Water Development Report 2022)</b>  <a href="https://unesdoc.unesco.org/ark:/48223/pf0000380721">https://unesdoc.unesco.org/ark:/48223/pf0000380721</a></li> <li>Tindimugaya C. [2016] <b>Registration of groundwater consultants in Uganda: rationale and status</b>, Paper and Presentation at the 7<sup>th</sup> RWSN Forum in Abidjan  <a href="https://rwsnforum7.files.wordpress.com/2016/11/full_paper_0189_submitter_0266_tindimugaya_callist.pdf">https://rwsnforum7.files.wordpress.com/2016/11/full_paper_0189_submitter_0266_tindimugaya_callist.pdf</a></li> <li>World Bank (2015) <b>Strengthening the Domestic Drilling Industry. Lessons from the Mozambique</b>, WSP  <a href="http://www.rural-water-supply.net/en/resources/details/767">http://www.rural-water-supply.net/en/resources/details/767</a></li> </ol>
Recommended web sites	<ul style="list-style-type: none"> <li><a href="#">The need for professional associations for water well drillers</a></li> <li>Association of Water Well Owners and Practitioners (AWDROP) [Online], Nigeria <a href="http://awdrop.org/">http://awdrop.org/</a></li> <li>MWE (2017) <b>Registered Hydrogeologists 2017/2018</b> [Online], Ministry of Water and Environment Uganda, Available at <a href="https://www.mwe.go.ug/library/registered-hydrogeolists-20172018">https://www.mwe.go.ug/library/registered-hydrogeolists-20172018</a></li> </ul>

Recommended videos	<ul style="list-style-type: none"> <li>ARMSTRONG, T (2015) <b>From Codes of Practice to a Code of Conduct – groundwater governance in Kenya, a drillers perspective</b>, "From Genesis to Revelation" [Online], Presentation in Groundwater Governance, UPGro-RWSN Webinar, Rural Water Supply Network, Switzerland <a href="https://vimeo.com/121992412">https://vimeo.com/121992412</a></li> </ul>
Take home messages	<p>There are a number of aspects of the legal and institutional frameworks that can be explored, including:</p> <ol style="list-style-type: none"> <li>Professional Enterprises and Consultants</li> <li>Laws or national codes of practice, code of conduct, drilling principles</li> <li>Permits to drill a borehole</li> <li>Abstraction Licences</li> <li>Country studies on drilling professionalism, cost-effective boreholes</li> </ol>
Module discussion forum (sample questions)	<ul style="list-style-type: none"> <li><b>Guidelines and standards:</b> Has the government in your country government published national guidelines or standards for borehole drilling and rehabilitation? If so, are they widely known? Are they easy to understand? Are there incentives to adhere to the guidelines, or is there any enforcement of standards?</li> <li><b>Drillers and consultants:</b> Is there a national (or state drillers association, and if so, is it active? What has it done? Is it reputable? Is there any regulation of drillers, e.g. through licencing? Who regulates, and how effective is it? Can an unregistered drilling contractor obtain work from government, an NGO or a private user? Is there any regulation of groundwater consultants, e.g. through licencing? Who regulates, and how effective is it? Can an unregistered consultant/contractor obtain work from government, an NGO or a private user?</li> <li><b>Regulation and licencing:</b> Is there any regulation of water use, such as abstraction permits? What type of groundwater abstraction requires a permit? Are there any challenges with these?</li> </ul>

## Module 5: Actions to Raise Drilling Professionalism

Introduction	<p>Drilled water wells are vital to achieving universal, clean drinking water. The water must be safe, affordable and available through services that last. To get there, these wells, or boreholes, need to be built in a professional manner. Professionalism is the skill, good judgement, and behaviour expected from a person or organisation who can undertake a job well. Consideration of water resources, design, siting, procurement, construction, project management and supervision are all key elements within a professional sector. Ideally, the legal and institutional framework should also be supportive of borehole drilling professionalism. Each actor involved has his or her role to play, and every organisation involved can engage in dialogue and take actions to improve drilling professionalism.</p>
Module goal	<p>The goal of this module is to integrate the knowledge gained in the first four modules and encourage participants, learn about what others have tried, and to enable each participant to consider what actions he or she, or their organisation can take to improve drilling professionalism in their own context.</p>

