M: ZAMBIA

M.1 INTRODUCTION

The Zambian country visit was undertaken by Imasiku A. Nyambe of the Geology Department, University of Zambia in March and April, 2002 as part of the SRK Consulting team.

M.2 BACKGROUND

M.2.1 Physiography and Climate

Zambia has six main catchment areas (Zambezi, Kafue, Luangwa, Chambeshi, Luapula and Lake Tanganyika), and four major rivers (Zambezi, Kafue, Luangwa and Luapula. It also has four main natural lakes (Bangweulu, Mweru, Tanganyika and Mweru-wa-ntipa), extensive swamps around Lake Bangweulu, Lake Mweru-wa-ntipa and the Lukanga swamps.

Major flood plains occur in upper Zambezi, middle Kafue, Chambeshi River and the Luapula River. It has shared watercourse systems, for example the Zambezi River basin with Angola, Botswana, Namibia, Zimbabwe, Mozambique, Malawi and Tanzania. The Zambezi Basin area is almost 1.5 billion km^2.with about 40% of the Basin within Zambia, and over 70% of Zambia's surface area and of its population are within this Basin. Another important tributary of the Zambezi is the Kafue River where almost half of the population lives. The Kafue Basin plays a central role in Zambia's economy, with most of the nation's mining, industrial and agricultural activities within its catchment.

The average rain season lasts 97 days with a mean precipitation of 1000 mm compared with a global average of 860 mm.

M.2.2 Water Resources

Zambia is endowed with relatively abundant water resources predominantly from a distinct rain season, which starts in October and ends in April. The total renewable water resources from both surface and groundwater is estimated at 144 cubic kilometres per annum and gives potential per capita water of 19500 cubic metres per annum. Groundwater recharge is estimated at 57.5 billion cubic meters per year equivalent to 78 mm per year (YACHIYO ENGINEERING CO., Ltd., 1995).

Groundwater plays a major role in the water sector in Zambia, both in rural and urban water supplies, irrigation and mining. Similar to many southern African countries, the bulk of water supply in rural villages is supplied through hand pumps, open wells and pumped boreholes. But even large urban centres, including Lusaka and Ndola, receive a large proportion of their water from groundwater. Both Lusaka and Ndola supply approximately half of their requirements through groundwater. For Lusaka this amounts to approximately 100,000 m^3/day abstracted from dolomite aquifer beneath and surrounding the city. The city of Kabwe was previously supplied completely by groundwater, but this has since been reduced to approximately 20% (the remainder being supplied by surface water) due to the increasing presence of lead and zinc in the groundwater.

At the time of the completion of the National Water Master Plan (1995) the distribution of groundwater use was as follows: 30% irrigation, 27% rural water supply, 22% livestock and 13% urban supply. Although there are no statistics, private development of groundwater is notably increasing in many parts of the country. Private usage is primarily for irrigation on farms and domestic water supply. Even in urban areas such as Lusaka, where reticulated supplies are available,

drilling for domestic supply is extremely common for residents who are trying to avoid the high tariffs charged by the water utilities or due to erratic water supplies.

The most significant fundamental change in water supply in Zambia is on-going privatisation, which will see the majority of the population receiving water from various utilities.

M.2.3 Overall Institutional Framework of the Water Sector

There are number of institutions involved in the water sector including government, non-government and the private institutions. Their nature of involvement ranges from policy/legal formulation and implementation, service provision and consumption. Because of the large number of institutions involved, the institutions were grouped into generally eight (8) broad categories to make sure that a broad number of stakeholder institutions are consulted and interviewed. As a result at least one or more questionnaires have been administered and received from each category except from Local Authorities (see Table 1) The broad categories are:

i) Government ministries and departments (e.g. MLGH, DWA);
ii) Local Authorities (e.g. city councils);
iii) Regulatory Authorities (e.g. Water Board, Environmental Council of Zambia (ECZ) and NWASCO);
iv) Commercial Water Utilities (e.g. Lusaka Water and Sewerage Company);
v) Private Sector (e.g. Water Wells Ltd,);
vi) Academic and research institutions (e.g. University of Zambia);
vii) Bilateral and multi-lateral institutions (World Bank, UNICEF etc.);
viii) NGOs and CBOs (WWF).

M.3 GEOLOGY AND HYDROGEOLOGICAL FRAMEWORK

M.3.1 Geology and Hydrogeology

The bulk of Zambia is underlain by Archean to Recent sedimentary units, with more limited areas of igneous and metamorphic basement present in the southeast. Generally the Precambrian continental basement in Zambia is comprised of granites, meta-igneous and meta-volcanic units. Relatively minor amounts of intruded dolerite dykes and sills are occasionally present in the bedrock formations.

Sedimentary bedrock units include the Precambrian Muva and Katanga supergroups and the Paleozoic/Mesozoic Karoo Supergroup. All of these formations include clastics and carbonates, while the Karoo Supergroup in addition includes basalt. These sedimentary bedrock units are present throughout the north and central regions, and are interpreted to underlie unconsolidated cover in the west of the country.

The Cretaceous to Recent Kalahari Beds as well as locally extensive areas of alluvium form a largely unconsolidated sedimentary cover over western Zambia as well as localised areas of alluvium in the other regions of the country. The thickness of the Kalahari Beds generally increases to the west and southwest where it can exceed 100 meters. The lithologies for the Kalahari beds are generally fine sands and friable sandstones, clays and duricrust horizons (silcrete and calcrete) whereas alluvial sediments are similar but lack duricrusts and can have coarser sand units.

A regional assessment of the hydrogeology of the country was completed as part of the National Water Master Plan completed in 1995. In this study, groundwater occurrence was divided into three major categories: aquifers with intergranular flow, aquifers with flow in fissures and discontinuities and basement aquifers.

Aquifers with primarily intergranular flow include the Kalahari Beds and alluvium as well as limited zones within some Karoo sandstone units. Over much of western Zambia's Kalahari sands, groundwater occurs in shallow perched aquifers and deeper semi-confined aquifers. Aquifers are best developed near present drainage systems where recharge occurs from both rainfall and surface flow. Laterally extensive alluvial deposits are associated with the major river drainages, particularly along the upper Zambezi near Mongu, and around lakes such as Lake Bangweulu. In areas along the Luangwa River, Karoo sandstones are characterised by intergranular flow. Yields within this aquifer type are variable and reflect grain size, sorting, clay content as well as secondary fracturing in consolidated sandstones and range from 1 to 20 l/s.

