ADDRESSING WATER INCIDENTS BY USING PIPE NETWORK MODELS

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Abstract

It is now widely accepted that, although infrastructure problems in the electricity sector are currently the demanding crisis in South Africa, another commanding crisis looms on the medium-term horizon: deteriorating water infrastructure, and associated water incidents. A large component of this infrastructure is the water pipe network and associated components. Water service providers often have limited understanding of their pipe networks, and hence cannot address potential adverse incidents. The CSIR has embarked on a program to provide an understanding to a water service provider of its pipe network, so that potential adverse incidents can be addressed.

An existing pipe network and associated components can be understood by measuring water quantities like flow rate and pressure with water meters. Such an approach provides a highly exact and realistic understanding, but is potentially very expensive to implement. This is especially so in view of the large number water infrastructure networks in South Africa which need urgent attention. A more cost-effective approach to understanding an existing pipe network, that also provides the ability to explore alternative conditions for the network, is a numerical model of the network. These models are based on physics that is well understood.

A pilot analysis is performed for a high impact town/urban area in South Africa with noticeable water problems. Model parameter data are obtained through as-built drawings, and are collected through site visits where the network is mapped from scratch. During site visits as-built drawings are verified, and critical unknown parameters (those whose absence are very detrimental to the model) are measured. The information on the pipe network is then imported into the computer model program EPANET. The model for the town/urban area is presented. The detailed implications of the model for incidents will be presented to the stakeholder in the future, and are not discussed.

The time- and cost-efficiency of the entire model construction process is accessed in view of the desire to replicate a similar procedure for the numerous areas in South Africa that demand understanding of potential water incidents.

Key words: model, water distribution, pipe network, WSA

INTRODUCTION AND BACKGROUND

Drinking water in South Africa is from two sources, surface water and ground water. Literature has shown that South Africa is categorised as a water-scarce country. The responsibility of providing safe and sufficient drinking water from these sources rests with the Water Service Authority (Local or District Municipality and Department of Water and Sanitation). According to a review by South Africa's water sector, (1) Zhuwakinyu (2012) reported that the degree of water scarcity has been a subject research of interest for hydrologists, with the aim to quantify and understand the relationship between rainfall and stream flow together with the relationship between rainfall and groundwater recharge. (2) Rand Water's Water Wise initiative, posits that the Department of Water and Environmental Affairs conducted a study which projects that water demand will outstrip supply in South Africa by year 2025.

The relevant Water Service Authorities (WSA) has since then made means to raise awareness to South African citizens about this matter, through social media and water awareness campaigns. WSA has continuously been giving water saving tips to the South African citizens and also encourage the sparing use of water.

PROBLEM STATEMENT

In spite of all the measures put in place to alleviate water wastage, the country has been faced with the challenge to supply sufficient water to communities. Moreover now that the overall South African dams level has decreased drastically over the past years. This has resulted to WSA enforcing water restrictions in order to meet water demand. In certain parts of the country such as the Gauteng province WSA have started to implement the water usage restriction to mitigate the risk of running out of water.

Previous studies have shown that apart from the lack of significant rainfall in the country over the past few years, another contributing factor to the insufficient water supply is water loss incidents (water pipe leaks and non-revenue water).

Water incidents in South Africa has always been a challenging subject to address, and many local municipalities often have limited understanding of their pipe network and associated components and hence cannot address potential adverse incidents. This could be caused by the network infrastructure being built many years ago as a result they are lacking 'As-Built' information, and illegal pipe connections to the water distribution system. Such lack of understanding has led these WSA not to be able to address water incidences related to pipe leakages due to pipe burst or illegal connections, resulting to inefficient water supply in the water network.

According to a report by (3) Sue Blaine, (2013) in Business Day Live, nearly 40% of municipal water is lost before reaching the consumer.

PURPOSE OF THE STUDY

The study seeks to address water incidents by using pipe network models and associated components. This is specifically in observation of the large number of water incidents in pipe networks in South Africa. This approach is more cost-effective in addressing water incidents and understanding an existing pipe network, and it also provides the ability to explore alternative conditions for the network. The method is expected to contribute positively towards alleviating the challenges face by water authorities in their pipe networks.

PILOT STUDY

The pilot study was conducted in Mlungisi Township, Stutterheim, Eastern Cape. The township has approximately an area of 4.13 km^2 and a perimeter of 12.16 km, with a population of approximately 7 087 (4) (Amahlathi LM, 2015/2016).

This township is under the Amathole District Municipal jurisdiction within the Amahlathi Local Municipality. Figure 1 below shows a cadastral map for Mlungisi Township.

