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Development of a Curriculum and Training of Supervision Teams in Borehole Construction in Malawi

Groundwater Systems and Water Quality Programme

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BRITISH GEOLOGICAL SURVEY

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Development of a Curriculum and Training of Supervision Teams in Borehole Construction in Malawi

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Front cover

Training course participants at the GITEC project headquarters, Namwera, Mangochi District.

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1 Introduction

The Government of Malawi through the Ministry of Water Development is committed to ensuring that people have convenient access to potable water. However, the water sector has suffered a number of weaknesses that include:

- Lack of sustainability in most of the water supply and water borne sanitation infrastructure.
- Poor service coverage
- Declining, and in some cases, poor quality of key water sources.
- A large number of boreholes are not fully functional because of poor siting, installation and workmanship.

A demand responsive approach to borehole construction and maintenance, whereby user communities apply for facilities and establish maintenance infrastructures, is in operation. To facilitate this process, the Ministry of Water Development recognises the need to built capacity of various stakeholders through training. As part of this initiative, the Water and Sanitation Programme, Africa Region (World Bank) has funded the Ministry of Water Development to undertake a first phase of the required training. This included curriculum development and a pilot training course for technicians in borehole siting and construction supervision. The British Geological Survey was the lead consultant in this project, together with the University of Malawi and GITEC.

An initial visit to Malawi was made during November 2001, and a draft curriculum was constructed following consultation with local partners (Appendix 1). The German funded Mangochi East Rural Water Supply and Sanitation Programme, based near Namwera in eastern Malawi, was identified as a suitable location for the course as a variety of best practice activities could be demonstrated in the field. Course material was collated, and new material was written by the BGS following this initial visit. In May-June 2002 the training course was delivered with counterparts from the University of Malawi, Blantyre, and the GITEC Mangochi Project.

The course goals are:

1. students appreciate the complexity of the subsurface environment, and understand that there are many different hydrogeological problems with various solutions.
2. students understand and be able to apply the concepts of hydrogeological sustainability and management of groundwater.
3. students are aware of sources of information on groundwater, and realise when to ask for assistance with a particular problem.
4. students are aware of the uncertainty inherent in many groundwater problems.
5. students are aware of the great value of hydrogeological data, and of simple methods for collecting such data.
6. students are aware of the many branches of hydrogeology, and not just focus on one aspect such as geophysics.
7. students realise that all the parts fit together, and the importance of thinking holistically of the “big picture”.
8. students are aware of the user community expectations and the importance of the community in ensuring that a project is successful in the long term.
9. students appreciate possible pitfalls when interacting with community members.

These goals are intended as general or thematic outcomes applicable to the whole course. The realisation of these outcomes should contribute significantly to better borehole siting and work supervision skills as well as enabling students to pass their knowledge on to others. This is in keeping with the strategy of the Ministry for Water Development in Malawi for improving service coverage and sustainability.

This hard copy report presents the course background and its content. The attached CD-ROM provides in addition::

- day to day lesson summaries with specific outcomes and skills intended for each lesson
- course notes
- PowerPoint™ presentations
- reports in PDF format
- related reference materials

2 The Course Outline

The course entitled the 'Workshop for Supervision Teams in Borehole Construction', took place between Monday 27 May and Tuesday 4 June, 2002. It was held at the headquarters of the GITEC Mangochi East Rural Water Supply and Sanitation Programme near Namwera in eastern Malawi, and at various nearby field sites. A classroom was made available and was equipped with tables and chairs, and was big enough to seat all students comfortably.

Eighteen students attended; twelve from the Ministry for Water Development and six from non-governmental organisations (NGOs) active in the rural water supply and sanitation sector (Appendix 2). The students ranged in skills and experience; some worked as hydrogeologists and had experience in several of the course topics, whilst others worked mainly in community training and awareness but had limited experience of technical matters. Few of the students had a detailed knowledge of the local geology. All of the students had an adequate command of English. The variety of backgrounds and ranges of experience of the students occasionally made some topics more challenging to some and routine to others. However, the wide variety of backgrounds and skills encouraged several interesting discussions regarding conflicting priorities and misunderstandings between implementers in the water sector. For example, the needs of the community have to be reconciled with hydrogeological constraints when planning boreholes, and this frequently has to be explained to all stakeholders.

The course covered a wide range of topics related to the types of work that the students were involved in. These included:

- basic groundwater theory
- different groundwater environments in Africa
- sources of groundwater information
- weathering patterns and profiles
- geophysical surveys
- borehole siting
- drilling methods
- borehole design and construction

- contracts
- bills of quantity
- sanitation
- borehole development
- pumping tests
- hand-pump mechanics
- water quality
- the demand response approach to sustainability

Only simple mathematical material was included, appropriate to the levels of ability of some of the students. Students were encouraged to ask questions and to relate personal experience freely. Certain students who did not wish to raise questions in class relayed them to the instructors via Mr Wellington Mandowa. The introduction to the course explained the scope and contents, and stated that topics or sections could be added or covered in more detail if the students wished.