Aquifers with flow in fissures and discontinuities include the sedimentary bedrock as well as Karoo basalt units within the country. The aquifer types include both fractured sedimentary and basalt units as well as fractured and karstic dolomite limestone units. The highest yielding aquifers in the country fall into the second group (dolomites and limestones) where yields range from 20 to more than 100 l/s. Due to the yield characteristics as well as the proximity of the aquifers to urban areas, this unit is a major source of supply for Lusaka, Kabwe and Ndola. Yield from fractured clastic and basalt lithologies of the Muva and Karoo Supergroups is more variable, but productive aquifers are locally developed (1 to 10 l/s).

Basement aquifers are present in the south-eastern portion of the country and are primarily formed in fractured and/or weathered zones in the shallow weathered mantle of bedrock. Borehole yields are low ($\leq$ 1 l/s), but are generally sufficient for handpump installation, which forms the primary water supply method in these areas.

As already indicated, groundwater will continue to play a major role in the water sector in Zambia, particularly in irrigation agriculture and water supply for domestic use. The completion of privatisation of the water supply sub-sector will see the majority of the population receiving water from various utilities with the most important aquifers in Zambia such as the Karstic Aquifers of Lusaka and Kabwe providing most of the supplies.

M.3.2 Natural Groundwater Quality

Groundwater quality in Zambia is generally acceptable for most uses, with limited cases of high salinity primarily to the west of the country. Fluoride is also locally above acceptable limits. The overriding quality problem in the country is contamination of aquifers from anthropogenic sources. Due to urbanisation of much of the population, as well as uncontrolled growth in the cities, local aquifers are at high risk from contamination. Major dolomitic aquifers, which generally have shallow water tables and high rates of local recharge, are particularly vulnerable. There are documented cases of groundwater pollution in the Lusaka area with contamination sources including uncontrolled dumping in low-lying (i.e. recharge) areas, uncontrolled industrial waste discharges, cemeteries and non-point sources such as runoff in the urban environment.

Water samples are collected during drilling for analysis by the DWA laboratory with field testing of pH, turbidity and TDS with field kits. Groundwater data are maintained in paper files with one copy to the project and one copy maintained by the lab. However, the lab is poorly equipped and the facility is in poor condition, thus limiting the quality of analysis.

There is a legal framework to enforce regulations in terms of pollution of water resources within the Environmental Pollution Prevention Control Act (1990). However, there is no quality monitoring outside of the Lusaka area.

Existing water quality standards for domestic water are generally compared to WHO standards, particularly for F, Cl, Fe, Mn and NO_3. The LWS samples water points within Lusaka every two days

with sources (boreholes) sampled every day. Analysis is carried out by their own laboratory for basic cations/anions, colliforms, and BOD. Heavy metals are analysed periodically by the University of Zambia laboratory. Several boreholes have identified problems related to coliforms although no heavy metal contamination has yet been noted. All groundwater is chlorinated.

There are no set guidelines on protection zones for boreholes. In rural areas there has not been significant problems, but in the urban areas, control of land use and waste handling is a pressing issue. For example a "temporary" dumping site in the Lusaka area in a known recharge area has yet to be closed by the authorities although the Environmental Council has noted that this is critical.

M.4 DATA ACQUISITION

M.4.1 Institutional Framework for Data Collection

There are many stakeholders in the water sector, grouped into eight categories as indicated previously. Their roles and functions are summarised below:

Government ministries and departments have over the years played various roles in both the water supply and water resources sub-sectors. The multiplicity of institutions without clear responsibilities and co-ordination tended to create operational overlaps and gaps, leading to duplication of activities and thereby straining the resources. In 1993, the Government adopted the so-called " Seven (7) Sector principles" to guide the reformation of the water sector. The reforms that began on the water supply and sanitation sub-sector have established very clear institutional structures from the national/central level to the local government level. The reforms in the water resources sub-sector were launched in June 2001 under the Water Resources Action Programme (WRAP), and like those of the WSS, are geared to also address the institutional and legal frameworks, amongst others.

The Ministry of Energy and Water Development (MEWD) through the Department of Water Affairs (DWA) and the Department of Energy, is the main institution responsible for water policy formulation and water resources management activities that include:

- Assessment planning and development of surface water;
- Assessment planning and development of groundwater;
- Planning and supervision of development, operation and maintenance of hydropower generation projects.

The completed restructuring process in MEWD in accordance with the Public Service Reform Programme has shifted the responsibility of the Ministry from being a provider of water supplies to that of management of the resource. This has led to a new institutional framework in the Ministry as follows:

- Three statutory bodies within the ministry: the Energy Regulation Board, the Water Development Board and the National Water Supply and Sanitation Council are currently in operation;
- Water Resources Action Programme under Department of Water Affairs has started its programme of implementing Integrated Water Resource Management.

The Ministry of Local Government and Housing (MLGH) through the Department of Infrastructure Support Services (DISS) is responsible for:

- Legal/policy formulation and enforcement;
- Resource mobilisation, through the Ministry of Finance, for the physical planning of water supply and sanitation services.

The Ministry of Environment, Tourism and Natural Resources through the Department of Forestry, Tourism and the Environmental Council of Zambia (ECZ) has a very broad mandate that includes:

- Environmental monitoring and enforcement of legislation;
- Conducting baseline studies on natural resources that include water resources;
- Ensure exclusion of all possible sources of pollution;
- Setting and monitoring standards for purity of natural waters;
- Improvement of watersheds through control of soil erosion and forestation;
- Supervision of surface water quality;
- Development of water for scenic enjoyment and adventure;
- Water resource utilisation for recreation purposes;
- Protection of sport fisheries.