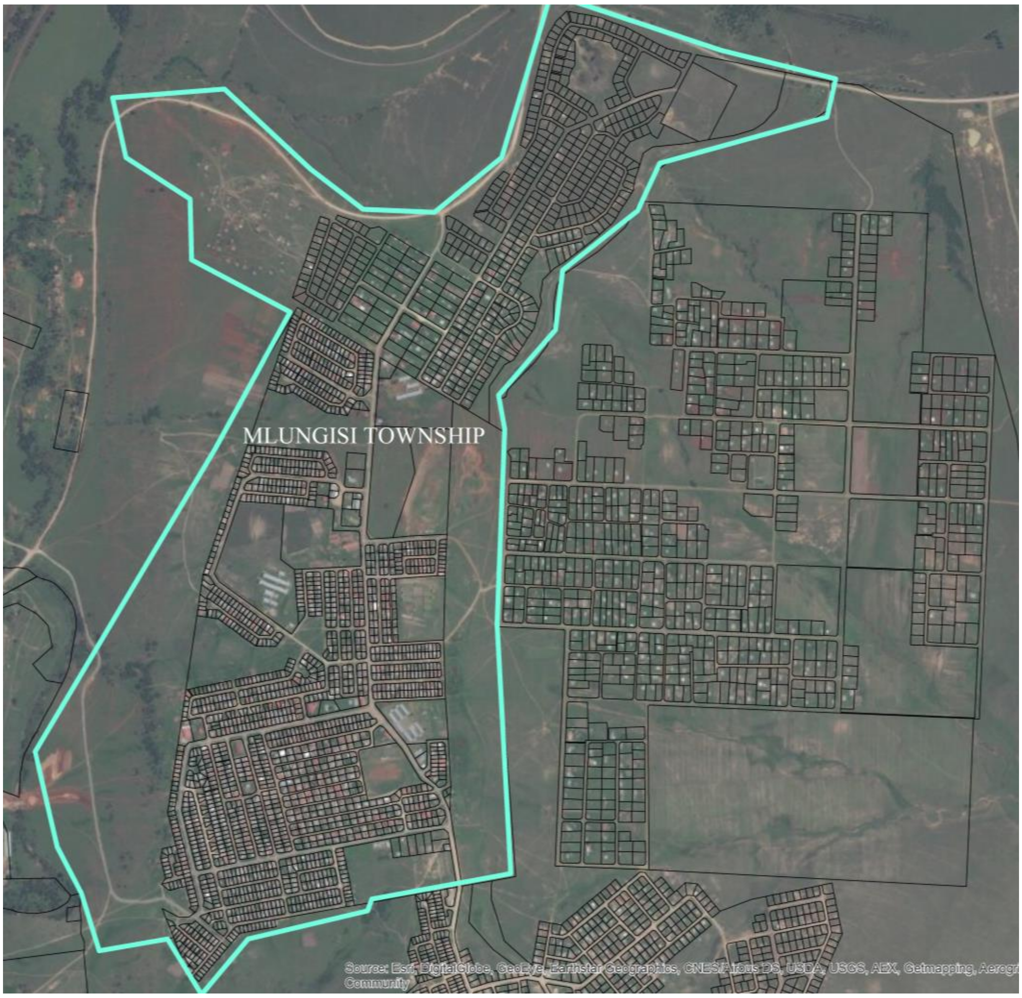

Figure 1: Cadastral Map of Mlungisi Township (ArcGIS and Bosch Stemele Consulting Engineers)

Figure 2 below represents the Mlugisi Township water network. The water is pumped from