The course tried to balance theory lessons and classroom discussions with practical field demonstrations of equipment and techniques. A total of three days were spent on practical demonstrations in the field, at various sites in the area. Most of the rest of the time was spent in the classroom. A variety of teachers were used, including specialists in drilling, sanitation, contracts and geophysics. Teaching methods included:

- lectures with questions
- practical demonstrations and experiments
- on site and end of day group discussion as well as a morning round-up of previous days activities
- PowerPoint™ and overhead transparency presentations
- instruction, "hands-on" experience and questions in the field
- informal question and answer sessions
- written assessment at the end of the course

The ongoing GITEC programme ensured that equipment such as drilling rigs, pumping test equipment, geophysical equipment and Afridev pumps was available and working for the practical demonstrations.

Resources required for the course included:

- course curriculum and daily course timetable.
- specially prepared modular course notes.
- a copy for each learner of the BGS/DfID manual entitled "Simple methods for assessing groundwater resources in low permeability areas of Africa".
- a copy for each learner of the manual "Groundwater: Guidelines for Boreholes in Botswana" produced by the Groundwater Association of Botswana.
- a copy of a typical drilling contract for each learner.
- WaterAid's notes and the ARGOSS manual on groundwater and sanitation.
- anthropologist's notes on demand response approach
- geophysical survey team with equipment and survey data

- PowerPoint™ slides of groundwater occurrence, problems, methods and equipment in Africa.
- PowerPoint™ presentations of contracts, bills of quantities, tender documents, and sanitation.
- over head projector transparencies of relevant diagrams, pictures, cartoons, tables, etc.
- overhead projector, digital projector, whiteboard, video camera, digital camera and foolscap sheets, with permanent and non-permanent markers.
- skilled training personnel, including geophysicists, hydrogeologists, civil and sanitation engineers, drillers, managers, an anthropologist, borehole technicians and drilling supervisors.

Resources required for demonstration purposes included:

- a GPS receiver
- a digital camera
- stereoscopes with aerial photograph pairs
- hydrogeological and geological maps
- posters of groundwater occurrence
- geological photo logs and geophysical borehole logs
- pH, conductivity and temperature meters
- permeameters
- rock samples and a half pipe for chip sample display
- a demonstration of an Afridev pump with components
- a whale pump and bailer for simple pumping tests
- numerous PowerPoint™ and overhead transparency images of hydrogeological techniques and environments.

Comprehensive notes were issued to the students, including specially designed course notes on many of the topics. Students added to these notes with their own notes during the course. A bibliography was supplied at the end to those students who wished for more information on groundwater. It was explained that all notes could be used by the students in instructing others, as well as to assist the students themselves.

Generally the course proceeded according to the timetable that had been prepared, with some minor deviations being made to accommodate the availability of field equipment. The feedback from students was mainly positive, both during and at the end of the course. It was acknowledged that a lot of information had been covered in a relatively short time, and a common request was for subsequent courses to be longer.

As an initial systems trial the course enabled the notes that had been prepared to be refined, and identified certain aspects that could be improved. It has given the convenors and facilitators a much better idea of common groundwater problems and issues in Malawi, and also of the capabilities and skills of water development professionals in that country. The course curriculum and notes have, therefore, been improved given the experiences of presenting this pilot course, and further such courses are envisaged.

3 The Course Programme

3.1 STRUCTURE AND GENERAL LESSON PLAN FOR THE COURSE.

The programme of training was based on the curriculum developed by British Geological Survey (BGS) and the Malawi Polytechnic a constituent college of the University of Malawi (Appendix 1). The programme covered ten days and the course involved theoretical presentations and field visits for practical demonstrations of equipment and methods. Out of necessity, the course was held at a remote location to take advantage of the on-going GITEC project, the availability of personnel and equipment and the facilities offered. These factors enabled delivery of an intensive practically oriented course. The emphasis was placed upon demonstration and explanation of methodologies involved in the everyday field aspects of water supply and sanitation projects. The programme content as finally presented is given below. To access details of the results and content of each day's tuition in the CD-ROM use the hypertext link (left click) on the relevant date.

The Course Timetable as Delivered

Monday 27 May 2002 [Day 1]

8:30-9:45	Arrival of students and guests
9:45-10:00	Tea
10:00-12:00	Opening ceremony
12:00-2:00	Lunch
2:00-2:30	Introduction (getting to know delegates to workshop)
2:30-3:00	Introduction to groundwater and the water cycle
3:00-3:15	Tea
3:15-4:30	African overview (photographs and slides on groundwater)
4:30-5:00	Discussions and questions

Tuesday 28 May 2002 [Day 2]

8:00-8:30	Review of previous day's work
8:30-9:45	How groundwater exists
9:45-10:00	Tea
10:00-11:00	How groundwater exists
11:00-12:00	Permeability and porosity, including experiment
12:00-2:00	Lunch
2:00-3:00	Geology and weathered profiles
3:00-3:15	Tea
3:15-4:30	Remote sensing and rock samples
4:30-5:00	Discussion of contract structure

Wednesday 29 May 2002 [Day 3]

8:00-8:30	Review of previous day's work
8:30-9:45	Data sources, data acquisition and the uses of data
9:45-10:00	Tea

10:00-10:30	Introduction to geophysics and the basic principles of two methods
10:30-12:00	Slide show and discussion of geophysical applications in Africa
12:00-2:00	Lunch
2:00-5:00	Field demonstration of geophysical equipment and techniques

Thursday 30 May 2002 [Day 4]

8:00-8:30	Review of geophysics
8:30-9:45	Introduction to four drilling methods
9:45-10:00	Tea
10:00-4:30	Field observations of drilling methods (packed lunch)
4:30-5:00	Classroom discussion and questions on drilling