The Ministry of Agriculture and Co-operatives (MAC) through the Departments of Fisheries and Agriculture is responsible for monitoring the use of water for, amongst others:

- dam construction for crop irrigation and livestock watering;
- improvement of watersheds though control of soil erosion;
- control measures to prevent toxic chemicals from getting into water basins and accumulating to toxic levels.

The Ministry of Mines and Mineral Development ensures proper exploitation of hydro-mineral resources and observance of water legislation in mining so as to maintain in good order the existing water supplies and avoid pollution.

The Ministry of Health is responsible for:

- setting standards for drinking water quality;
- monitoring drinking water quality.

The Ministry of Lands through the Department of Lands and Survey has a role in water resources management. By allocating land, the Commissioner of Lands also allocates the groundwater resources passing through or located under the particular piece of land.

Local Authorities (cities, municipalities, districts) are, by the Water Supply and Sanitation Act (1997), obliged to provide water supply and sanitation services to the areas under their jurisdiction. The same Act, however, gives the Authorities options through which they might discharge this responsibility. Through this window most LAs have entered into joint ventures with other LAs and established commercial water utilities under the Companies Act. By so doing, such LAs are no longer responsible for the daily operation and management of water supply and sanitation services. There are, however, other areas that have not as yet commercialised the provision of water services. In such areas the local authorities are still responsible for providing the services. However, the exact role of the local authorities in water resources management is still not clear as none of the current laws gives them explicit functions except for that of pollution prevention contained in the public health Act.

Regulatory Institutions in the water sector statutory bodies are established by acts of parliament. They are sector specific and their roles are defined in their respective establishing legislations. However, all the regulators are concerned with the economic, environmental and quality of service regulation. The main regulatory institutions are:

- The **Water Board** which is responsible for allocating raw water rights of all surface water resources to the various sectors of the economy, operates under the Water Act, Cap 198 (1948). The Act empowers the Board to control the use of water resources by charging abstraction fees.

However, groundwater is NOT included and this is subject of discussion in the Water Bill under review. Groundwater is indirectly controlled through town and country planning.

- The **National Water Supply &Sanitation Council (NWASCO)** which was established under the water supply and sanitation Act (28) 1997 and is responsible for regulating the provision of water supply and sanitation services throughout the country. It regulates through issuing operating licences to all providers, developing policies, setting standards and other guidelines and taking any necessary measures to provide for efficient and sustainable provision of services throughout the country. As an economic and quality of service regulator, NWASCO is responsible for approving all water tarrifs, determining the service standards and monitoring service performance. In relation to groundwater, a series of groundwater related regulations and standards are being formulated, primarily to provide an adequate framework for the extensive on-going privatisation in public water supply. This will include guidelines for deep well (borehole) construction, hand dug well construction and handpump standardisation. The guidelines, when finalised, will be published through the Zambian Bureau of Standards. The regulatory structure will be three-tiered, from government to the utilities and finally to the users.

- The **Environmental Council of Zambia (ECZ)** which was established under the Environmental Protection and Pollution Control Act No 12 of 1990 is empowered to (a) establish water quality and pollution controls standards; determine conditions for the discharge of effluents into the aquatic environment; (b) formulate rules for the preservation of fishing areas, aquatic areas, drinking water sources and reservoirs, recreational and other areas, where water may need special protection; (d) initiate and encourage international co-operation in the control of water pollution, in particular with those neighboring countries with which Zambia shares river basins; (e) collect, maintain and interpret data on water quality and hydrology which are relevant to granting of licenses.

  The ECZ has a primarily role in ensuring the preservation of the integrity of all natural water bodies in the environment, both surface and ground. This is for both the bodies within Zambia and those that are shared with other countries.

Commercial water supply and sanitation utilities (CUs) have been established as a result of the water supply and sanitation reforms that began in 1994. They have been established by Local Authorities under the WSS Act (1997) to provide water and sanitation services in designated areas. The mandate of CUs is to provide efficient and sustainable supply of water and sanitation services under the general regulation of NWASCO. There are currently nine established CUs and these are Chipata, Kafubu, Lusaka, Mulonga, Nkana, North-Western, Southern and Western.

The **private sector** constitutes an important end-user category of the water resources. These include the manufacturing, food and processing industries, mining, agricultural and hydropower generation. Hydropower generation is the largest user of surface water in Zambia. For instance, approximately 90% of the water rights on the Kafue River are allocated for hydropower generation. Although there are some private companies that provide water supply services as a fringe benefit to their employees (e.g. Chilanga Cement, Zambia Sugar, Maamba Collieries, ZESCO Ltd and Konkola Copper Mines (KCM)), these are in a minority. However, the most obvious contribution from this sector is the number of drilling companies such as Water Wells Ltd and various consulting firms who provide services in the siting, drilling and provision of groundwater in Zambia.

Academic and research institutions' participation is mainly in the area of training personnel and in various researches. The University of Zambia (UNZA) and the Copperbelt University are the premier training institutions for water and related professions at both the under and post-graduate levels. The undergraduate programme at the Geology Department contains a general hydrogeology component and some of those currently employed as hydrogeologists in Zambia are as result of this training.

Others include the Natural Resources Development College and the trades training institutes spread throughout the country. In addition these institutions provide research in various fields such as water quality assessment and monitoring. The National Institute for Scientific and Industrial Research (NISIR) conducts research in water quality of both drinking water and in nature, of surface and ground water.

Bilateral and multilateral institutions have been the main financiers of water programmes in Zambia for over a decade now. They have provided over 90% of the total costs of all major programmes of the past decade, through direct finance and technical assistant. Recent external support include providing funds for the reform of the water supply sector and the establishment of the commercial water utilities, and financing the current WRAP initiative. It is thus clear that little would be achieved in the sector without external support. Prominent amongst these are the World Bank, the African Development Bank, UNICEF, KfW, NORAD, GTZ, Ireland Aid and Sida.

There are a number of **NGOs and CBOs** involved in water activities in both the water supply and water resources. These include the International Union for the Conservation Nature (IUCN), the World Wide Fund for Nature (WWF), the Environmental Conservation Association of Zambia (ECAZ), Care International, Water Aid and World Vision International. WWF have been actively in funding the management of catchment areas and key wetland areas such as the upper Zambezi Flood Plain, Kafue Flats and the Bangweulu Swamps.

