

Development of a IT / GIS Model Designed to Help Local Municipalities in South Africa to Manage Water and Sanitation Services and for the Benefit of Poor and Rural Communities

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Key words:

SUMMARY

The national Dept of Water Affairs and Forestry (DWAF) in South Africa has developed a strategy, in line with government policy, to devolve the responsibility to supply water and sanitation services, to local municipalities. All water and sanitation assets owned by DWAF will be transferred to local municipalities (LMs) over the next three years.

Government has finally realized that the delivery of basic services to communities is best carried out at the local level. DWAF plans to provide local municipalities with the necessary resources to manage these services and LMs are generally in favour of this new government policy.

There are several problems which will affect the implementation of this strategy including extremely poor as-built information of the water and sanitation services, a culture of non payment of services by communities, limited resources of LMs to manage and operate water and sanitation services etc.

This paper presents an IT / GIS / Facilities Management Model designed by survey consultants engaged by DWAF, that will address the problems listed above and effectively empower LMs to manage and expand their water and sanitation services. The model combines IT and GIS technology with GPS technology, data management technology, innovative database design, local skills empowerment and the re-engineering of local government business processes. Implementation will commence in January 2003 and will extend to November 2004, at a cost of approximately €2.0 million

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1. INTRODUCTION

District Municipalities (DMs) and Local Municipalities (LMs) in South Africa have been assigned the responsibility of delivering essential services to end users. These services include water, sanitation and refuse collection. Municipalities are also responsible for disaster management and primary health care.

Many municipalities are newly constructed in terms of the Municipal Structures Act 117 of 1998 and in many cases (approximately 25%) of LMs do not have any computer facilities. This is especially true in the rural areas of South Africa and particularly in the Eastern Cape.

Notwithstanding the above, LMs are expected to perform and government has and will allocate grant funding to assist municipalities in meeting their service obligations.

This paper presents a Geographical Information (GI) strategy adopted by provincial and local Government to assist DMs and LMs alike to operate and manage water and sanitation assets.

The strategy presented is sustainable, efficient and effective in its deployment of human resources and technology and could form the blueprint for other similar implementations in other provinces of South Africa.

2. BACKGROUND

It is the Government of South Africa's stated intention to provide water for all of its citizens. To this end the Department of Water Affairs and Forestry (DWAF) has been mandated to facilitate water service delivery to the rural poor and others who have not previously had access to water services. Hence, the Government of South Africa has embarked upon an extensive multi-faceted water services sector support programme to provide water and sanitation services to improve the quality of life of poor rural communities. This programme is being supported by funding from the European Community (EC) through the Commission of the European Communities in terms of a financing agreement. The work will be focused in the provinces of Northern Province, KwaZulu Natal and Eastern Cape where province specific plans have been put in place known as Multi- Annual Action Plans (MAAP). At a national level the programme is known as Masibambane. It is expected to provide sustainable services to approximately 2.4 million people.

DWAF are in the process of transferring all of their water assets (dams, water infrastructure, records etc) to local authorities. Most of these assets are in a poor state of repair.

The Water Services Act identifies local government as having the ultimate responsibility for water service delivery and the Division of Revenue Act specifies that no capital funds will be spent without agreements being in place to ensure long-term sustainability of the envisaged service. Therefore the implementation of the programme requires close co-operation between DWAF and local authorities to ensure that the capital programme is in line with local authority expectations and their ability to provide the service over the long term.

The recent local authority demarcation process has also created several new authorities, in addition to some existing authorities, that have limited institutional capacity to provide the above service. Hence, the programme is being undertaken in an environment in which democratic local government structures have only recently been put into place and new legislation places the responsibility for sustainable service provision on these new institutions.

In view of the lack of institutional capacity within many of these institutions to undertake such a rapidly deployed multi-sectoral programme, the Department of Water Affairs and Forestry (DWAF) is responsible for facilitating the provision of water and sanitation services. DWAF also has to ensure that this work is integrated with other works that are being co-ordinated by the Department of Provincial and Local Government (DPLG). In addition, the other aspects of the programme aimed at providing institutional and social development to ensure sustainability of water and sanitation services are also being channelled through DWAF.