Friday 31 May 2002 [Day 5]

8:00-8:30	Review of drilling methods and questions
8:30-9:45	Data collection and sampling methods at the drill site - introduction
9:45-10:00	Tea
10:00-4:30	Field observations of pump testing, well development, data collection and drilling (packed lunch)
4:30-5:00	Questions and discussions, with special class on geophysical interpretation

Saturday 1 June 2002 [Day 6]

8:00-8:30	Review of previous day
8:30-9:45	Borehole design construction and development
9:45-10:00	Tea
10:00-11:50	Sanitation discussion and relation to weathering patterns and porosity
11:50-12:00	Assignment for Saturday afternoon and Sunday to be set
12:00-2:00	Lunch
Afternoon	Students to begin assignment

Sunday 2 June 2002 [Day 7]

Free day, or students to complete assignment

Monday 3 June 2002 [Day 8]

8:30-9:00	Discussion and review of assignment
9:00-9:45	Slides on the assignment, and on African weathered profiles
9:45-10:00	Tea
10:00-12:00	Sanitation and health
12:00-2:00	Lunch
2:00-2:45	Principles of pumping test analysis
2:45-3:00	Principles of the Afridev pump
3:00-3:15	Tea

3:15-4:00	Demonstration of the Afridev pump
4:00-5:00	The Demand Response Approach

Tuesday 4 June 2002 [Day 9]

8:30-9:45	Test and evaluation questions
9:45-10:00	Tea
10:30-11:30	Bills of quantities and the tendering process
11:30-12:00	Field visit to community pump and sanitation installations
12:00-2:00	Lunch
2:00-3:00	Final questions, and means of accessing further material
3:00-3:15	Tea
3:15-4:00	Closing ceremony and presentation of certificates
4:00-5:00	Closing barbeque

Wednesday 5 June 2002 [Day 10]

Students depart

3.2 COURSE COMPOSITION AND CONTENT

The course is composed of five modules based on the structure of the course curriculum. Each module comprises a selection of topics. The presentation of each topic uses relevant reference materials as a basis and the experience and knowledge of the presenter who adapts the basic materials to the local environment and conditions. The modular nature of the course, the topic content of each module and the reference material required for the presentation of each topic is explained in the table below. To access the reference material use the hypertext link (left click) on the item required in the right hand column. To access the results and content of each day's tuition use the hypertext link (left click) on the relevant day in the left hand column.

Table 1 Course Content

Day/Time (mins)	MODULES/Topics	Reference Materials (on CD or hard copy)
Day 1	**GROUNDWATER AND THE WATER CYCLE**	
30 mins	Introduction to the course	
30 mins	Introduction to groundwater and the water cycle	Water Cycle Why do we use Groundwater
75 mnis	Overview of African hydrogeology	World water intro
30 mins	Discussions and questions	
Day 2	**GROUNDWATER AND THE WATER CYCLE**	
30 mins	Review of previous day's work	
135 mins	How groundwater exists	What is groundwater River Basins and Groundwater Catchments Using Groundwater Measuring groundwater Confined and unconfined aquifers Intergranular and fractured aquifers Simple methods manual
60 mins	Permeability and porosity	Equipment
60 mins	Geology and weathered rock profiles	Geology Maps
75 mins	Remote sensing and rock samples	Simple methods manual
30 mins	Discussion of typical contract	Standard contract
Day 3	**GROUNDWATER EXPLORATION**	
30 mins	Review of previous day's work	
75 mins	Sources, gathering and uses of data	How can groundwater be found? Things to remember
30 mins	Introduction to geophysics	Simple methods manual
90 mins	Application of geophysical in Africa	Geophysics
180 mins	Field demonstration of geophysical equipment and techniques	

Day/Time (mins)	MODULES/Topics	Reference Materials (on CD or hard copy)
Day 4	**DRILLING AND BOREHOLE DESIGN**	
30 mins	Review of geophysics	
75 mins	Introduction to four drilling methods	drilling techniques, Borehole drilling Guidelines for Boreholes in Botswana
390 mins	Field study of drilling methods	
30 mins	Discussion and questions on drilling	
Day 5	**DRILLING AND BOREHOLE DESIGN / SUSTAINABILITY OF SUPPLY**	
30 mins	Review of drilling methods and questions	Borehole drilling field day 1
75 mnis	Introduction to data collection and sampling methods at the drill site	data gathering during drilling borehole cleaning and development test pumping and evaluation satisfactory and sustainable yields
390 mins	Field study of pump testing, well development, data collection and drilling	
30 mins	Questions and discussions, with additional geophysical interpretation	
Day 6	**SUSTAINABILITY OF SUPPLY**	
30 mins	Review of previous day	Borehole drilling field day 2
75 mins	Borehole design construction and development	Borehole design and construction
110 mins	Sanitation discussion and relation to weathering patterns and porosity	Health and sanitation fact sheets Argoss manual
10 mins	Assignment for Saturday afternoon and Sunday to be set	
180 mins	Students to begin assignment	
Day 7		
	Rest/assignment day	