In the water supply sector, NGOs, such as Care, and CBOs such as RDCs, co-operate in the promotion of community-based management of water supply schemes, mostly in Lusaka and thus groundwater resources are key in this provision. The role of NGOs has also extended to mainstreaming gender roles in the protection and provision of community water services. Others, such as Zambia Water Partnership (ZWP) focuses on sharing of information across sectors and encouraging stronger stakeholder participation in water issues, and has actively participated in WRAP process and several strategy formulation exercises in the water sector, and looks forward to the revision of the Water Act to include groundwater resources.

M.4.2 Groundwater Data Collection

Groundwater data collection is generally limited throughout most of the country. DWA maintains paper files for siting and drilling operations on standard forms. There is a siting report form and a borehole completion form. Data from 1970 onwards are present in the files. Borehole numbers are given based on a consecutive number followed by the year of installation. Costing information for private clients is also kept on forms maintained in the library.

Data collected for projects outside of DWA, such as UNICEF or LWS projects, are rarely submitted to DWA. Various levels of data are kept by these institutions in their reports. However, the restructuring of DWA and the creation of the new posts generally reflects an increasing emphasis on the groundwater sector.

In the present study, at least most respondents (Table 1) to the questionnaire during the interview and administration had a fair understanding of this project "Compilation of the hydrogeological map and atlas for the SADC region" and thus provided some useful information in the implementation of such a project in Zambia and SADC.

Table 1: Distribution of Questionnaire Response and institutions relevant to groundwater information, monitoring and mapping

Category	Date	Institution Contacted and Names	GG	MT	M	1	2	3	4	5	6	7	8
Government ministries and departments	05/04/02	Department of Water Affairs P.O. Box 50288, Lusaka Mr. Simon Kangomba – Hydrogeology Section	R	R	R	√	√	√	√	√	√	√	√
	25/04/02	Department of Water Affairs Mr. N. H. Mpamba – Drilling Section	R	R	R	+	√	√	√	√	√	√	√
	05/04/02	Department of Water Affairs Mr. Jonathan Kampata – WRAProgramme	R	N	N	√	√	√	√	√	√	√	√
	25/04/02	Department of Infrastructure and Support Services, Ministry of Local Government and Housing, Box 50027, Lusaka, Zambia Mr. C. Mulambo	R	N	N	+	√	N	√	N	N	√	N
	27/03/02	Geological Survey Department, P.O. Box 50135, Lusaka, Zambia. Mr. M. Mwale and Mr. R. N. Ndhlovu	R	N	R	√	√	+	√	√	√	√	√
	23/04/02	Zambia Meteorological Department, P.O. Box 30200, Lusaka, Zambia. Dr. R. Mugara	N	R	N	√	√	√	√	√	√	√	N
	27/03/02	Zambia Survey Department, Mulungushi House, Independence Avenue, Box 50397, Lusaka Mr. Mwiya Mooka	R	N	N	√	N	N	+	√	√	+	N
	22/04/02	Irrigation Section, Ministry of Agriculture, Mulungushi House, P.O. Box 50291 Lusaka. Mr. George Phiri	R	N	N	+	+	+	√	+	√	√	√
	15/04/02	Mines Development Department, Ministry of Mines and Mineral Development, P.O. Box 31969, Lusaka. Mr. C. W. Chansa and Mr. S. C. Maango	R	N	N	√	+	√	+	N	N	N	N
Regulatory	08/04/02	Water Development Board, P.O. Box 51059, Lusaka, Zambia, Mr. C. Chibwe	R	R	N	N	√	√	√	√	√	√	√
	24/04/02	Environmental Council of Zambia, P.O. Box 35131, Lusaka. Mr. J. Sakala and Mr. J. P. Daka	R	R	N	√	√	√	√	√	√	√	√

Category	Date	Institution Contacted and Names	GG	MT	M	1	2	3	4	5	6	7	8
	25/03/02	NWASCO, P.O. Box 34358, Lusaka. Mr. Rees Mwasambili	R	N	N	N	N	N	N	N	N	√	√
Commercial Utilities	26/03/02	Lusaka Water and Sewerage Company, Box 50198, Lusaka. Mr. Henry Mtine, Mr. Banda	R	R	N	N	√	N	N	N	N	√	√
Private Companies	10/04/02	Azurite Water Resources Ltd., 338 Kalundu Market, Off Lunsemfwa Rd, Kalundu, Lusaka Dr. C. Mdala	R	N	R	+	√	+	√	√	+	√	√
	19/04/02	Rankin Engineering Consultants Ltd. Box 50566, Lusaka. Mr. Vahdat Alavian	R	N	R	+	+	N	√	√	+	√	N
	30/04/02	Water Wells Ltd. P.O. Box 30635, Lusaka. Mr. J. F. Geldenhuys	R	N	N	N	√	+	√	+	N	√	√
Research and Training	23/04/02	Department of Surveying Engineering, School of Engineering, University of Zambia, Box 32379, Lusaka, Mr. Alick Mwanza	N	N	R	+	N	N	√	√	+	√	N
	26/04/02	Computo-Geological Advisory Unit, Geology Department, School of Mines, UNZA, Box 32379, Lusaka. Mr. Simon Nkemba	R	N	R	√	N	√	√	N	√	√	√
Bilateral & Multi-lateral	10/04/02	The World Bank, African Region, Anglo American Building, 74 Independence Avenue, P.O. Box 35410, Lusaka. Mr. C. Maseka	N	N	N	N	N	N	N	√	N	√	√
NGOs & CBOs	25/03/02	World Wide Fund for Nature, P.O. Box 50551, Lusaka. Mr. C. Chileshe	N	N	N	+	N	+	N	N	+	√	√
TOTAL		20				**8**	**11**	**8**	**14**	**11**	**10**	**18**	**14**
		Percent (%) of √ to the TOTAL				**40**	**55**	**40**	**70**	**60**	**50**	**90**	**70**

Key

GG = General Groundwater information, collection, storage & processing, MT = Monitoring / time dependent data, M = Mapping, 1 = Hydrogeological maps, 2 = Monitoring and Sampling, 3 = Data management, 4 = Services, 5 = Quality Assurance and Quality Control, 6 = Budget, 7 = Way Forward, 8 = Comments. R = Relevant, √ = over half to fully answered, + = only partly answered, N = Not Applicable or No comments

M.5 INFORMATION SYSTEMS

M.5.1 Hardware and Software

The available hard / software for each relevant institution is given in Table 2.