The programme involves the expenditure of some €230 million over three years in the Masibambane provinces. At present this amount includes donor support of some R600 million, of which R500 million is from the European Community, while the United Kingdom, Netherlands and France provide the remainder. All of these donors have particular implementation, review and reporting requirements.

In the Eastern Cape, it is anticipated that the MAAP programme will amount to some €90 million over three years. Of this, donor funding will amount to approximately €30 million. The programme is divided into 3 main theme areas:

- *Theme 1: Sector Orientation.* This theme includes a review and update of policy and legislation taking into consideration the new Water Services Act and related legislation, particularly that related to local government. The result of the theme should be a more consumer orientated water and sanitation services sector that is integrated with other local services.
- *Theme 2: Service Delivery.* This involves the sustainable provision of water and sanitation services in the above Provinces as well as the necessary health and hygiene education and orientation. It also includes the transfer of water service infrastructure currently operated by DWAF to local government.
- *Theme 3: Institutional Support.* This involves providing support for the development of institutional capacity at all levels of Government as well as in the private sector to ensure the sustainability of the programme.

It includes:

- Support to DWAF at the national level so that it can fulfil its regulatory, monitoring and evaluation and support functions.
- Support to DWAF at the regional level to strengthen its regulatory functions and support the transfer of schemes and resources to local government where appropriate.
- Support to Local Government to ensure it can fulfil its functions as Water Service Authority (WSA).
- Support to facilitate the establishment of Water Service Providers (WSPs).
- Assisting the Non Government Organisation (NGO) and Social Consultant fraternity in ensuring community participation in the development of water services.

In the development of the overall strategy for the MAAP, information systems were identified as a key enabler in terms of achieving the sustainable delivery and operation of water services in the region. To this end, a feasibility study was carried out in late 2001 and early 2002 on the feasibility of establishing an integrated GIS to service the requirements of key institutions in the water services sector in the province. This was followed by a User Requirements Analysis (URA) study and system design which was completed in May 2002.

DWAF gave the go-ahead to implement a water and sanitation GIS based on the consultant's recommendations.

This paper explores the system components of a water and sanitation GIS that is set to be implemented from April 2003.

3. SITUATIONAL ASSESSMENT

A comprehensive situation analysis and user requirement study was conducted by GIS consultants. The main outcomes of this exercise are as follows:

- i. DMs and LMs show a strong willingness to manage and operate their newly acquired water assets. The possibility of revenue generation in the future is an incentive.

Four of the six DMs in the Eastern Cape and eighty percent of the LMs in the Eastern Cape have severe capacity and skills problems. The rural areas of the Eastern Cape are not perceived as favourable work destinations for IT and GIS people.

None of the other DMs and LMs in the Eastern Cape province have had any significant GIS experience or even exposure.

- ii. The condition of as-built records of water and sanitation services throughout the Eastern Cape varies between poor and non-existent. The records that are available are lodged in consulting civil engineers offices.

All records are in hard copy format and most plans that exist have never been updated to reflect additions to water and sanitation infrastructure.

- iii. The water infrastructure in the Eastern Cape consists of approximately two hundred formal water schemes and fifteen hundred stand-alone schemes. The formal schemes consist of a water source, a water treatment plant and extensive bulk and reticulation pipe infrastructure. Formal schemes typically serve in excess of five thousand people with water.

Stand-alone schemes consist of a water source (normally a borehole), a reservoir and a network of reticulation infrastructure that serves a village community.

The formal and stand-alone water schemes serve about forty percent of the population of the Eastern Cape with water. The remaining sixty percent of the population access water directly from rivers, wells and fountains.

- iv. DMs are designated as Water Service Authorities (WSAs) in terms of the Water Act, for the areas under their control. They are therefore responsible for the supply of water to all end users living in their area. LMs are usually contracted by DMs as Water Service Providers (WSPs) and construct, operate and maintain the systems on behalf of the WSAs. This is a contractual arrangement, which can be terminated if the LMs fail to deliver on their contractual obligations.