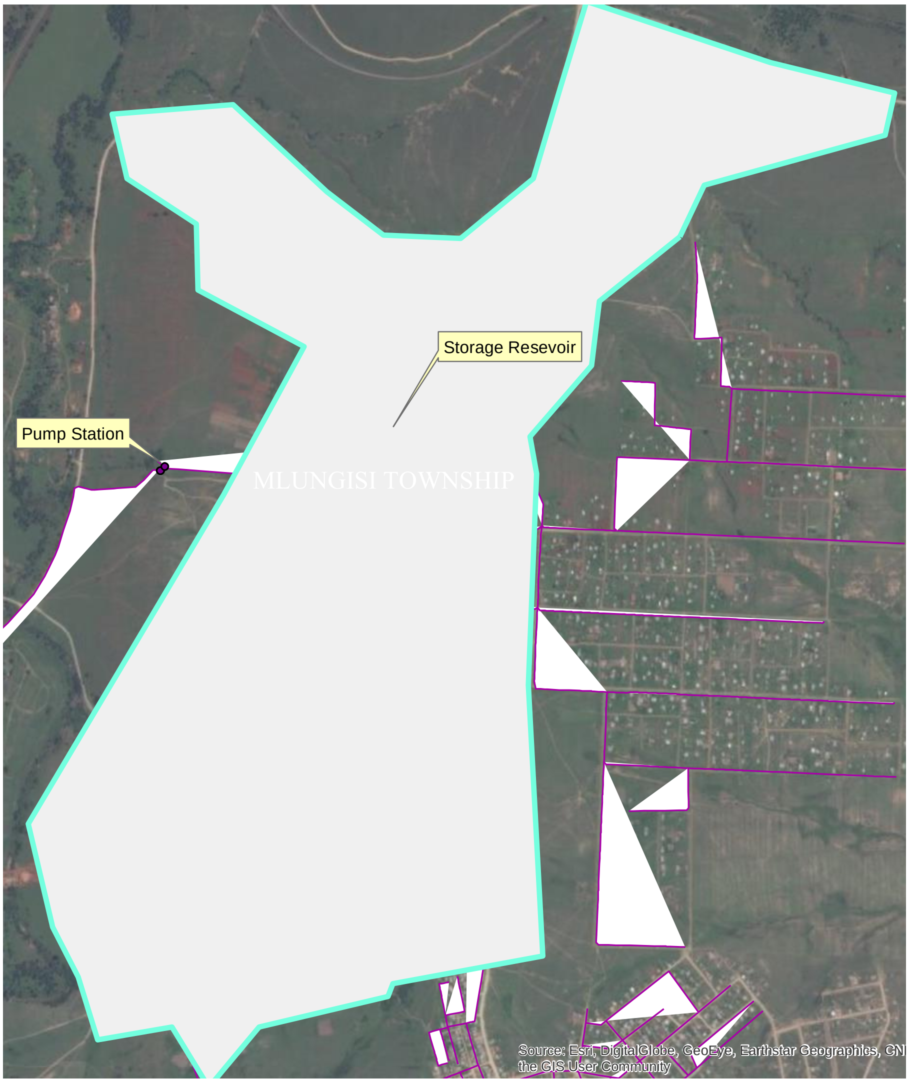

Figure 2: Mlungisi Township Map (Drawing courtesy of Bosch Stemele Consulting Engineers)

METHODOLOGY

The study is part of a project called Water Network Infrastructure Status Report (WNISR) conducted by CSIR. The project seeks to develop an assessment of the water infrastructure status report.

Such and assessment will provide an understanding to a water service provider of its pipe network, so that potential adverse incidents can be addressed. Thus, the relationship between reports about the network and parameter uncertainties in the model was investigated.

The study intensively engaged in discussions with the Amathole District Municipality to understand the issues and problems. ‘As-built’ drawings of the pipe network were obtained and used to setup the model.

STUDY FINDINGS AND DISCUSSION

Current infrastructure and status

The identified township receives water from the Stutterheim Water Treatment Works, which is then gravitated to Mlungisi pump station through approximately 5.6 km pipeline before being pumped to the storage reservoir through a 943 m pumping main. The whole area is gravity fed from the reservoir which is approximately 3.5 ML.

Water distribution system challenges in Mlungisi

Investigations have shown that leakages are a major issue in the area's pipe network.

Network Model

The model was setup and analysed for the current year (2015) water consumption, projected for 2020 and 2025. Figure 3 below shows the Mlungisi Township pipe network model. The simulated model mainly focussed on the predictions of water flow rate and velocity in the pipeline, pressure head on each node and operation levels of the reservoir.