<b>Learning objectives</b>	<p>By the end of this module participants are expected to:</p> <ol style="list-style-type: none"> <li>1. Know which key national (or state level) agencies play roles in supporting, regulating and building capacity for borehole drilling in their country</li> <li>2. Have identified issues that hinder drilling professionalism in their country (or state, or municipality)</li> <li>3. Have identified at least one opportunity, or action that they could take to improve borehole drilling professionalism.</li> <li>4. Be ready to consider the perspectives of other stakeholders in relation to borehole drilling professionalism.</li> </ol>
<b>Orientation video</b>	Presentation: Module 5 Orientation_V1.ppt
<b>Mandatory videos and readings</b>	<ol style="list-style-type: none"> <li>1. <b>Part II of UNICEF/Skat Foundation (2016) Professional Water Well Drilling: A UNICEF Guidance Note</b>  <a href="https://www.rural-water-supply.net/en/resources/details/775">https://www.rural-water-supply.net/en/resources/details/775</a></li> <li>2. <b>Zambia : Short course on drilling supervision (2018)</b>  <a href="https://vimeo.com/290225478">https://vimeo.com/290225478</a></li> </ol>
<b>Learning videos (optional)</b>	<ol style="list-style-type: none"> <li>1. <b>Unlocking Africa's Groundwater Potential</b>  <a href="https://www.youtube.com/watch?v=hLJxw6hkjYM">https://www.youtube.com/watch?v=hLJxw6hkjYM</a></li> <li>2. <b>Professional Water Well Drilling: Guidance for Ensuring Quality -</b>  <a href="https://vimeo.com/215145287">https://vimeo.com/215145287</a></li> </ol>
<b>Recommended readings</b>	<ul style="list-style-type: none"> <li>▪ Danert (2020) <b>Groundwater and Drilling: Insights from over 50 countries</b>  <a href="https://www.rural-water-supply.net/en/resources/details/880">https://www.rural-water-supply.net/en/resources/details/880</a></li> <li>▪ AGW-Net (2015) <a href="#">The Role of Stakeholder Participation and Communication in Groundwater Management</a> – module 7 of The Integration of Groundwater Management into Transboundary Basin Organizations in Africa, Africa Groundwater Network, Available at (AGW-Net, 2015)</li> </ul>
<b>Recommended web sites</b>	<ul style="list-style-type: none"> <li>▪ <b>RWSN Professional Water Well Drilling website</b> – a collation of resources and reports, some of which have been used in this course  <a href="https://www.rural-water-supply.net/en/sustainable-groundwater-management/professionnal-water-well-drilling">https://www.rural-water-supply.net/en/sustainable-groundwater-management/professionnal-water-well-drilling</a></li> <li>▪ <b>RWSN Sustainable Groundwater Development community</b> – online community of practice on groundwater, including drilling practices  <a href="https://dgroups.org/rwsn/groundwater_rwsn">https://dgroups.org/rwsn/groundwater_rwsn</a></li> <li>▪ <b>Africa Groundwater Network (AGW-Net)</b> – membership of over 300 groundwater professionals in Africa. AGW-Net has training materials and run courses (<a href="http://www.agw-net.org/">http://www.agw-net.org/</a>).</li> <li>▪ <b>International Association of Hydrogeologists (IAH)</b> – raising awareness of groundwater issues and working with national and international agencies (<a href="https://iah.org/">https://iah.org/</a>)</li> </ul>

<b>Take home messages</b>	<p>Actions which could be undertaken to improve drilling professionalism within organisations, and the wider context are numerous. They include, but are not limited to:</p> <ol style="list-style-type: none"> <li>1. Improving national (or state) policies, regulation, standards and procedures of borehole drilling, including the clarification of roles and responsibilities.</li> <li>2. Groundwater data and information – ensuring that drilling records are collected, quality assured and collated. This data, together with information generated from it, should be made readily available to help inform future borehole siting and design, as well as groundwater resources management.</li> <li>3. Capacity– raise the skills and knowledge of groundwater development and encourage the availability of suitable equipment in the country.</li> <li>4. Project design, implementation and monitoring– improve the design, implementation and monitoring of specific borehole drilling or rehabilitation projects, and ensure that documentation of the process and results is readily available.</li> <li>5. Dialogue &amp; awareness– foster dialogue between government agencies (including regulators), drilling contractors and consultants, NGOs, development partners and civil society. Encourage and support efforts that raise awareness of decision-makers and the public about groundwater potential, management and its exploitation.</li> <li>6. Invest adequate financial resources to improve and sustain professional groundwater development.</li> </ol>
<b>Module discussion forum</b>	<p>Based on your experience and context, as well as what you have learned in the course so far, please provide your own experiences or perspectives on the following contention:</p> <ul style="list-style-type: none"> <li>• A client tries to squeeze the driller to work for a very low (and unrealistic) price, and a driller takes on a job, knowing that the conditions are not ideal.</li> <li>• The donor or client is not willing to offer direct financial compensation for drilling dry boreholes, even though some will be drilled in high risk areas.</li> </ul>