DMs are responsible for maintenance management whereas LMs are responsible for the actual maintenance of the infrastructure. It is vital firstly that maintenance information is appropriately recorded for maintenance events, and secondly that this data is conveyed to the DMs for processing to useful information.

- v. The Eastern Cape province is large, measuring seventeen thousand km². Sixty percent of its people live in the rural areas.

There are local people, some employed by LMs and DMs, some employed by consulting engineers and other local community people who have knowledge of the location of most of the water and sanitation infrastructure.

- vi. All DMs in the Eastern Cape are connected to the Provincial Departments via a computer network called Govnet which is a wide-area network system. The system architects are able to dedicate 64k lines for GIS applications, between DWAF Regional Office in King Williams Town and each of the DMs.

Most of the LMs in the rural areas have access to dial-up modems at best. The larger urban LMs that fall outside the scope of this project have reasonable networks and dedicated lines to the Internet backbone.

- vii. The Department of the Premiers Office has been assigned the responsibility of provincial GIS champion. The efforts to date of the Department have however been poor. No GIS policy guidelines have been forthcoming and the Department has not offered any assistance to LMs or DMs on GIS or IT strategies.

The regional office of DWAF has been forced to go out on its own to implement a GIS strategy for water and sanitation services, with very little support from other Government Departments, who, appear to lack capacity to deal with a more widely based GIS strategy as is described in this paper. This is a reality in several of the provinces of South Africa.

- viii. The National Department of Land Affairs (DLA) is custodian of the country’s cadastral and topographical databases. Both of these datasets could be useful in a water services GIS for the Eastern Cape.

The cadastral database can at best be served only as backdrop data. The data is highly inaccurate and incomplete, and it only contains urban and farm data. The communal tenure systems that are prevalent in the rural areas of the Eastern Cape have not been demarcated in any way. Most of the villages and rural communities are however covered by 1/10 000 digital orthophoto mapping. These maps will serve as useful backdrop data.

- ix. There are not GISs in the Eastern Cape where spatial and attribute data is maintained on a regular basis. All systems inspected are purely “mapping” systems that contain spatial information captured at a certain point in time.

GIS technology is not used as a decision support tool anywhere, neither in government nor in the private sector.

- x. The DMs need access to a variety of up to date data to operate, manage and expand their water and sanitation services to the people of the Eastern Cape. The essential required datasets are given in the table below:

	Dataset	Business Requirement
1.	Pipeline infrastructure. (pipes, valves, meters, reservoirs) with design, maintenance and condition attributes (not given here).	Operating infrastructures. Maintaining infrastructure. Planning and designing extensions to infrastructure. Managing the delivery of water to consumers.
2.	Water sources and pump equipment together with pump details, water quality attributes etc.	Managing water supply. Maintenance and operation of equipment. Maintaining service levels.

	Dataset	Business Requirement
3.	Water and sanitation schemes, settlements and villages with demographic data and levels of service enjoyed.	Assessment of needs and levels of service. Planning and design for new infrastructure. Capital budgeting.
4.	Access roads and topographical features.	Logistical planning. Disaster management. Operational planning.

It is immediately apparent from the above that a water and sanitation GIS cannot be a simple “mapping” system as is the case with other GISs in the province. Spatial and attribute data will require regular updates. Spatial completeness will be key to the success of a GI service.

4. SYSTEM FEATURES

The lack of computer infrastructure and IT and GIS capacity and skills and the remoteness of the rural LMs mitigates against establishing sophisticated GI systems in these locations.