Table 2: Available Hardware and Software for each relevant institution

Category	Institution Contacted and Names	Hardware	Software			
			Operating System	Database Software	Graphical Software	Software facilities
Government ministries and departments	Department of Water Affairs P.O. Box 50288, Lusaka Mr. Simon Kangomba – Hydrogeology Section	PC	Windows		GIS -	MS Office / Office Professional
	Department of Water Affairs Mr. N. H. Mpamba – Drilling Section	PC - 1	Windows			MS Office / Office Professional
	Zambia Meteorological Department, P.O. Box 30200, Lusaka, Zambia. Dr. R. Mugara	PC	DOS, Windows	Clicom	Surfer GIS – IDA/ IDRISI	MS Office / Office Professional
	Irrigation Section, Ministry of Agriculture, Mulungushi House, P.O. Box 50291 Lusaka. Mr. George Phiri	PC - 6	Windows		Surfer GIS - ArcView	MS Office / Office Professional
	Mines Development Department, Ministry of Mines and Mineral Development, P.O. Box 31969, Lusaka. Mr. C. W. Chansa and Mr. S. C. Maango	Server/ Network	Windows		CAD, Autocad, GIS– ArcView, ArcGIS	MS Office / Office Professional
Regulatory	Water Development Board, P.O. Box 51059, Lusaka, Zambia, Mr. C. Chibwe	PC	Windows			MS Office / Office Professional
	Environmental Council of Zambia, P.O. Box 35131, Lusaka. Mr. J. Sakala and Mr. J. P. Daka	Server/ Network/ Workstation/ PC	Windows		GIS– ArcView, ArcGIS, Arc/Info	MS Office / Office Professional
Research and Training	Computo-Geological Advisory Unit, Geology Department, School of Mines, UNZA, Box 32379, Lusaka. Mr. Simon Nkemba	Network, Workstation and PC	Windows	MS Access	Surfer, Autocad, ArcView/DAK GIS- ArcView Arc/Info, Erdas Imagine	MS Office / Office Professional
TOTAL	8					

From Table 2, three institutions have servers or network systems and graphical software capable of handling large amounts of data such as involved in the making of a hydrogeological map. A good example is the University of Zambia's Geology Department, where the system is user friendly and in most cases able to export to others through the University of Zambia network. Whereas, DWA have groundwater database from which a SADC Hydrogeological Map can be constructed, unfortunately it has no capacity to solely undertake such an activity but can do so in colloboration with those with facilities such as Geology Department, UNZA and Rankin Engineering Consultants Ltd. (see also Section 9: Capacity and Commitment).

M.5.2 Data Saved

The computer database on groundwater that was set up as part of the National Water Master Plan (Yachiyo Engineering Co., Ltd., 1995) is available at DWA, though it is no longer active. In addition, the Water Board in the Ministry of Energy and Water Development indicated that they own an electronic database of hydrological parameters that operates on Windows starting from 1998.

Unfortunately, the respondent does not know the database software it runs on but it is updated every three month and interpreted every month, citing lack of funds as the main reason for backlog in data capture.

M.6 GROUNDWATER MONITORING

The restructuring has provided the institutional framework in which groundwater could be managed, controlled and monitored. However, the existing Water Act for Zambia dates from 1948 and does not address groundwater. Other existing laws related to development and management of water are:

1) The Environmental Protection and Pollution Act (1990)
2) The National Water Supply and Sanitation Act (1997)
3) The Zambezi River Authority (1986)

The Water Act (1948) only specifies that if a given parcel of land has no groundwater potential, access to groundwater in adjacent areas must be granted. Revision of the Water Act includes a specific section for groundwater. It provides for permitting of groundwater abstraction by the Water Board, and specifies data collection requirements and drilling reports that must be submitted to the Board. Additionally, there is a stipulation that groundwater should not be abstracted in excess of its reasonable and beneficial manner, and later it is indicated that the permitting will be for a specific quantity of groundwater that can be abstracted. However, there is no standard procedure for recommended yield determination presently used by government bodies.

The Environmental Protection and Pollution Act calls for establishment of water quality and pollution control standards, the contracting or carrying out of investigations on actual or suspected water pollution, the prevention or abatement water pollution, the setting of standards for analytical methods for pollution testing, and enforcement of rulings. The Act also includes a licensing framework, but it only addresses effluents to watercourses.

With only a limited legal framework at present for groundwater, control and management of the resource is extremely limited. There is no permitting of groundwater abstraction, no system of nationalised borehole numbering, and no requirement for groundwater data submission to DWA.

M.6.1 Monitoring Network and Frequency

There are presently no groundwater monitoring activities carried out by DWA. The only governmental monitoring recently initiated is groundwater quality monitoring in the Lusaka Dolomite Aquifer by the Environmental Council. Sampling of the initial existing borehole network is done annually (wet and dry seasons). It is planned for this type of environmental monitoring to be expanded to other urban areas in the near future. Water supply utilities are also monitoring boreholes regularly including water levels, abstraction rates and water quality. At present these data are maintained in daily report sheets internally only.

DWA is expected to take an active role in expanding the level of monitoring in the country. One area where such monitoring is urgently needed is groundwater abstraction.

DWA indicates that the objective of the monitoring network is mainly for resource management and science purposes and that it consists of water supply boreholes and wells. On hydrogeological monitoring only yield testing / pumping rates and physical parameters (water level, K, S, T) are carried out manually and transferred using pen and paper. The Water Board's (WB) monitoring network consists of spring flow and weirs, and meteorological stations. However, both DWA and WDB indicate that there is no monitoring and identification system in place.