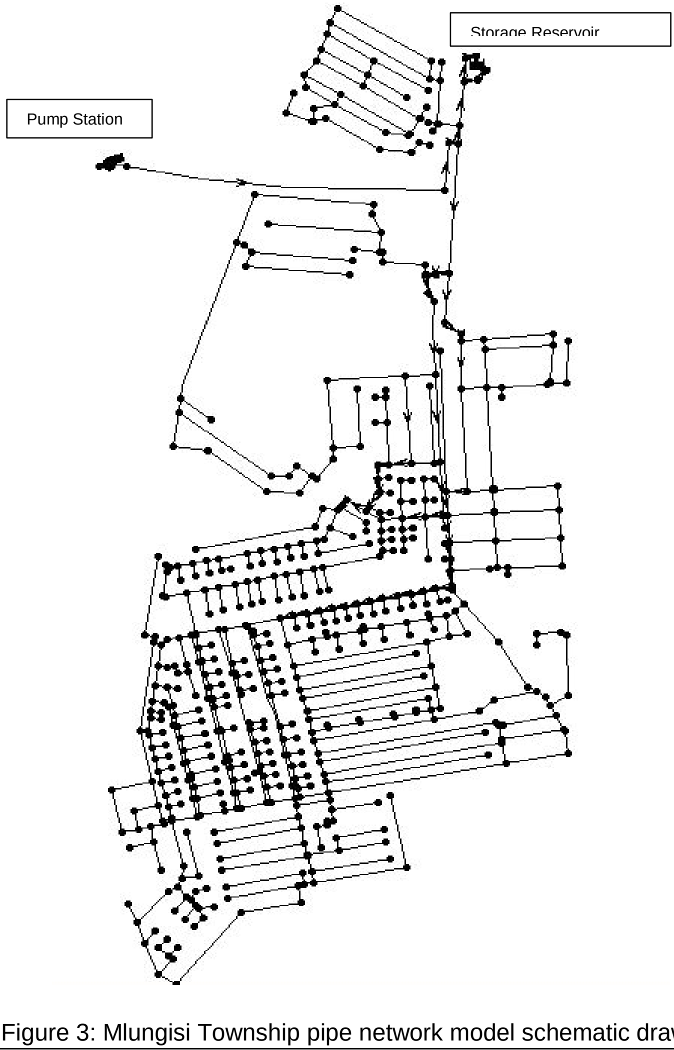

Figure 3: Mlungisi Township pipe network model schematic drawing

Network analysis and water consumption projections

The model has revealed that the pipe network has water throughout the site; however the houses closer to the storage reservoir are not receiving adequate water due to low pressure in the distribution system. This is mainly caused by the supplied area not having sufficient pressure head. This situation gets worse during peak demand (i.e. 05h00-08h00). Figure 4 below shows a typical schematic layout of the model for the 2015 year horizon.

Figure 4: Current water consumption model

Network Table - Nodes at 6:00 Hrs

Node ID	Elevation m	Head m	Pressure m
Junc J1	841.35	927.94	86.59
Junc J2	839.12	975.99	136.87
Junc J3	907	968.10	61.10
Junc J4	908	966.82	58.82
Junc J5	913	918.17	5.17
Junc J6	918	921.86	3.86
Junc J7	919	921.61	2.61
Junc J8	919	921.31	2.31
Junc J9	918	921.21	3.21
Junc J10	917	933.21	16.21
Junc J11	906	917.81	11.81
Junc J12	906	917.55	11.55
Junc J13	905	917.46	12.46
Junc J14	904	917.43	13.43
Junc J15	905	917.80	12.80
Junc J16	905	917.79	12.79
Junc J17	905	917.75	12.75
Junc J18	906	917.75	11.75
Junc J19	906	917.75	11.75
Junc J20	906	917.70	11.70
Junc J21	907	917.67	10.67
Junc J22	898	917.44	19.44
Junc J23	896	917.39	21.39
Junc J24	890	917.41	27.41
Junc J25	881	917.42	36.42

Figure 5: Pressure Table for 2015 year horizon

Improvements by modelling

Having assessed the water network for three different year horizons, i.e. year 2015, 2020 and 2025. The outcomes has revealed that for the current year (2015) the area studied does receive water throughout the network, however the region with low pressures struggles to get adequate water supply during peak demand. The velocities in pipes are also on the lower end of the acceptable 'Red Book' guideline standards.

The other results from the projected network model operations show that with the current infrastructure, Mlungisi Township would be faced with a water supply crisis for the area closer to reservoir due to the new development just north of the storage reservoir.

The model was able to project water consumption patterns in Mlungisi Township for the next 10 years. Also giving an indication that in some of the areas, pipe sizes need to be replaced to increase velocity and adjust pressures in the pipeline. This will enable the municipality to plan for water incidents before running into a crisis.

CONCLUSION AND RECOMMENDATIONS

The findings of the pilot study show that Mlungisi Township is not adequately serviced by the storage reservoir, more especially during peak demand. It is safe to say that the recent developments within the area has led to more people migrating to Mlungisi Township, and this has resulted to increased water demand.

It was also noticeable that the yard connections in the lower areas of the study area show high pressures. Even though these pressures are considered to be within the maximum allowable pressure head, overtime they can lead to pipe network disruptions and resulting to pipe leaks. Site investigation has revealed that house connections and poor plumbing are the main cause of leakages in the rea. This problem has resulted to the area having high value of non-revenue water, and this is costing the municipality hundreds of thousands per annum.

This study concludes that the current water distribution system is insufficient to service the area of study and that, if the problem remains unsolved within the next 5 year. Then the municipality might see themselves being strike by water shortage sooner that might have been envisaged. Considering the fact that water scarcity is a national crisis, this will contribute further towards the almost 40% non-revenue water lost each year.

It is recommended that a thorough investigation for all yard connection and plumbing be assessed for leakages, and that for all new RDP houses a competent contractor be appointed to carry out the plumbing and household connections.

To ensure adequate supply to the whole of Mlungisi Township, it is highly recommended that the municipality construct an elevated tank to boost the supply of the area west from the storage reservoir, thus increasing the storage capacity of the reservoir due to the new development around this area. Pipe sizes would also need to be changed, to increase pipe velocities and to balance pressures in the distribution system

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