14 USING TECHNOLOGY AT THE RUSTENBURG LOCAL MUNICIPALITY TO ADDRESS THE ULTIMATE BASIC PRINCIPLE: FAILURE TO PLAN IS PLANNING TO FAIL

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ABSTRACT

Management of water resources and related municipal infrastructure is crucial in water-scarce South Africa, a situation highlighted by the current drought. Rustenburg Local Municipality is no exception with variable rainfall, intersected by exponential population growth and significant mining operations. In the light of this, Rustenburg identified the need for the improved management of its water and sewer infrastructure and related processes. A solution would need to include: consolidation of and easy access to infrastructure information; system performance results; and a plan to accommodate anticipated future growth within the municipal boundaries.

The first step was to establish electronic water and sewer hydraulic models by collating data from numerous sources. The second step was to load the hydraulic models with real-world demands through the analysis of municipal water billing information, conversion to water consumption and spatial distribution within the models. Once accurate hydraulic models were established the models were analysed to identify critical areas and prioritise actions to improve the existing system performance. Projects were then identified as a result of the analysis and a number are already being implemented. Mid- and long-term projects form the master plan to accommodate a potential doubling of the present water demand over the next 45 years.

Another challenge facing the Rustenburg Local Municipality is to effectively identify, quantify and collect consumers' debt. Improved revenue enhancement strategies have become central to building and supporting a financially sustainable municipality. This challenge was addressed by the conversion of the billing information into accurate and useable information; non-metered and non-paying consumers are identified, spatially represented and quantified. Key areas were identified to optimise the use of resources and progress is monitored to ensure that improvements are being made.

All the information gathered and converted is displayed on a web based viewer. This allows for the latest network models and billing information to be displayed on a number of interactive maps in a user-friendly environment, facilitating rapid access to and interrogation of municipal infrastructure and billing information at a pipe-by-pipe and stand-by-stand level of detail. The initial project was completed within 10 months and the systems are now maintained on a monthly basis. At Rustenburg Local Municipality, technology has become a driver of innovative change to overcome service delivery challenges and satisfy infrastructure-related demand. Rustenburg has made great strides towards becoming a smart-solutions-centred municipality.

1. INTRODUCTION

1.1 Rustenburg Local Municipality

The Rustenburg Local Municipality (RLM) falls entirely within the Bojonala District Municipality which in turn is entirely in the North West Province and shares boundaries with the following local municipalities: Madibeng, Moses Kotane, Kgetlengrivier, Mogale City, Merafong and Ventersdorp. The area is shown in Figure 1.

The area is well known for its mining activities and there are many mining companies within RLM that own villages and bulk water and sanitation facilities within the municipal boundaries. The demand for water and growth in the municipality is intrinsically tied to the mining activities in the surrounding area. This interdependency impacts both the demand for and availability of supply of bulk water.