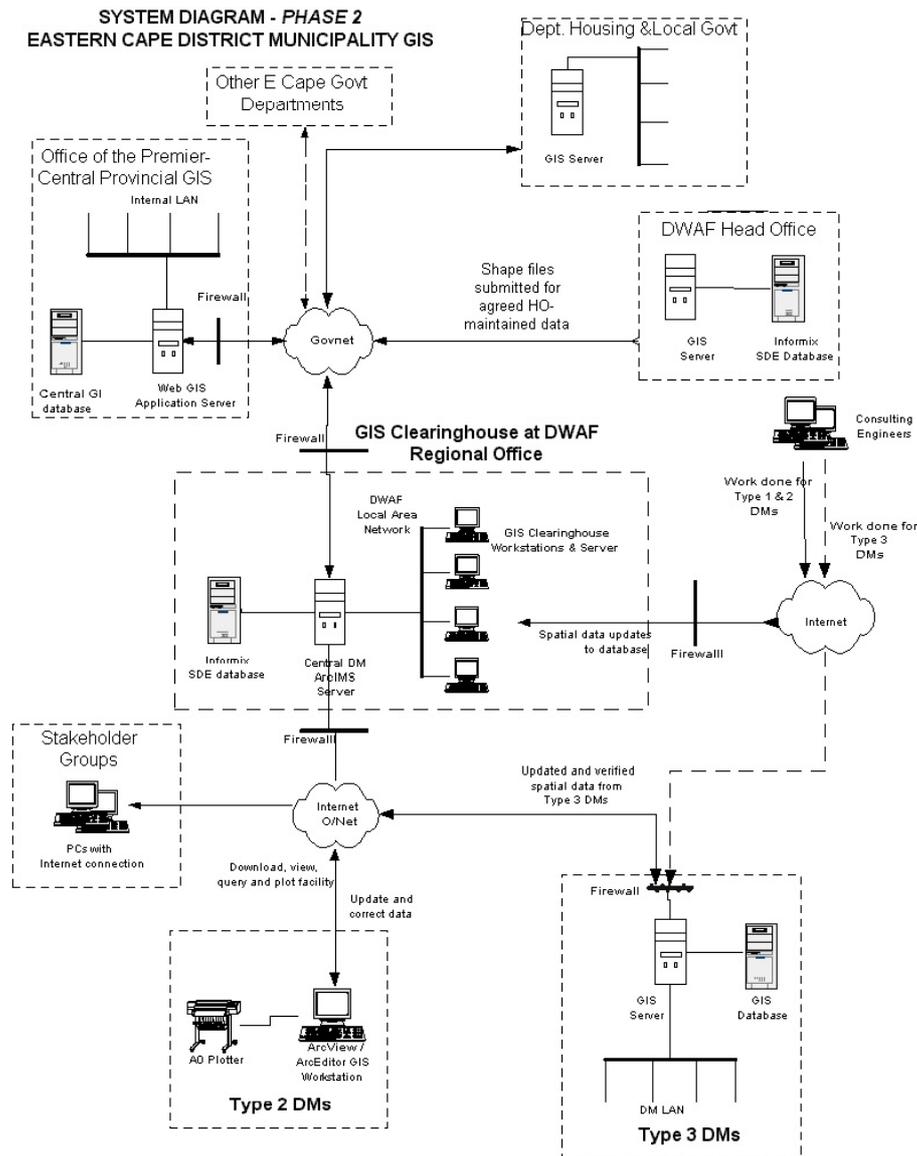
DWAF and their funding sponsors have agreed to recommendations by their consultants, to implement a web-based GIS to serve the five DMs. The LMs in turn will use A3 colour map-books produced by the DM GIS facilities, showing water and sanitation infrastructure overlaid on orthophoto map data, to locate, maintain and operate the water and the sanitation infrastructure under their control. Implementation is set to commence during April 2003.

The unique Ids for all water and sanitation assets will be displayed on the map sheets to enable LM field staff to locate assets and to record the unique ID of assets during asset maintenance repair operations.

The conditions of the records of the water and sanitation infrastructure is so poor that it was decided by DWAF and the MAAP sponsors to conduct a complete field data capture survey, where consortiums of contractors are to be appointed to attend on each water and sanitation scheme and capture water and sanitation infrastructure information, access roads, scheme boundaries and water sources using GPS (1m accuracy) equipment and in accordance with the database design. Digital photographs will be taken of all assets.

The total cost of this exercise is approximately €2 million. Work is set to commence in April 2003 and will be complete by August 2003.

A high level system diagram showing the hardware and software components of the GIS is shown below.