M.6.2 Quality Assurance and Quality Control

M.6.3 Available resources for monitoring, identification of gaps

WRAP indicated that although there are QA /QC measures in place during monitoring / sampling and data management stages, this is done some of the time whereas the WDA hydrogeology and drilling, Geological Survey indicated that it is done all the time. The private sector (Azurite) on the other hand indicated that it is done most of the time. Most of the procedures involve random checks with on-going training provided mainly as in-service training.

Overall, inadequate resources has led to a lack of monitoring. Some of the initiatives started by DWA of monitoring water levels in the Lusaka area in the mid-90s are no longer carried out. This a major gap in the water sector in Zambia particularly where groundwater is concerned.

M.7 HYDROGEOLOGICAL MAPPING

M.7.1 Existing Hydrogeological Maps

The first and only countrywide hydrogeological map was compiled under the Sub-Saharan Africa Hydrological Assessment Study (MacDonald and Partner Ltd, 1990). The data from which this map was compiled are not available at DWA but at SADC Water Sector. Except for the Department of Water Affairs and the Geology Department, University of Zambia no other institution seem to have a copy of the map.

The main purpose of this map was to summarise the current status of available hydrogeological information for Zambia. The map was produced at a scale of 1:1,500,000 and serves rather as a reconnaissance map presenting the available hydrogeological information and should not be used for the actual siting of new boreholes as careful fieldwork is necessary for this. It is presented in one sheet inclusive of a Brief Description of Zambia, Legend, Explanatory Note and two inserts maps of Geological Outline and Hydrogeological Data coverage. In somewhat detail, the map depicts the following:

Groundwaters are either bicarbonate type (in Muva Sediments, dolomites, Kundelungu and Karoo Groups) or sulphate type (in Basement rocks, granites, Mine Series and Kalahari). Sodium chloride waters are known to occur in the Muva sediments of the Lunsemfwa Valley.

Classification and Legend of the Map

Explanation on the Classification and Legend of the map is contained in the Explanatory Note on the Map Sheet. MacDonald and Partners Ltd., (1990), when making the map, used three ONC sheets (N4, N5 and P4), 4th edition at an original scale of 1:1,000,000 as the topographic base. The geographic projection is Lambert Conformal Conic with topographic contours at 500 feet (152m) intervals.

Geological information was mainly taken from the 1981 edition of the 1:1,000000 geological map of Zambia published by the Geological Survey Department, Lusaka. Geological information was supplemented by various reports including C D Chenov (1978), Geological Survey sheet descriptions and reports on Lusaka, Ndola and Kabwe water supplies.

The geological legend shows both the present, commonly accepted formation names and the lithostratigraphic names as standardised in 1983 by the Stratigraphic Committee, Geological Survey Department.

Chenov's 1978 report and data from the Department of Water Affairs provided the basis for the borehole locations and water level change information. The boreholes shown were those drilled or utilised during the Chenov study.

Depth to water table, water level elevations and abstraction rates for urban supplies have been taken from consultant's reports and Department of Water Affairs data. Dewatering volumes from mines were provided by the Ministry of Mines and Mineral Development. It should be noted that the data are the latest available and do not refer to any particular year.

Water quality data are mainly derived from Chenov's 1978 report. Inconsistencies between total dissolved solid and electrical conductivity values shown in report tables and on the report maps were resolved by assuming that conductivity values were correct.

Hydrogeological classifications were based on drilling and pumping test data in previous reports, including Italconsult, Chenov and Lambert, together with annual reports of the Department of Water Affairs.

The **Legend of the map** consists of the following components:

- Groundwater Development Prospects
- Lithologies
- Groundwater Features
- Surface Water
- Topographical symbols

The Groundwater Development Prospects of the legend depicts the aquifer types and yield categories and lithologies (Table 3). Aquifers are divided into three types and these may further be subdivided (Table 3).

Table 3: Hydrogeological Classification of Groundwater

Occurrence	**Intergranular Aquifers**	**Fissures, channels or other discontinuities aquifers**	**Limited potential aquifers or regions without significant groundwater**
Description	These are moderately productive aquifers consisting mainly of alluvial sands and gravels.	(a) These are highly productive aquifers consisting mainly of Upper Roan Dolomites and Kundelungu Limestones.	(a) Low yielding formations of are mainly the Karoo basalts, Mine Series, Shales and Basement Gneiss.
		(b) These are locally productive aquifers of mainly undifferentiated Kundelungu, Lower Roan quartzites, Muva sediments and granites.	(b) These are unproductive formations, which are mainly Karoo shales, metamorphic and igneous rocks.
Example	Kalahari Group and Karoo sandstones.	(a) The Karstic aquifers of Lusaka and Kabwe fall into this subgroup.	(a) Mine Series aquifers of Zambia Copperbelt or Basalts in the Livingstone area
		(b) Lower Roan quartzites of the Zambian Copperbelt	(b) Karoo shales in the mid-Zambezi Valley

Occurrence	**Intergranular Aquifers**	**Fissures, channels or other discontinuities aquifers**	**Limited potential aquifers or regions without significant groundwater**
Yield (l/sec)	TYPE COLOUR AND COLOUR SHADES		
	BLUE	SHADES OF GREEN	SHADES OF BROWN
0.1 - 15	Dark blue		
1 - 70		Deep green	
1 - 10		Light green	
0 – 2			Pale (medium) brown
			light brown

The Lithologies part of the legend depicts the symbol in different hatches of shades of grey, lithology itself, lithostratigraphic unit or equivalent and age. The lithologies are varied and consist of different types of sedimentary, metamorphic and igneous rocks, ranging in age from Archean to Recent.

Groundwater features show:

- Borehole Location and Date in red + symbol with the letters N, T, C and D at the ends of the cross where:
  - N = Borehole number
  - D = Depth to water (m below ground level)
  - C = Specific capacity (l/sec/m) or yield (l/sec) where underlined.
  - T = Total dissolved solids (mg/l)
- Geological fault in solid black line
- Contour lines on equal depth to water level (m) in dashed green line
- Contour lines on groundwater elevation; m above sea level in solid green line
- Rise in groundwater level (m) during Nov 1977 – Apr1978 rainy season in solid red line
- Dewatering abstraction ('000m3/day) in open red triangle
- Major supply abstraction ('000m3/day) in open red circle
- Thermal or saline springs, in concentric blue lines

Surface water features indicated include rivers, lakes, marsh and land which is subject to inundation; all in blue.

