# K: SWAZILAND

## K.1 INTRODUCTION

The Swaziland country visit was undertaken by Gert Nel of SRK Consulting from 3-8 February 2002. The visit focussed around discussions with the Department of Geological Survey and Mines's (GSM) groundwater branch since they act as regulator of all groundwater-related activities. Another important role-player, the Rural Water Supply Branch (RWS) functions as implementing agent for rural groundwater projects but do not maintain or keep updated records of their drilling activities. Transfer of information from RWS to GSM is irregular.

Some of the basic information on groundwater occurrence and institutional aspects has been taken from the country report for the 'Minimum Standards' project, updated where necessary.

## K.2 BACKGROUND

Swaziland is located between the Republic of South Africa and Mozambique. It is one of the smallest (third) of the SADC Member States with a land area of 17,400 km$^2$. The country has a variable topography and climate, which can be divided into four distinct physiographic zones:

- *The Highveld* is located along the western side of the country and is characterised by mountainous topography. The rock type mainly comprises large granite masses and metamorphic units in the northwest.
- *The Middleveld* is located east of the Highveld, with more rolling hilly topography and comprise granites and gneises forming a landscape of open plains and small hills.
- *The Lowveld* is the largest region, covering approximately 37% of the country and is underlain by sedimentary rocks of the Karoo Sequence and is characterised by generally flat bush country and is often affected by drought.
- *The Lubombo Plateau,* the smallest region of Swaziland, covering about 8% of the country, is adjacent to Mozambique. It comprises mainly volcanic rocks at the top of the Karoo Sequence.

## K.3 GEOLOGY AND HYDROGEOLOGICAL FRAMEWORK

### K.3.1 Geology and Hydrogeology

A large area is underlain by igneous and metamorphic rocks of the Archean Basement Complex. These are located primarily over the western two-thirds of the country. There is a limited region of Karoo Sequence sedimentary rocks present in a narrow band in the eastern Lowveld region and post-Karoo igneous intrusives in the Lubombo region. The Karoo units primarily include the upper formations of deltaic sandstone/mudstone and aeolian sandstone. Recent alluvial deposits are present in small areas along the major river valleys. There are no laterally extensive aquifers.

All the rocks in Swaziland's stratigraphic succession have been affected by faulting and folding to some degree (Piteau, 1992). Two major north-south trending mylonite shear zones are present in the central area, affecting the Archean granites and gneisses and the Mozaan Group sediments. Because of the abundance of thick, relatively impermeable rocks, secondary permeability is considered to be of prime importance for groundwater flow and storage (Piteau, 1992). Groundwater flow is primarily in zones of deep, continuous weathered bedrock (Ezulweni, Malkerns and Manzini areas) or predominantly through either fractured or jointed bedrock, or shallow, discontinuous weathered zones.

The most comprehensive national groundwater resource assessment was carried out during the Groundwater Survey Project (1986-1992). The total renewable groundwater resources were calculated to be 21 $m^3/s$. The estimate was based on recharge studies including water balance, water table monitoring and stream baseflow monitoring, as well as general observations of wellfields. As part of the project a hydrogeological map was produced and a groundwater database developed.

### K.3.2 Natural Groundwater Quality

Groundwater quality in Swaziland varies considerably considering the small size of the country. Water quality in the western Highveld and Middleveld is quite good, but higher levels of mineralisation make groundwater quality in the Lowveld commonly poor. TDS values for the western section of the country, with basement complex aquifers, is predominately < 800 mg/l while in the Karoo basalts, average TDS is > 1,000 mg/l. Fluoride and nitrate concentrations above accepted water quality levels have also been noted in some locations. The fluoride problem does not appear to be associated with any specific aquifer lithology but there does appear to be a positive correlation between high levels of fluoride and nitrate in groundwater. High levels of nitrate in groundwater are generally attributed to natural sources within the aquifer materials.

## *K.4 DATA ACQUISITION*

### K.4.1 Institutional Framework for Data Collection

The following main institutions & personnel were interviewed:

- **Department of Geological Survey and Mines**. In Mbabane, Obed Ngwenya (Senior Hydrogeologist). General groundwater information from boreholes drilled on groundwater projects are kept here. Information pertaining to the collection of data, storage and processing of data is also available at GSM, as well as the Hydrogeological Map and accompanying report. The groundwater database is maintained by Victoria Dlamini. Although not comprehensive, monitoring and other time dependant data are also kept at GSM;
- Representatives from the **Water Resources Branch**, Ministry of National Resources and Energy, in Mbabane were interviewed. The branch has a hydrological database (surface water), but no groundwater data.
- Members of the **Rural Water Supply Branch** were telephonically interviewed as they were not available for formal interviews at the time. They are involved in rural groundwater water supply, but do not keep records or maintain a database.