The main features of this model are:

- i. All hardware and software to support the GI model has been purchased by the MAAIP Initiative (February 2003) and is ready to be installed.
- ii. The crucial feature of the model is the establishment of a central clearinghouse facility at the DWAf Regional Office in King Williams Town.
- iii. The system will be staffed by a combination of private sector and public sector individuals. The clearinghouse will serve as the brain center of the system. The Regional Office has existing GI infrastructure and staff which will be added to with two private sector GIS specialists and a clearinghouse manager. They will ensure that data entering the clearinghouse is verified, and will update the central data warehouse as

well as the meta-database. The two private sector GIS specialists will be on site at the DWAF King Williams Town office. They will be responsible for all technical GIS and database operations associated with the capture and conversion of agreed datasets that the clearinghouse is responsible for, and update of the central clearinghouse datasets and meta-database. They will be responsible for the hands-on training of DM GIS staff where required and serve as a help center for the DM GIS operations. They will also be responsible for quality assurance of GIS data supplied by consulting engineers and could assist these consultants in conforming to the predefined standards of data provision.

The private sector GIS specialists will report directly to the DWAF Regional Office GIS Manager who in turn reports to the DWAF Regional Director for Planning Development & Implementation. A new “dotted line” reporting to the Director : Geomatics and Director : Macro Planning and Information Systems at DWAF Head Office will ensure that national policy and data management standards are adhered to in the clearinghouse operations. It would also ensure a constant communication between Head and Regional offices, thus eliminating possible duplication of effort.

- iv. The clearinghouse will be responsible for building the database with base data and with water and sanitation data that is set to be captured by the survey contractors. The clearinghouse manager will also project manage the data collection process.
- v. GI data will be served to the DMs using ESRI’s ArcSDE via the WAN. DMs in turn will be able to use GI services in different ways, depending on their resources:

A type 1 DM GIS has:

1. Access via the Internet to the spatial positions of water and sanitation assets and to all other datasets stored in database.
2. The ability to query attributes or assets according to information stored in database.
3. The ability to print screen images to an A4/A3 colour printer located in the DM offices.

A type 2 DM GIS has the same as type 1 plus:

1. The ability to download GI from the database server and thus undertake high end GIS analysis using GIS software.
2. Ability to customize GI output in terms of scale, size and content and output it using a large format (preferably A0 sized) plotter.

A type 3 DM GIS has the same as type 2 plus the system offers:

1. The implementation of a GIS intranet/internet site that gives on-line access to the spatial information assets of the DM to relevant DM and LM role-players.
2. More independence in terms of the customization of the system to suit high end user requirements.

- vi. Digital orthophoto data and access roads relevant to each DM will be loaded onto the local drives of the DM GIS work stations. All water and sanitation data will be served from the central server over the WAN. ArcView 8 on the DM side is able to access local drive data and served data and present this data to an active ArcView session. This feature will minimize network traffic.

The access times have been tested and are acceptable in terms of ESRI's guidelines. More importantly, the DMs are satisfied with the GI services.

5. GI SERVICES

The GI database, though simple in design, incorporates all the data requirements of DMs and LMs in the Eastern Cape. Careful thought was given to the sustainability of the database, bearing in mind earlier statements made regarding the state of GI services in the Eastern Cape.

The GIS will certainly improve the management effectiveness of WSAs and operation effectiveness of WSPs, by virtue of the location capability of the technology alone.

The DMs are insistent that the GIS must improve decision support for its maintenance management function and in particular, budgeting decisions regarding replacing or repairing equipment. The database caters for the linking of maintenance information to relevant spatial features. All features of the spatial database will be assigned unique numbers to allow the linking of multiple attribute tables.

New job cards have been designed for field plumbers and supervisors to record maintenance events. These people will be trained to use the job cards and to use new maintenance procedures that will result in maintenance information being channeled to the DMs and clearinghouse consultants for capture to the GI database.