Day/Time (mins)	MODULES/Topics	Reference Materials (on CD or hard copy)
Day 8	**GROUNDWATER QUALITY, PUBLIC HEALTH AND CONTRACTS / SUSTAINABILITY OF SUPPLY**	
30 mins	Discussion and review of assignment	
45 mins	Slides on the assignment, and on African weathered profiles	Geological traverse down the escarpment
120 mins	Sanitation and health	Argoss manual Health and sanitation fact sheets
45 mins	Principles of pumping test analysis	Pumping tests Pumps
15 mins	Principles of the Afridev pump	Afridev paper
45 mins	Demonstration of the Afridev pump	Afridev pump
Day 9	**GROUNDWATER QUALITY, PUBLIC HEALTH AND CONTRACTS**	
75 mins	Test and evaluation questions	Test questions Evaluation
60 mins	Bills of quantities and the tendering process	
30 mins	Field visit to community pump and sanitation installations	Mangochi East A Mangochi East B DRA report Community management
60 mins	Final questions and round up	

4 Discussion

The enthusiastic support and participation of all partners ensured the smooth running of the course. The logistics of the course were dependent upon the availability of equipment, personnel and weather. A number of other factors came to light during the course and these are mentioned briefly below. Was the course successful? Methods of evaluation were employed during the course but much will depend upon the post-course demand for similar exercises either in Malawi or elsewhere.

4.1 COURSE LOGISTICS

Reference materials

The course structure follows that of a typical contract document. The elements of the contract document are illustrated using:

- Standard texts on drilling and field guides
- BGS manuals – ARGOSS and simple field methods
- Other manuals e.g. drilling manual from Botswana

- Simplified notes written for the course and from WaterAid
- Relevant local reports

Resource centres have been established at the Ministry of Water in Lilongwe, the University of Malawi, Blantyre and WaterAid in Lilongwe. WaterAid acts as a focal point for local NGOs in Malawi. Suitable reference materials have been deposited by BGS at these resource centers.

Presentation equipment

Presentation of the course requires access to and the use of equipment such as

- Computer with Microsoft Windows 2000 or later operating system
- PowerPoint™ presentation system
- Photocopier
- Overhead projector
- Digital camera / video camera

These items were made available by the University of Malawi for use on the course at Namwra.

Availability of field demonstration sites

The course was held at the beginning of the dry season when geophysical borehole siting activities were ongoing and the drilling contractor had just been remobilised to the area to begin drilling operations. Such operations could be located close to the course base thereby minimising distances and time travelled to visit field sites.

Accommodation

Suitable accommodation for students had been arranged at Namwera but was lost due to their late arrival prior to the first day of the course. Students had to be accommodated at Mangochi necessitating their travel to and from there each day.

Transportation

A minibus was provided by the Ministry of Water for transportation of students to and from Lilongwe to Namwera, to and from Namwera to Mangochi each day and between the project HQ and the field sites visited. Additional vehicles were provided by the University of Malawi and the Mangochi East Project

Per Diem payments for students

The World Bank funded the daily allowances paid to the government employees attending the course. NGOs were requested to fund their participating employees at the same daily rate. Payment was made by the World Bank accountant in two instalments on site.

Meals

Tea breaks and lunch was provided by the course either at the course venue, at a hotel in Namwera or out on site during field visits. Course presenters were accommodated at the GITEC project manager’s residence.

Partner Groups and reporting

Representatives of the Ministry of Water, University of Malawi and the World Bank were present at the opening ceremony. The WaterAid senior hydrogeologist was present for the last two days of the course. BGS personnel were able to report to representatives of WaterAid and the University of Malawi on completion of the course, but were not able to report to the Ministry of Water or the World Bank before departure.

4.2 ADDITIONAL ISSUES AND THOUGHTS

- The manual and extra hand-outs have been very useful as auxiliary material and in coping with different competencies. The notes alone would not have been enough. The pictures and slides have also been invaluable. So have the example maps and aerial photos. Think multimedia: - chalk and talk is not enough! Break up the course with demonstrations and practical sessions.
- Note that slides should be brought on CD as well, in case a slide projector is not available.
- It does seem necessary to cover the basics (permeability, porosity, etc) as these are needed to understand many of the issues of sustainability and sanitation, etc.
- No one had a background in geology, although geological terms were constantly referred to. A brief introduction with basic notes on the main rock types, etc, would be beneficial.
- Humour has been useful in making points, relieving tedium etc. Perhaps have a few more suitable pictures or slides to help with this.
- The experiments with the permeameters and the local sediments were very useful in teaching porosity and permeability, and also broke up the classroom session.
- The posters (e.g. of groundwater development in Tanzania and Ethiopia) and the drilling logs have aroused much interest, and make the room much more like a proper lecture venue or classroom.
- Be aware of the very different competencies in the class – some are experienced in one or more aspects of hydrogeology, perhaps very experienced. Others are not, and only have a basic understanding of groundwater – these people may be specialists in the community relations and capacity building side.
- There can sometimes be a problem with not knowing in advance exactly what is going to be seen in the field, and not being able to prepare the students accordingly – try to anticipate this.
- If pump testing is to be explained, devote more time and material to this.
- There does seem to be a tendency on the part of the students to want to cover the more technical and complex groundwater issues such as pumping test analysis or computer modelling, without necessarily having an adequate background in the more basic issues. There also seems to be a latent tendency to feel that little can be done without expensive equipment (e.g. GPS receivers, laptops, etc.).
- The “software” issues and the DRA would benefit from being covered earlier in the course, and could then be discussed as and when it came up.
- Students should all be aware of the respect and trust necessary for interacting with community participation and committee structures, and should behave accordingly during field visits.