Topographical symbols include roads, tracks and trails, railways, power transmission lines, towns and contour in feet above sea level; all in very fine, somewhat faint grey shades (lines and symbols).

Overall, although the map depicts aquifer types and their expected borehole yields, it ignores storage and recharge. The various groundwater features are superimposed against a detailed drainage, subdued lithological and topographic symbols in the background. Due to the scale of the map, and the various colour shades of the aquifers, it is rather difficult to recognise some of the lithologies despite the fact that they have been simplified.

Two Map Inserts

Two maps are included with the map. These are the geological outline and the hydrogeological data coverage. The geological outlines shows general structural belts and lithologies whereas the hydrogeological data coverage shows four levels of hydrogeological data. These include:

- Detailed coverage
- Moderate density of data
- Low density of data
- Very low density of data

As expected, Lusaka, Kabwe and Ndola have a detailed coverage with adjacent areas having a moderate density of data. Because of the extensive borehole set-up in Western Zambia, the Mongu and surrounding areas also shows a moderate density of data. Parts of Lusaka (west of Lusaka city), Central (west of Kabwe), parts of Southern (south-west of Lusaka), parts of Eastern (west of Chipata) and area around Lake Mweru in Luapula show low density of data.

The need for a new comprehensive hydrogeological map is recognised and the outcome of the SADC Groundwater Atlas project is anticipated.

National Water Master Plan hydrogeology related maps

Various maps relating to hydrogeology are present in the National Water Master Plan. In this study, the classification of geology of Zambia was simplified into the following groups and component rocks (Table 4).

Table 4: Classification of Aquifers

Lithostratigraphic Unit		Main Aquifer Lithology	Productivity of Groundwater	% of the Whole Country (%)
Cenozoic Super Group	Alluvium	Sand, Gravel	Medium-High	11.9
	Kalahari	Sand	Medium-High	23.8
Karoo Super Group	Upper Karoo	Basalt	Low	0,5
		Sandstone	Medium-High	4.5
	Lower Karoo	Mudstone	Low	0.7
Katanga Super Group	Kundelungu	Carbonate Rock	High	2.0
	Undifferential Kundelungu	Shale	Low	12.9
	Upper Roan	Dolomite	High	0.4
	Lower Roan	Quartzite, Dolomite	Medium-High	0.8
	Mine Series	Quartzite, Shale	Low-Medium	3.7
Muva Super Group		Shale	Low	9.4
Basement Complex		Gneiss, Migma-tites, Schist	Low-Medium	14.2
Granite		Granite	Low-Medium	15.2
Other Igneous Rocks		Basic-Igneous Meta-Igneous	Low	
Metamorphic Rocks		Metasediment, Metavolcanies	Low	

Source: Hydrogeological Map of Zambia (scale 1: 1,500,000) and Groundwater Resources Inventory of Zambia (Chenov, 1978).

Groundwater occurrence was divided into three major categories: aquifers with intergranular flow, aquifers with flow in fissures and discontinuities and basement /finer material aquifers and depicted in a very simplified hydrogeological map. Briefly these aquifers are:

Aquifers with intergranual groundwater flow
The alluvial formations, Kalahari Group and Karoo Group are included in this category. This type of aquifer is distributed mainly in the western half of Zambia, in Western Province and parts of North-Western Province and Southern Province. It also occurs around Chambeshi River and Lake Bangweulu in Luapula and Northern Province and along Luangwa River in Eastern and Northern Province.

Aquifers with flow in fissures, channels or discontinuities
The aquifer is subdivided into two types:

Highly productive aquifers
The Upper Roan dolomite and Kundelungu limestone are included in this category. Limestone, dolomites and dolomitic-limestones are often the most productive aquifers in Zambia. This type of aquifer is distributed in Copperbelt, Lusaka, North-Western and Central Province. The area of distribution is limited and very narrow, but some large cities are located around this type of aquifer.

Locally productive aquifers
The Lower Roan Quartzite, Muva sediments, granites and undifferential Kundelungu formations are included in this category as locally productive. These aquifers are distributed largely in Northern, Luapula, Central, North-Western, and Copperbelt Province.

Basement / finer material aquifers (low yielding with limited potential)
This category includes the major part of argillaceous formations, Karoo basalts and the older Basement Complex. This type of aquifer is distributed in almost half of Eastern, Southern and Lusaka Province, and parts of Northern, Luapula, Central, Copperbelt and North-Western Province.

The **legend** of this map only depicts the three aquifers above with no other symbol or feature on the map.

M.7.2 Existing Geological Maps

The country is covered by geological maps at various scales produced by the Geological Survey Department:

- 1:100,000. At this scale about 40% of the country is mapped accompanied by published reports. Most of these areas are within or near transport infrastructure such as rail or roads.
- 1:250,000. These regional geological maps exist for parts of the country, but major parts of Western Zambia and minor in parts of the Eastern provinces have the reconnaissance mapping completed only and maps are still awaited.
- 1:2,000,000. Gravity Survey map;
- Some 1:250,000 and 1:100,000 scale Geochemical maps are available,
- 1:1,000,000 Geological Map of Zambia in four segments
- Magnetic map of Zambia can be obtained at a scale requested.

M.7.3 Existing Physiographic Maps

The Surveyor General: Zambia Survey Department, Ministry of Lands is responsible for production of topographic maps. As of 2002, the following coverages are available:

- 1:250 000. Whole country;
- 1:50 000. Whole country

However, for some of the map sheets, the survey has run out of print.

M.7.4 Other Maps

Several reports on the Surface Water Resources of Zambia are available at the Department of Water Affairs including maps. A number also appear in the Master Plan Report of 1995 by JICA.