Apart from the basic GI services supplied to each DM via the ArcIMS/SDE software, an additional five water and sanitation applications have been designed for the DMs. These applications are described below:

Application 1: Show level of service by area

This application will be developed within the GIS software environment at the GIS clearinghouse and will be run on a monthly basis (after the initial quarter) by the clearinghouse GIS specialists. The resultant maps will be exported to Adobe Acrobat Reader (.PDF) format and will be created at a Provincial, District Municipality and Local Municipality level. These maps will be served on the clearinghouse website and will be available for download under a link called "Service Level Maps" off the main GIS webpage.

The advantages of the above approach are as follows:

- Latest data is available immediately to all in a format that everyone can read
- No training required- all legend and explanatory information will be on the digital map
- Users can zoom into areas of high data density within the Adobe viewing software
- Users can plot the map on the paper size of their choice- some might have access to an A0 plotter, some might only have an A4 printer.
- Users can e-mail the maps
- Users can easily incorporate the maps into PowerPoint presentations or reports
- Development time is cut to a minimum- 80% of programming time is consumed with 20% of the functionality and ensuring that the application “unbreakable” in the hands of inexperienced users.
- Qualified specialists will be running the model and will ensure that the results are correct
- The application can be changed with no impact on the users to accommodate evolving data over time.

Application 2: Mapbook application

This application is critical because it will facilitate successful information sharing with the LMs. It will also provide a very portable and tangible product to the DMs technical services’ staff.

The mapbook application will be produced in the ArcMap environment (for ArcView 8). This will facilitate the use of the powerful cartographic capabilities within ArcGIS 8.

It will be delivered as an Arc8 extension and therefore can be e-mailed to the DM GIS technicians for installation. Help documentation will be provided for the application as well as instructions on correct data pathing.

The fact that data will be provided and standardised by the clearinghouse consultants means that the application may be hard-coded with the input spatial and attribute data filenames. Updated datasets will be provided on the clearinghouse website for download by the DMs and replacement with the data stored locally on their GIS workstation or server.

The user will simply select the District Municipality, Local Municipality or specific map sheet numbers that they wish to print or reprint and the application will do the rest. The map book application will have the following features:

- Automated index creation referencing each map page with the Local Municipality name and settlement name
- Automatic inset creation where water assets are too close to one another to be distinguished at the fixed map book scale
- Automatic border and legend creation with symbology description, true north sign, scale bar and numeric expression, title, map/page number and adjacent map numbers

An example of what the mapbook will look like is attached as Annexure A.

Special A3 punches will be manufactured, one per DM and two for the clearinghouse. This will ensure that pages are punched optimally to fit the pre-punched covers. Hard covers embossed with the DM names as well as each of the LM names will be delivered to the relevant DMs. A full set of mapbooks will be produced and maintained at the clearinghouse for use by the DWAF Regional Office.

Application 3: Detailed asset information

This application will evolve over time and will be developed in two phases.

The initial phase will require an ArcIMS application view to be developed. The view will allow for multiple hotlinked data and for the thumbnail images as specified. The clearinghouse staff will administer the data but will set standards for the District Municipalities in the naming conventions of the scanned data or digital photographs. This will enable the clearinghouse to semi-automate the hotlinking and thumbnail creation for all the data.

The first phase application will be served over the intranet and will obviously entail the download of the digital images live over the WAN.

The second phase will be initiated once the DMs begin to use the application regularly and require the ability to add large file images to system. Detailed as-built drawings that are required and that don't exist digitally could consume a large amount of vital bandwidth between the DM and clearinghouse.

The second phase application will be developed on MapObjects and will operate as a stand-alone program on the DM network. The DM GIS technician will be required to administer the application data and will supply the clearinghouse with new data that is added to the system by the DMs, on a bi-monthly basis.

This application will evolve over time as different DMs declare different requirements of the application. An example would be the requirement to view an additional CAD format.

Application 4: Shortest route application

The development of a robust application that calculates and displays a best route as well as the distance requires the use of ESRI's Network Analyst. It also requires good quality road data that is 100% clean i.e. access, district, provincial and national roads all interconnect perfectly.

The first step in this application development will necessitate a detailed clean up of the national, provincial and district road network. This will require the use of the digital orthophoto's and 1:50 000 topographic maps to enable the gaps to be filled and the data to be verified. This data will then be combined with the sustainability audit data gathered by the audit consultants. It will also serve as a sound backbone network against which to check the quality of the incoming data.