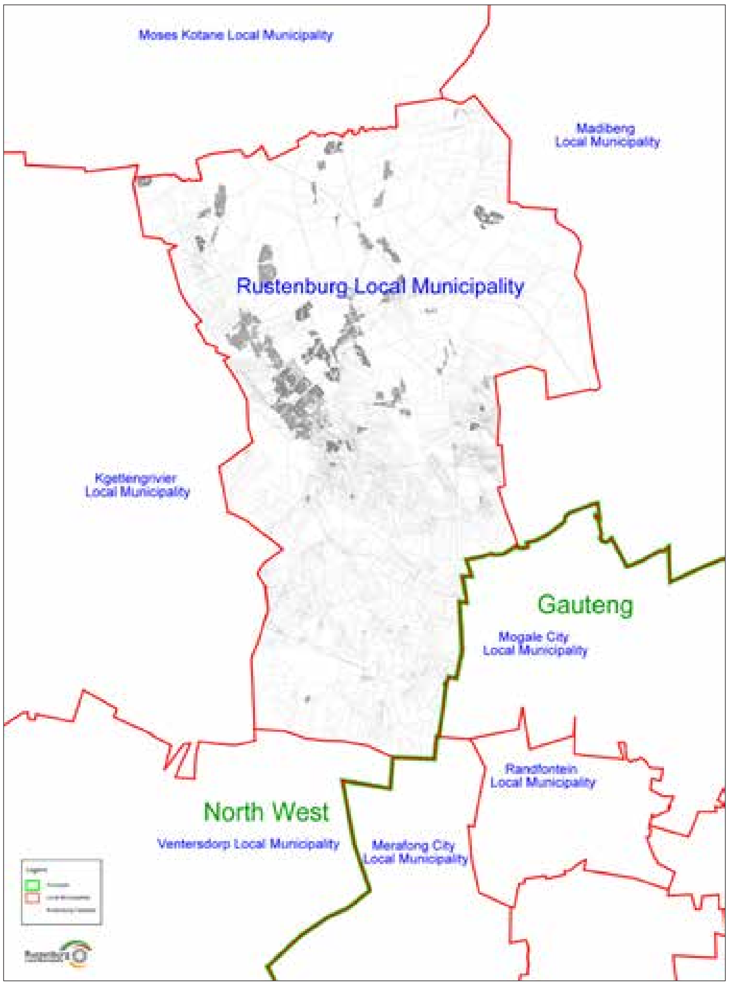

FIGURE 1: Locality Plan of Rustenburg Local Municipality

Rustenburg Local Municipality is the Water Services Authority (WSA) in the Rustenburg municipal area and is therefore responsible for the provision of water and sanitation services to consumers. RLM contracts out the bulk Water Services Provider (WSP) function to Magalies Water (MW), Rand Water (RW) and the Rustenburg Water Services Trust (RWST), and fulfil the retail WSP function itself.

The Royal Bafokeng Nation owns and manages very large portions of land within RLM, and also shares some of the bulk water & sanitation facilities. Whereas the water and sanitation facilities of Royal Bafokeng Nation and the mines were considered in the planning studies done for RLM, it was only done to the extent that they may have had an impact on the bulk systems that they share with RLM. Internal reticulation systems of Royal Bafokeng Nation and the mines were included in the hydraulic models where information was available, but excluded from all analyses.

The official population figures for RLM are:

Census:	2001 – 395 761 (116 635 households)
Community Survey:	2007 – 449 768 (146 542 households)
Census:	2011 – 549 575 (335 776 households)
Community Survey:	2016 – 626 522 (262 576 households)

These population figures seem anomalous, with only 2.2% p.a. growth between 2001 and 2007, followed by 5.0% p.a. between 2007 and 2011 and then again 2.7% between 2011 and 2016. In addition, there is a very significant increase in households between 2007 and 2011, followed by a decrease from 2011 to 2016, which seems somewhat unrealistic. If the community surveys are disregarded, the population growth from 2001 to 2011 was 3.4% p.a. and the household growth 11.1%. It is possible that migration patterns to and from mining employment opportunities may have played a role in the seemingly anomalous figures. In order to steer away from the uncertainties related to population figures, all planning and analyses were done based on cadastral land parcels and informal dwellings that could be identified on aerial photographs.

It is estimated that ± 84% of the population is urbanised, either in urban or rural settlements. In total, 24% of the urbanised population lives in settlements located on land belonging to the Royal Bafokeng Nation. The largest portion of the urbanised population (60%) lives in settlements located on non-tribal land. The rural areas house 10% of the total municipal population and the mines house the remaining 6% of the population.

1.2 A Leader in Water Management

As stated in the draft Integrated Development Plan for 2017 – 2022 the municipality has set itself a goal to become a leader in water management. As a forerunner to this goal it was identified that the municipality requires a water and sewer master plan. Additionally the infrastructure, system performance and planning information should be readily available, easy to interpret and up-to-date to ensure that:

- The system is used by the municipal staff
- It constitutes a significant improvement from the current processes within the municipality and assists the municipality in carrying out its duties as a WSA in a more efficient manner.