M.8 DATA AVAILABLE FOR SADC HYDROGEOLOGICAL MAP

Approximate amounts of money that are allocated to map activities were indicated as follows:

(a) Geological Survey Department, K60,000,000 towards map production
(b) Computo geological Advisory Unit (**CGAU**), overall budget of K25,000,000 with K10,000,000 for data management and K5,000,000 for map production
(c) Ministry of Agriculture, Irrigation Section indicated K1.2billion for training and water awareness programmes for the general public with a further K80million for map production.
(d) Zambia Survey Department indicated K370 million for map production.
(e) Meterological Department indicated overall budget of K750 million with K300 million for monitoring, K120 million for data management and K10 million for map production. It is anticipated an estimate of capital investment of maintenance of K25 million.
(f) Water Affairs Department, Hydrogeology and Drilling Section (Table 1) indicated an estimated annual budget of K1 billion with K500million - K800million on monitoring, K150million on maps and K80million – K200million on data management. These figures indicate what is supposed to have been available in a normal operation but are far from reality. The hydrogeology section further indicates an estimate of capital investment within the next two years of K800million on hardware, K100million on software and K500million on maintenance. As for development of the SADC map WDA indicates a budget of K40million – K200million with a manpower of about 10.

However, for most organisations particularly government units, these funds are mostly on paper and do not translate into actual liquidity. For example, due to limited funds, DWA have not updated their groundwater database for the past four years.

To access these data, for example in government departments, the main channel or protocol is through the Director of the Department or Water Board Secretary.

M.9 CAPACITY AND COMMITMENT

The capacity in Zambia is varied and various services and products are offered. These services and products are mainly requested by the general public, government and private organisations, and include processed data on maps, borehole siting, drilling and rehabilitation, casing, and groundwater evaluation.

M.9.1 Commitments on Contribution to the Regional Mapping Project

The following commitments have been indicated by government departments as follows:

- **Geological Survey Department:** commit the use of equipment such as hardware e.g. industrial scanner –colortrac large format –3640 and various software e.g. Mapinfo and their skilled cartographers can assist in the production of the map with assistance of geologists
- **DWA – WRAP and Hydrogeology section:** Only WRAP section indicated use of their technical staff in data collection and entry and mainly from hydrological. Hydrogeology section indicated use of their hardware with no specification.

- **Ministry of** Agriculture – Irrigation section: can offer use of their digitising tablets, computer, plotter and printer with Arcview software. They can allocate 30% of their time to the map with 3 members of staff involved.
- **Department of Infrastructure and Support Services (DISS), Ministry of Local Government and Housing:** Can only assist in form of manpower of 2 staff with a total allocated time of 25%.
- **Meterological Department:** Can assist in terms of manpower of 2 staff with GIS skills at a dedicated time of 40%.

The regulatory bodies indicated that:

- **Water Development Board:** can assist in terms of manpower of 4 staff with hydrology skills at a dedicated time of 40%.
- **Environmental Council of Zambia:** can assist in terms of use of their hardware and software facilities which of course will involve their staff.

The research and training institutions indicated that:

- **Computo-Geological Advisory Unit, Geology Department, University of Zambia:** use of their Remote Sensing and GIS PC workstations and various software such as ArcInfo, ArcView, Edars Imagine with a manpower of 5 at a dedicated time of 25%.

Engineering Survey Department, University of Zambia: can assist in data collection and manipulation and management through use of hardware and software with a manpower skilled in surveying, mapping and GIS.

The private sector indicated that:

Water Wells Ltd.: can only be involved if there is need for boreholes to be drilled.
Rankin Engineering Consultants: can produce hydrogeological maps through use of their hardware e.g. colour AO printer and have skilled manpower in map drawing and geological inventory with a number of staff of 6.

M.9.2 Concerns

The major concerns of **government departments** are mainly with the ownership of water resources, particularly with aquifers that cut across political boundaries and there is a need therefore for a clear regulation or protocol on international waters (shared river basins) that should include groundwater. Other concerns were on strategic planning, maintenance of systems as well as political / security and a few wanting to know who would be the custodian of such a map. However, they indicated that such a map would offer better planning / management and ultimately reduce financial cost and thus improve on community health and services and empower local people. Most indicated that three categories of staff should be trained i.e. managerial, technical and data collection staff with a few suggesting that political leaders should also be capacitated.

The major concerns of **regulatory institutions** are mainly with ownership of water resources, political security with one each going for either maintenance of system, strategic planning and communication between partners. The regulatory institutions emphasize the need to involve all the stakeholders from the beginning so as to tackle some of the policy issues above and provide a way forward as to how these common water resources could be shared sustainably. However, all indicated that such a map would offer better planning / management and 2/3 indicating that this will ultimately reduce financial costs and only one felt that this will empower the local people. 2/3 indicated training of political leaders, managerial and technical staff and only one suggested data collectors should also

be trained.

The major concerns from the **research and training institutions** are in the ownership of water resources, strategic planning and maintenance of such a system. Transboundary aquifers are some of the policy issues to be sorted out. However, the map would provide for better planning / management of resources, financial cost reduction and ultimately improve community health and services and hence empower the community. The research and training institutions suggest training or capacitating all the groups mentioned i.e. political leaders, managerial staff, technical and data collectors as the level of knowledge in groundwater is very low in Zambia.

The World Bank indicated strategic planning, followed by political /security and then ownership and maintenance as major concerns with ownership of groundwater resources and transboundary aquifers as policy issues that should be addressed before such a map is implemented. However such a map would allow for better planning / management of resource and make available country specific information. Further comments made are that the Atlas should be linked to:

Private Companies (Rankin, Azurite and Water Wells) had varied response to this section. However 2/3 indicated communication between partners as a major concern with ownership of water resources, strategic planning and maintenance of the system as other concerns. Issues that should be addressed include aquifer management and contamination prevention, and implementation of groundwater laws. However such a map would allow for better planning / management of resource (**all**), improved community health and services (2/3) and probably reduce financial cost and empower local people (Azurite only). 2/3 indicate that all four categories should be trained including political leaders.
Azurite indicated that the Map should indicate:

- Areas of maximum groundwater recharge
- These areas then to be zoned and protected from any development

NGOs such as **WWF 's** major concerns are political / security and strategic planning. However, the map would allow for better planning / management of resource. WWF would only train the technical staff.

Overall the main constraint in implementing such a map is finances followed by manpower with few indicating hardware and software.

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