The second step will involve the integration of the transport data with the access roads to be captured by contractors with GPS. The development of this application will require Network Analyst for ArcView.

Application 5: Determination of water consumption and loss

The DMs expressed the intention of installing bulk meters to cover whole water scheme areas or large portions of schemes. Sales type meters would also be installed for individual connections and for stand pipes.

The meters would be read on a regular basis (to be determined) even if consumers were not billed for water consumption. The strategy here is to determine consumption trends and to establish whether there are any significant water losses in the scheme.

The application required does not have to be sophisticated. It is most unlikely that investment will be made in SCADA systems or other expensive monitoring equipment. What is required is a simple 80/20 application that gives an indication of whether there are major water losses in an area or not.

The database design caters for bulk meter and sales meter reading. The problem of course is that readings are taken at different time intervals.

The application to be developed will function along the following lines:

- i. User uses GIS to identify scheme where water loss determination is to be made.
- ii. The application interrogates database to extract all sales meters within scheme or user defined polygon.
- iii. User identifies bulk meter that is “parent” to all sales meters under investigation. The GIS symbolises bulk meters for ease of identification.
- iv. Application then examines database to examine history of meter readings of sales meters and bulk meter. These are displayed for user to visually inspect.
- v. User decides to proceed with application i.e. readings are sufficient.
- vi. Application balances consumption between bulk meter and sales meter readings by using an interpolation model to bring all readings to a specific timeframe.
- vii. Estimate of water losses per week or per day are displayed and printed.

This application will be developed in the ArcGIS 8 environment and will be delivered to each DM. The GIS technicians in each DM will be trained on the use of the application by the clearinghouse specialists.

6. ORGANISATIONAL DEVELOPMENT

The GIS is scheduled to be fully functional within eighteen months. Each of the DMs have appointed GIS technicians (most are inexperienced) to operate the DM GIS facilities. The clearinghouse consultants are required place an experienced GI professional in each DM for a six month period to train DM GIS technicians and to ensure that GI services are delivered

efficiently. These GI professionals will also assist consulting engineers appointed by the DMs to produce as-built information of new infrastructure in the laid-down GIS format.

The GIS consultants stationed at the clearinghouse facility in King Williamstown will also be required to transfer their skills to DWAF GIS staff over a period of eighteen months. The system will therefore operate free of consultant intervention after an eighteen month period of operation.

7. OUTCOMES

The outcomes expected at the conclusion of this eighteen month project life-cycle are:

- i. A successful GIS that works efficiently to support the operations and management of water and sanitation services in the Eastern Cape.
- ii. An appropriate model that can be implemented in other rural areas of South Africa with little adaption. A model that integrates GI data between Local Municipality and Provincial Government levels.
- iii. Data maintenance procedures that include the recording of information resulting from maintenance events relating to the infrastructure, and secondly, the construction of new infrastructure.
- iv. A model where private enterprise and Government can work together to provide solutions to the supply of services to rural areas of South Africa.
- v. Demonstration to other sectors of the GI industry in South Africa that GIS technology can be used effectively to improve service delivery.

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TS26 Best Practice in Facility Management