To this effect the Rustenburg Water Services Trust appointed consultants and initiated the project to analyse and spatially correlate billing information, build and assess water and sewer hydraulic models for the current and future scenarios and to make the significant quantity of data available in an easily accessible and user friendly platform.

2. INTEGRATION OF DATA

The first step was to collect and convert all available water services infrastructure data within the municipality to hydraulic models. The basis of the hydraulic water and sewer models was GIS models captured for asset register purposes. In order to convert the asset register models into functioning hydraulic models more than 11 200 files were interrogated and information captured as necessary. These included GIS files, as-built/construction/design drawings, reports of previous studies and survey results. All plans currently residing in the planning office of the municipality were scanned and the electronic versions captured as part of the models. In the cases where the plans were not in a sufficiently good condition to scan, the hard copies were captured in the hydraulic models before all plans were returned to the municipality. Additionally operational staff and consultants were interviewed to clarify any uncertainties and to determine missing information and changes that may have been implemented but were not available in hardcopy or electronically.

The perceived integrity as well as the electronic plan number of the source data were captured as part of the model, to be able to refer back to the source data if required. Items with a high degree of uncertainty resulting from conflicting information, or low perceived integrity such as design drawings at tender phase, were flagged for investigation in the master plan.

The information was captured over a period of 3 months but the model could be balanced and was used for ad hoc analyses after 2 months.

3. DEMAND ANALYSIS AND REVENUE ENHANCEMENT

3.1 Demand Analysis and realistic loading of the hydraulic models

In lieu of using the Red Book theoretical demand per consumer or stand, the current water demand was determined through the analysis of the municipality's billing data. For each stand the following was identified:

- whether the stand is vacant or occupied,
- the current land use and future zoning,
- the number of existing water meters associated with a stand,
- in which suburb the stand is located,
- the average annual daily demand (AADD) and total water demand (TWD) based on the last 12 months' readings.

The billing data was spatially correlated with the surveyor general cadastre and further refined using the valuation roll. This allowed for visual inspection of the billing data and accurate placement of the resulting demands on the hydraulic models. Several checks and corrections were applied to the data:

- stands with no linked billing data were identified,
- stands with a linked billing record but no meter/no readings were identified,
- land use was verified through visual inspection of the aerial photography,
- the connection to the cadastral for all large users, being users with an AADD greater than 20 kl/d, was verified, to ensure the record is located correctly.

For billing records of large users that did not link with the cadastral information, a more in-depth investigation was conducted to locate the physical location of the consumer and then to correct the created GIS code in order for it to link correctly to the Surveyor General ID of the cadastral.

The current hydraulic model was then populated with the latest billing data to create an operational model in order to best represent of the current state of the system. Prior to planning for future development it is also necessary to consider an interim scenario in which the existing areas are fully developed and all stands are occupied according to their ultimate zoning, which aids in the identification of short to medium term deficiencies in the network. For this purpose theoretical unit water demands (UWD) were determined based on the actual consumption habits per suburb and land use. Outliers were firstly identified and excluded from the calculations. Large consumers were also excluded from the calculations. Secondly the overall resulting unit demand from all billing data per land use was determined for the entire Rustenburg and used as a baseline UWD. Each suburb was then inspected individually per land use to determine whether the deviance from the baseline UWD was significant enough and based on sufficient data to warrant its own UWD. For example, the average unit water demand for stands between 500 m^2 and 1 000 m^2 was 1.0 kl/d if all Rustenburg billing data was considered. However in the suburb of Cashan, where there are approximately 500 such stands, the average was 1.15 kl/d and this was then adopted as the UWD for Cashan for this land use category.

The bulk meter data was also analysed to determine the total input into the system from the various sources. A comparison of the bulk data to the billing data, the stands identified as likely to be using water but not having a corresponding billing record/meter readings and the identified informal areas yielded a total system water balance This process was conducted for each discreet sub-zone that could be defined given the available bulk meter data. The water balance distinguishes between areas with potentially high real losses vs. areas with billing inconsistencies and potentially high loss of revenue. This distinction assists the municipality in selecting the most appropriate corrective measure.