The existing Water Act (Act No. 25 of 1967) provides regulations pertaining to the drilling of boreholes and information required It is therefore required by law that the driller and the owner of the borehole provide the government with the relevant borehole specifications. Unfortunately, the law cannot always be enforced and therefore few data are provided in cases where drilling takes place outside of a state funded contract. Data are collected ad hoc and are project specific. The Rural Water Supply branch (RWS) is directly involved in the funding and implementation of rural water supply projects, but the data are not automatically transferred to DGSM.

The new Water Act has already been drafted (1998) and approved by the cabinet and is pending parliamentary approval. The new Act will establish the National Water Authority as a corporate body with a mandate to immediately develop a Water Resources Master Plan and a Department of Water Affairs. The act has not yet been passed.

Groundwater data are collected during DGSM activities. Siting, drilling and yield details are recorded in the field and then submitted to the database section on return to the office. Boreholes are located on orthophoto maps and coordinates determined. Borehole logs are produced for each borehole and are finally verified by the Senior Hydrogeologist. The paper copies of all data forms for each borehole are then filed. Mr. Ngwenja (Senior Hydrogeologist) again verifies the correctness of data before being entered into the database. When an outside client requests borehole data, the data are drawn from the database and again verified before being handed over to the client.

## *K.5 GROUNDWATER INFORMATION SYSTEM*

### K.5.1 Hardware and Software

DGSM is the custodian of the national groundwater database and aims to fulfil the role of managing data collection. The database was updated in 1992 and is in DBASE format. Monitoring and pumptesting data are kept in EXCEL. The GIS section of the DGSM assists in the production of general geological and hydrogeological maps and has the following hardware and software:

- 2x PC's, one a Pentium Pro (r) and the other a Pentium (r)';
- 1x scanner (A4) - Scanjet 6100 C;
- 1x Plotter - Hp Designjet 450 C - A1;
- 1x colour printer - Hp 1600 C;
- GIS software includes MAPINFO;

Hard drive space varies from 2 GB to 7.85 GB and the RAM from 32 M to 64 M.

An additional two Pentium II PC's with MS Office and Windows 98 as operating system are available from Mr. Ngwenya and his secretary. The groundwater database runs off DBASE 7, whilst the groundwater monitoring (water level data) is being done in EXCEL.

### K.5.2 Data Saved

The existing DGSM database (set up during the CIDA project) is well designed and working well. The hydrogeology database (SWAZIDAT) not only stores the data but also allows manipulation (i.e. test pumping data analysis) and form and log presentation. As only DGSM is primarily involved in groundwater development, it contains the bulk of the groundwater data for the country. Summary reports of boreholes drilled and tested are produced monthly. The database has been designed in DBase and as such can export data in a variety of formats. At present there are ± 2000 records from DGSM boreholes and approximately 600 records for boreholes drilled by other organisations. Although it is not presently used within a GIS system, all boreholes have UTM coordinates. Data from the groundwater database (in DBASE 7) can be exported to MAPINFO where the required maps and data ouputs are archived. The level of training in the use of the software and graphical output is limited.

### K.5.3 Quality of data

A quality control system has been developed for the verification of monitoring data and new borehole data. Monitoring data are being kept in EXCEL format and controlled by Mr. Mgwenya. The data collected during the hydrogeological study by Piteau & Ass in 1992 have been thoroughly verified and field checked before being used in the compilation of the existing hydrogeological maps.

### K.5.4 Available resources for maintenance

Operation and maintenance for rural water supply is undertaken by village committees in conjunction with the RWSB. Communities elect a local water committee that is changed every two to three years as per custom. This has created some problems in terms of training and local capacity building.

Minor maintenance is carried out by the community, with major maintenance and repairs the responsibility of RWSB.

### K.5.5 Institutional and Legal Framework

Although groundwater is a critical aspect of rural water supply in the country, groundwater development is centralised completely in the DGSM. Although the quality of their work is excellent, they do not have the human or equipment capacity to provide for the growth in demand. Additionally, since their focus is strictly on groundwater development, there is little or no management of the resource.

The new Water Act will provide a framework for control and management of groundwater, but significant capacity development will be required to fully implement the requirements of the new law, i.e. permitting, monitoring. It would also appear that involvement of the private sector will be required to take the pressure off the over-extended and inefficient rural water supply structures.

## *K.6 GROUNDWATER MONITORING*

### K.6.1 Monitoring Network and Frequency

Water level monitoring was begun during the DGSM/CIDA project in 1992, where more than 50 boreholes located throughout the country were monitored. At present, spring discharges or water quality are not being monitored. Water quality of boreholes is tested only during drilling and/or test pumping operations. Water level monitoring is being done infrequently and selectively, primarily because of a lack of manpower and funds. The monitoring programme that was started in 1992 could therefore not be sustained.