- Skills in algebra and in manipulation of units are very basic, this needs to be taken into account when explaining concepts that are normally illustrated numerically such as Darcy's Law.

4.3 MEANS OF COURSE EVALUATION

1. Informal and ongoing evaluation during all teaching activities, including the gauging of levels of interest, standards of questions asked by the students, levels of participation in class activities and interaction of the students with each other and with the demonstrators.

   The initial low level of interest shown at the start of the course was rapidly dispelled by use of lots of images and humour during the first couple of talks. By the end of the first day the students were displaying keen interest with animated discussion of the points raised. The level of interest appeared to increase as the course progressed. This and the fact that the students turned up at the venue on time and that all stayed to the end of the course were seen as very positive indicators by the participating university staff.

2. Standard of answers to specific questions asked by demonstrators.

   Pertinent questions were frequently asked by students during the various talks and demonstrations.

3. Levels of skill, awareness and knowledge displayed in the field by the students.

   Students were encouraged to participate in certain activities on site and ask questions especially of the project field staff, who themselves were encouraged to explain their activities to students, during field visits. Activities to be observed during field visits were reviewed before hand and summarised at the start of the following day using images of the field work session produced using a digital camera. On site problems due to equipment failures and poor siting of boreholes in relation to pit latrines were identified by students and discussed at length. These sessions promoted better understanding of the limitations and errors that can occur with the methodologies described that are basic to any water supply project.

4. Answers to a short written test on the final day of the course (Appendix 3).

   Considering the short nature of the course and the mixed abilities of the students they all appeared to have positive comments about the course. Most thought that the course should have been longer considering the large subject area of the course.

5. Discussion with other demonstrators and with GITEC staff.

   All of the course staff including participating field staff thought that the course was worthwhile and were very pleased with the positive attitude of all of the students Positive discussions were held with the Vice-Chancellor of the University in Blantyre following completion of the course.

5 Summary

This course is an introductory pilot course of short duration. It is designed to demonstrate the complex nature of hydrogeological investigations required to effectively undertake RWSS programmes. If students are enthused by parts of the course then they should be encouraged to participate in longer more specialised training courses located elsewhere within the SADC region.

The course structure is based upon that of a typical contract document. Suitable reference materials, produced and collated for the course, have been deposited at three resource centers to facilitate the replication of the course. Locally lost reports, such as those describing the hydrogeology of Malawi and the nature of rural water supply programmes in the 1980s need to be digitised by BGS and produced on CD-ROM format for use in Malawi.

A large and varied library of images and figures, in JPG or TIF formats, showing aspects of hydrogeology, water supply and related topics from Malawi and elsewhere in Africa need to be collected for use in PowerPoint™ presentations. Those provided by this course will form the basis of such a library.

Additional institution/project combinations, suitably equipped for training purposes, need to be identified for replication of the course.

The results of the training course have been summarised and presented on a poster.

6 Conclusions

The course is a success: the students stayed, they turned up on time, they discussed the course content amongst themselves and course staff, they felt that they had learnt and had received a significant amount of useful knowledge. The course should be repeated. This was a trial course and needs to be further refined. The course:

- is replicable and can be implanted into other suitable institutions in Malawi and elsewhere in Africa
- explains the content of a typical rural water supply and sanitation programme and borehole siting/drilling contract thereby facilitating better supervision of works by technical personnel
- promotes collection of valid accurate hydrogeological data and seeks to explain and demonstrate why data are required
- is practical, interactive and illustrative but with sufficient theoretical background

7 References

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Acronyms and Abbreviations

ADC	Area development committee
CBM	Community based management
CDA	Community development assistant
CI	Cast iron pipe
CSG	Community support groups
DCT	District coordinating teams
DDC	District development committee
DDF	District development fund
DEC	District executive committee
DRA	Demand responsive approach
DWO	District Water Officer
EAC	Executive area committee
EW	Extension worker
EWT	Extension worker teams?
FS	Field supervisor
GI	Galvanised iron pipe
HA	Health assistant
HAS	Health surveillance assistant
KAP	Knowledge, attitude and practice
MASAF	Malawi Social Action Fund
MOHP	Ministry of Health and Population
MSO	Management specialist officer?
MWD	Ministry of Water Development
MWYC	Ministry of Women, Youth and Community Services
NGO	Non-governmental Organisation
O & M	Operations and Maintenance
PAT	Project advisory team
RWO	Regional Water Officer
RWS	Regional Water Supply
RWSS	Rural Water Supply and Sanitation
SADC	Southern African Development Community
T/A	Traditional Authority
TOT	Trainers of Trainers
T-WORKS	Treatment works
VDC	Village development committee – group village headman and members
VHWC	Village Health and Water Committee
VIP	Ventilated improved pit-latrine
WMA	Water monitoring assistant
WPC	Water point committee – 5% contribution towards capital costs of a borehole etc

Appendix 1 Draft Curriculum for Supervision Teams in Borehole Construction

Prepared by the British Geological Survey for the World Bank Group for use in Malawi, October 2001

The course is broken down into five parts. Much of the course contains practical hands on experience, and practical observation in the field. Each student will receive a set of A4 instruction sheets, each devoted to a particular topic such as the water cycle, drilling equipment or the occurrence of groundwater. It is proposed that the course be held at the GITEC project station for the Mangochi East RWS. A digital copy of course notes and reference material will be left on CD with the course supervisors so that future copies can be modified and printed on demand.