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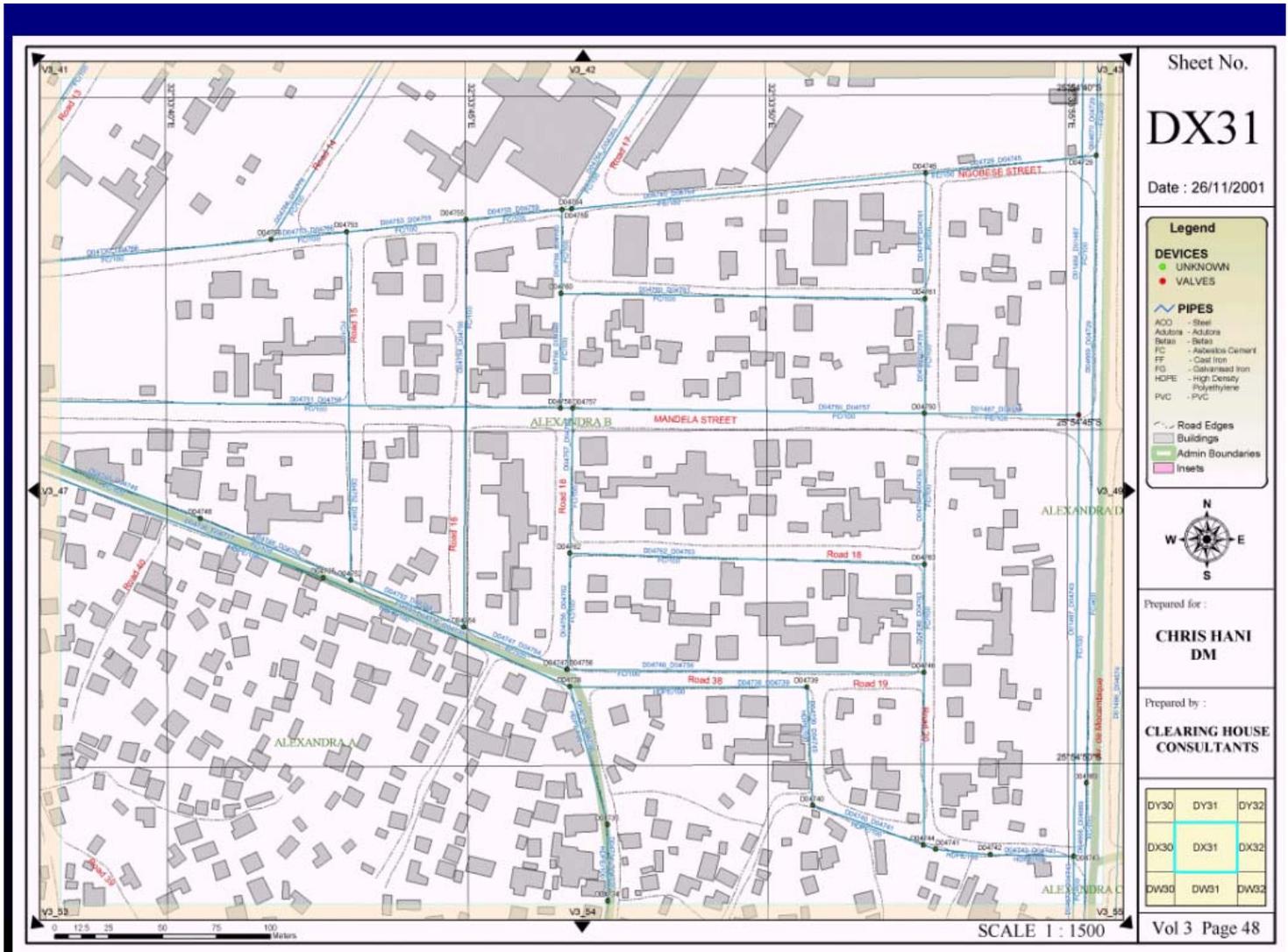
TS26.3 Development of a IT / GIS Model Designed to Help Local Municipalities in South Africa to Manage Water and Sanitation Services and for the Benefit of Poor and Rural Communities

FIG Working Week 2003

Paris, France, April 13-17, 2003

ANNEXURE A

Example of a Mapbook



Sheet No.
DX31

Date : 26/11/2001

- Legend**
- DEVICES**
- UNKNOWN
 - VALVES
- PIPES**
- ACO - Steel
 - Adutora - Adutora
 - Beton - Beton
 - FC - Aesobas Cement
 - FF - Cast Iron
 - FG - Galvanized Iron
 - HDPE - High Density Polyethylene
 - PVC - PVC
- Road Edges
 Buildings
 Admin Boundaries
 Insets



Prepared for :
CHRIS HANI DM

Prepared by :
CLEARING HOUSE CONSULTANTS

DY30	DY31	DY32
DX30	DX31	DX32
DW30	DW31	DW32

SCALE 1 : 1500

Vol 3 Page 48