**Table 1: Monitoring Summary**

| Item | Comment |
|---|---|
| ▪ Purpose of monitoring | General water resource evaluation - abstraction control |
| ▪ Monitoring is done by | GSM |
| ▪ What is being monitored | Rest water level, water quality, abstraction |
| ▪ Details of monitoring network | Ad hoc monitoring |
| ▪ Monitoring frequency | Irregular - problem specific |

### K.6.2 Quality of the monitoring data

Monitoring data are being kept and updated in EXCEL under the direct supervision of the Senior Hydrogeologist, Mr. Ngwenya. Quality control measures exist.

### K.6.3 Available resources for monitoring

All available resources focus on rural water supply and the monitoring is done as and when needed. There is no set monitoring programme and hence no resources have been allocated.

## *K.7 HYDROGEOLOGICAL MAPPING*

### K.7.1 Existing Hydrogeological Maps

The first and only countrywide hydrogeological map was completed in 1992 as part of the CIDA project. The map (1:250,000) indicates water quality (conductivity and fluoride content), as well as depth of borehole and depth to static water level. The maps also indicate "Recommended Development Areas" which have identified potential, based on available data where sustainable borehole yields are expected to be >1 l/s and quality is acceptable. Additionally, the whole country has been divided into regions of 'no', 'fair' and 'moderate' groundwater potential, based on the overall conditions expected in those areas.

During the Groundwater Survey, the geologic/structural units of the country were divided into a series of six major subdivisions, within which are defined sub-groups. Additionally, each of these was given a two letter code which could be combined with other codes to specify not just a simple case, but also instances when more than one type of aquifer was present. Of the identified units and sub-units, the Greenstone Belt, Mozaan Group, weathered basalts and fault zones were found to be the most productive.

The Groundwater Resources of Swaziland map portrays the following information:

- Twenty seven major hydrogeological units,
- Nine rock types,
- Two cross sections (cations/anions),
- Borehole positions & blow yields,
- Geological structures (e.g. faults),
- Surface water features,
- Spring positions,
- Topographical contours (v.i.125m),
- Four insert maps depicting groundwater quality (chloride, fluoride, electrical conductivity, Piper Diagram - including concentrations)

Map grid references refer to the Universal Trans Mercator Clark 1880 - modified (UTM) system . Hydrogeological data were compiled from information collected between 1986 and March 1991, including 395 boreholes drilled and tested by the DGSM (Piteau & Ass.)

A series of 1:50 000 Groundwater Survey maps were also produced and contain hydrogeological information and basic geological information obtained from DGSM. These maps depict:

- Groundwater chemistry plots (Ca, Mg, K+Na, $HCO_3$+$CO_3$, Cl, Piper Diagram with hydrogeologic unit),
- A groundwater Chemistry Map (borehole water quality pie diagrams, Bh positions),
- Daily precipitation,
- Water level monitoring hydrograph (1986-1990),
- Borehole positions, yield, static water level and depth,
- Spring positions, yield, flow rate and temperature (thermal springs).
- Written inserts (hydrogeological summary, groundwater chemistry plot & map and hydrogeological units),
- Two cross sections (hydrogeological units and borehole depth / position).

Map grid references refer to the UTM system and the schedule of 1:5,000 orthophotos available from Public Works Department, Swaziland.

### K.7.2 Existing geological & Physiographic and other maps

Other existing maps include geological, physiographical and topographical maps (See Table 1 below).

**Table 2: Summary of existing maps**

| Map Type | Scale | Year | Inserts | Done By |
|---|---|---|---|---|
| Hydrogeological | 1:250 000<br>1:50 000 | 1992<br>1992 | Water Quality<br>Geol. section | Canadian International. Development Agency |
| Geological | 1:250 000<br>1:50 000 | 1982 | Magnetic structures<br>Geological setting | Swaziland & UK |
| Physiographic Map | 1:250 000 | 1989 | none | Swaziland |
| Topographical Maps | 1:50 000 | 1992 | none | Swaziland |

## *K.8 DATA AVAILABLE FOR SADC HYDROGEOLOGICAL MAP*

According to Piteau & Associates the data that they used for the compilation of the hydrogeological map in 1992 have been transferred to the Swaziland database. The geological, topographical and physiographical maps are produced outside the GSM and their data sources and formats are not known.

## *K.9 CAPACITY AND COMMITMENT*

Funds and resources are very limited, but Mr. Ngwenya and his team are very committed to the programme and have pledged manpower support where possible. History has, however, shown that they do not have the necessary manpower or resources to upkeep a comprehensive monitoring network or groundwater database. There is, however, a firm commitment towards the protection of Swaziland's groundwater resources. Issues such as health and job creation form the main focus of funding from central government each year. Very little is spent on groundwater development or management.