The course components are:

1. GROUNDWATER AND THE WATER CYCLE (half day)

Springs, wells and boreholes and gravity schemes

To highlight the main groundwater sources, and to look at the water table and what may happen to the water table during the rainy season and the dry season, and in a borehole or well that is being heavily pumped.

Groundwater and the rocks

To look at the occurrence of groundwater in both intergranular and fractured aquifers, comparing the alluvial deposits of the Shire Valley with the weathered basement of the plateau. Depth of weathering and the influence of geological structures will be described to highlight favourable groundwater prospects. Transport of groundwater under the force of gravity will be described and a simple practical demonstration of water storage will be given using a bucket filled with dry sand.

The catchment and the river basin

The idea of the surface and groundwater catchment will be explained so that areas of good groundwater prospects such as lowlands and valley bottoms can be compared with poorer hill top locations. The respective groundwater prospects of plateau, escarpment and rift valley will be put into this context using geological/hydrogeological cross sections.

Rainfall, runoff and recharge

Where does groundwater come from? The concept of recharge will be discussed in the simple terms of the rainfall runoff budget. Patterns of rainfall (wet and dry seasons), ephemeral streams and sheet run-off will be described and Lake Malawi levels used as a demonstration of changing conditions. Recharge and discharge to gaining and losing streams will also be described. The concept of groundwater age and of time will be broached in terms of sustainability of supply.

Man's influences

Pollution and vulnerability of the resource will be discussed as will the role of land use and changing land use. Source protection will be described briefly with particular regard to on-site sanitation. Climate change and drought will be discussed along with issues such as bush clearance and the formation of sand rivers.

2. GROUNDWATER EXPLORATION (one and a half days)

Ownership

The importance of community ownership of both resource and more particularly source, will be explained from the outset and the Demand Responsive Approach (DRA) to community development explained. The important role of education and knowledge of what to demand will be underlined.

The lay of the land

Messages that can be gleaned from the topographic features of an area will be explored. Hard rock and soft rock, likely depth of weathering, alluvial flood plains, geological structures, vegetation, ant hills and other features all have a tale to tell. The practical value of stereoscopic aerial photograph pairs will be demonstrated and students invited to see in 3-D, using local images. The need to use topographic maps (1: 50 000 scale) in conjunction with GPS will be demonstrated.

Geology and soils

The underground context will be explained looking at lateritic soils, through the regolith to the weathered bedrock describing where and how groundwater may accumulate. The difficult conditions of the Escarpment will be contrasted with those of the weathered basement areas of the plateau. Groundwater occurrence in fluvial deposits will be explained and likely drilling target depths and borehole yields will be discussed.

Local knowledge

What do the people know of their own area? The importance of local knowledge will be emphasised. What are the problems with existing water sources – how can they be avoided with new sources. What are the preferred technical choices? In addition what information is available in reports and databases on local and regional conditions? Are there, for example, hydrogeological maps available for the area?

Geophysics – resistivity, EM, magnetic

The role of geophysics in locating areas of deeper weathering in basement or suitable geological structures for ponding of groundwater will be described. A practical demonstration of electrical resistivity surveying and interpretation of results (in a comparative fashion only) will be carried out in the field. Comparison of the geophysical data against known borehole data will help to show the meaning of the geophysical results. The EM system will also be demonstrated if available, but both EM and magnetic surveys will be described. The value of combining resistivity with EM will be explained. In addition the request to the geophysicist for plain and simple reporting in terms of best sites because … and worst sites because … will be demonstrated by example.

Borehole site selection

The art of optimum borehole site selection drawing together all the different strands of observation and enquiry will be explained using a local example. At this stage the location design depth and outline design of the borehole should be definable. Some idea of the nature and depth of weathering or of the type and location of geological structure will now be known. Bringing the strands together will allow an element of recapitulation of everything learnt so far so that the group can collectively discuss the evidence to come up with their own optimum drilling site and specifications. A flow diagram of the information necessary for the borehole design will focus discussion.

3. DRILLING AND BOREHOLE DESIGN (one and a half days)

Drilling equipment – when, where and how

This section will look at the different types of drilling equipment available in Malawi. It will concentrate on when where and how should the Vonder Rig, the Eureka rig and other specialist equipment such as the reverse circulation rig be used, and will describe the use of the more commonly deployed air percussion rig and the ordinary percussion or jumper rig. The respective benefits and disbenefits of each methodology will be described and the operation of the air percussion rig and the jumper rig described in the field. It is anticipated that a day will be spent with an air percussion rig watching from spudding in at surface through drilling and sampling to total depth, and completion with casing and screen, formation stabilizer and cement surface seal.

Circulating fluids and logging

The positive and negative aspects of drilling with water, foam, air or mud will be described. Sample chipping collection, cleaning and presentation will be demonstrated in the field. The importance of colour changes in weathered basement will be explained and what to look for and log described. Data gathering will also include the role of the penetration rate log and recording of water strike and water make as the borehole is drilled and monitoring of depth from drill pipes. The decision when to stop drilling and complete the borehole will be taken collectively and the reasons for so doing discussed.

Drilled diameter and planned final diameter

The relationship between drilled diameter and completed diameter and the role of temporary conductor pipe will be discussed. The standard completion design of 4 inch plastic casing in a 6 or 8 inch drilled hole and the role of centralizers and formation stabiliser will be described. Alternative non-standard completions will be briefly talked about. Slotted pipe will be handled and discussed in terms of the standard 0.8 mm machine slot screens and possible alternative screens. The need for a plain casing sump, and a plain casing length to surface will be explained and the criteria for deciding where the screen should be placed will be discussed.

Supervision and design options

The important need for rig supervision will be stressed, and the importance of drilling data gathering will be underscored. A rapport with the driller will be encouraged so that the supervisor works alongside the driller without actually telling the driller how to do his job. The supervisor has enough to do in logging, and data collecting towards his own decision making is required to decide on total depth and completion design.

Well-head protection

The importance of well-head protection through the casing cement seal and the civil works at surface will be described and examples visited in the field. The comparable lack of security of many hand dug wells and unfenced spring sources versus properly designed and completed boreholes will be described.

4. SUSTAINABLILITY OF SUPPLY (one day)

Borehole cleaning and development

A practical demonstration of borehole cleaning and development will be given stressing the need to agitate the near field environment of the borehole to ensure that all drilling debris and fine grade material are removed from the borehole. Monitoring of discharges will provide some idea of borehole yield. Measurement of grit and sediment yield will allow the process of development to be monitored. The operator must be aware of the depth to the top and bottom of the screened section. The sanitary seal is only emplaced after development to allow the formation stabiliser to settle into place and be topped up if necessary.

Test pumping and evaluation

A borehole will be tested in the field. A simple step test at 0.25, 0.5 and 1.0 l/s (or three steps of lesser yield) will be carried out in order to ascertain a suitable test yield. Given 90% recovery of the water level, the borehole will then be pumped at the appropriate yield for three hours with full measurements made through the drawdown and recovery phases. Demonstration of yield measurement via a V notch weir and by timing a known volume will be made. Analysis of the data for specific yield and transmissivity will be made and the meaning of these values explained. The simple bail test will also be described as a viable alternative to formal pumping.

Is the yield satisfactory and sustainable?

The pump test data will be combined with other observations to make judgements on the sustainability of the source. An awareness of where the water is coming from is essential. This will include the relative merits of lowland and valley bottom sites, the problems of throughflow and drainage from the Escarpment-type environment, and possible interconnection of the source with surface waters or possible sources of pollution.

Pumps – technical choices

The Afridev pump will be described and demonstrated. The working parts of the pump and the problems associated with wear and tear will be discussed highlighting the role of pump monitoring and pump maintenance. Other types of pump will also be discussed and situations when they could be deployed will be described. The family bail pump will be highlighted as a valuable small yield alternative to the conventional hand pump.

Maintenance and monitoring

The significance of data in maintaining working water points will be described in terms of the necessary infrastructure required to support a rural water development programme. The role of community ownership will again be discussed. Detail such as field numbering of borehole sites and cross reference of data holdings to location and village name will be described. Examples of both a project database and the national Malawi borehole database will be used.

5. GROUNDWATER QUALITY, PUBLIC HEALTH, THE LAW, AND CONCLUSIONS (half a day)

Water quality – bugs and minerals

The natural baseline quality of groundwater will be described highlighting problems of fluoride occurrence in lakeside areas of northern Malawi, and the occurrence of iron and manganese in some groundwaters in the basement aquifers. The occurrence of pathogenic bacteria in groundwater will be described and the possible pathways from source to target identified. Simple means of water treatment will be discussed, including aeration and disinfection.

Vulnerability to pollution

The relative vulnerability to pollution of shallow and deeper groundwater resources will be discussed. Simple means of protecting shallow resources will be discovered through discussion of the issues pertaining to groundwater pollution. The need for sanitation development and health and hygiene education to proceed in parallel with rural community water development will be described. The physical relationship between pit latrine and borehole will be discussed to provide awareness of the dangers of interconnection between the two.

Contracts and the law

A brief look at legal matters will include the tender and contract process surrounding most drilling activities and example contract documents will be inspected. Awareness of quantities and dimensions will be stressed. Problems and pitfalls will be presented. The legal constraints within the water sector in Malawi will be reviewed including the WHO water quality stands, the legal onus on NGOs, and matters concerning health and safety and staff welfare.

Logistics

An awareness of weights of mobile equipment and tolerance of bridges and tracks will be provided. The vagaries of mobilisation during the rainy season will be highlighted.

A precious resource

This final section will provide a round-up of the whole of the course and will again revisit DRA and ownership. It will end by asking students what they will be taking away with them and how this may help them in their future work.

Appendix 2 Students of the Workshop

A total of 18 students attended the ten-day workshop in supervision of teams in borehole construction at Namwera 42Km East of Mangochi District. They are listed below

Name of Participant	**Position**	**Organization/Address**
Bright Tembo	Construction Technician	Concern Universal P.O. Box 1535 Blantyre Malawi Tel: 265 623 761, 265 476 412 Fax: 265 623 846
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Christina Mphasa	Data Preparation Clerk	Ministry of Water Development Private Bag 390 Lilongwe 3 Malawi Tel; 265 770 344 Fax: 265 773 737
Chrispin Mzumara	Water Monitoring Assistant	Ministry of Water Development Private Bag 390 Lilongwe 3 Malawi Tel; 265 770 344 Fax: 265 773 737
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Shadreck. Chimangansasa	Technical Supervisor	Water Aid P.O. Box 402 Salima Malawi

Denis Jiko	Water Engineer	Christian Service Committee P.O. Box 949 Blantyre Malaw Tel: 265 950 270 Email: deliwewe@yahoo.com.uk
Kiswell Phiri	Technical Assistant	Ministry of Water Development District Office P.O. Box 10 Mangochi Malawi Tel: 265 594 029l
Vyalema Khosa	Field Officer	C.C.A.P. Synod of Livingstonia P.O. Box 1000 Mzuzu Malawi Tel: 265 333 735

Appendix 3 Twelve evaluation questions

Give a reason why collecting groundwater data or information is important.

1. Name one source of information about the groundwater of an area.
2. Why is recharge important to the hydrogeologist?
3. What is one advantage of EM34 compared with resistivity?
4. Give one reason why a cable-tool percussion rig is sometimes used, even though they are slow.
5. Give one way in which the Demand Response Approach (DRA) tries to make sure that communities will maintain their boreholes.
6. What are your comments on the notes that were handed out?
7. What do you think was the best part of the course?
8. What did you dislike about the course?
9. What topic or subject should be added to the course next time?
10. Was the length of the course appropriate?
11. Who else do you think would have benefited from the course?

Comments on the questions:

1. Only one learner got question 1 wrong. This topic was emphasised throughout the course, and demonstrated in a variety of ways.
2. Three students got this question wrong, or left it out. It is possible that this question was phrased badly, with some students not understanding what a "source" was.
3. Five students got this wrong or left it out. It was a new concept to many students, and was also covered fairly quickly. If it was phrased differently (such as "why is it important to estimate how much groundwater goes into an aquifer") the response would probably have been better.
4. Eight students got this wrong or left it out. It was covered in lectures and in the practical session on geophysics. Some students were not clear what the difference between the two techniques was. This is partly to be expected, since at least half of the students had not used geophysics before.
5. Only one learner got this question wrong. The slowness of cable-tool percussion was a discussion topic, and the pros and cons of the technique were reinforced in lectures and in the field.
6. Two students got this wrong or left it out. Generally the issues of community involvement contributing to sustainability were very well understood.
7. Most students found the notes to be useful. Many said that they were clear, concise and well explained. Some said that they would be useful for their own training purposes. One comment was that the notes need to be simpler.
8. A wide range of topics were listed, covering most of the course content (although, interestingly, not the community liaison and DRA parts). Several students put geology and/or geophysics, whilst sample collecting and the field visits were also mentioned by a few. Three respondents put "all".

9. Six students answered “nothing”. Two mentioned that the time was too short, and two mentioned inadequate accommodation arrangements. Other comments included: interpretation of geophysics and pumping tests was too complicated, not enough time for questions, difficult geological terminology, not enough field trips, and one facilitator did not speak loudly enough.

10. Three students wanted more experience with geophysics – plotting graphs, and using the equipment to get real data. Two others mentioned waste water treatment and disposal. There was a wide variety of other suggestions, including: shallow wells and spring protection systems, more on contamination, groundwater modelling, pumping test and geophysical interpretation using software, water sampling and analysis, more on borehole design, more on monitoring and evaluation, borehole logging (geophysical?), and geological surveys. Some of these topics should probably be added, such as shallow wells and spring protections, water analysis, and more on pumping test interpretation. However, some are clearly beyond the scope of the course, such as computer modelling and waste-water treatment.

11. Five students felt that the length of the course was about right. All the rest felt that it was too short, with one feeling that it should be three to four months long!

12. Groups of people who were mentioned by more than one learner included Ministry of Health personnel, contractors and drillers, district water planners, and anyone involved in water and sanitation. Other groups mentioned included technicians, government geologists, government policy makers, NGO staff, MASAF, and community members.

This CD-ROM is part of report CR/02/219N 'Development of a Curriculum and Training of Supervision Teams in Borehole Construction in Malawi'. The CD contains course notes, manuals and reports supplied to participants and annotated versions of PowerPoint™ presentations made during the course undertaken in Malawi.

The files are presented in Word and PowerPoint™ formats so that they can be adapted for use by others undertaking similar training courses. The CD-ROM contents must be accessed using the Microsoft Windows 2000 (or later) operating system.

Additional reports included on the CD are:

- ARGOSS 2001. Guidelines for Assessing the Risk to Groundwater from On-Site Sanitation. British Geological Survey Commissioned Report, CR/01/142
- The Manual of Simple Methods for assessing groundwater resources in low permeability areas of Africa (Report CR/01/168N)
- A brief review of groundwater for rural water supply in sub-Saharan Africa (Report WC/00/33)
- Van Dongen, P and Woodhouse, M , 1994. Finding Groundwater: A project manager's guide to techniques and how to use them. UNDP-World Bank Technical Report.

Some of the reports are in pdf format and can be read with Acrobat Reader. Acrobat Reader version 5.0 has been included on the CD and can be installed by double clicking on **ar500enu.exe**

To read a file: open Windows Explorer and navigate to the CD drive; then double click on the desired file name. To access the Training Course Report file double click on Main Report, then select the version according to CD drive access letter: D or E. The data files can be accessed either by clicking on the blue underlined hyperlinks within the text of the main report or by double clicking on the relevant Word or Excel file.

This CD was compiled by Jeff Davies and Jude Cobbing from the British Geological Survey.

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