The sewer flows were determined using a unit hydrograph for each stand linked to the model to simulate the leakage (base flow) and domestic contribution to sewer flow as a percentage of the AADD. The unit hydrographs were assigned per land use and are the result of flow recordings in similar studies in Gauteng. The unit hydrographs take contributions to the sewer flow from on-site leakage and ground water infiltration into account, but make no allowance for storm water ingress.

3.2 Revenue Enhancement

The demand analysis procedure discussed in section 3.1 above deals with the conversion of billing data into accurate and useable water consumption information. To conduct the revenue enhancement portion of the project, this analysis was extended to all services; water, electricity, sanitation and refuse. Further interpretation of the billing data was carried out using algorithms to identify revenue enhancement opportunities. Since all records were spatially linked to their appropriate stands it enabled the visual display of data within a variety of thematic maps viewable on the web platform. Thematic maps were and are updated monthly on the web platform to reflect the latest billing data and enables RLM to do quick and simple visual assessments of any property or suburb with regard to various revenue enhancement parameters such as:

- stands with water meters, but showing no water consumption,
- days since last meter reading,
- stands with no water meters,
- developed stands not being billed,
- service comparison maps (e.g. Stands with water consumption, but have no electricity consumption),
- stands with no basic service charges,
- total debt and days overdue per stand.

Figure 2 shows a screenshot of how the data is presented on the web platform.

All stands were further rolled up per suburb in order to provide a summary report per geographical location to prioritise site visits. The summary reports contained information such as addresses, stand owner names and account numbers required to send teams out to do field investigation and implement the remedial actions required. Record was kept of the stands that were visited and contain the site feedback as recorded by RLM personnel. These records were linked back to the source data in order to monitor progress specific to stands visited, and site progress could also be viewed on the web platform as shown on Figure 3.

This is now an ongoing process and as part of the revenue enhancement project, certain key performance indicators (KPI's) are and will be monitored and included in half yearly reports. The report will include number of stands, theoretical demands as well as the potential income gained for various KPI trends such as:

- reduction in stands not billed for consumption (water and electricity),
- reduction in stands not billed for basic charges (water, electricity, sanitation and refuse),
- billing totals per month for all services (basic charges and consumption).

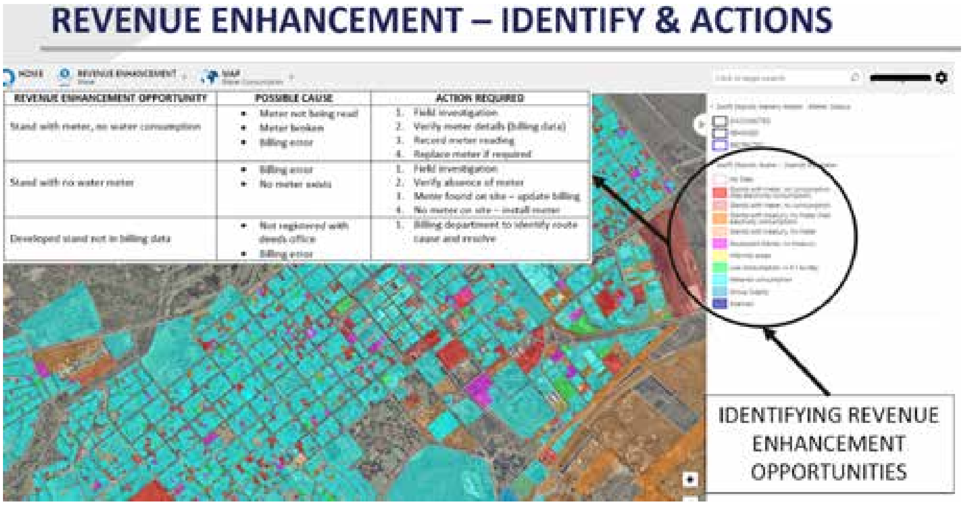

FIGURE 2: Map on the web platform indicating possible revenue opportunities

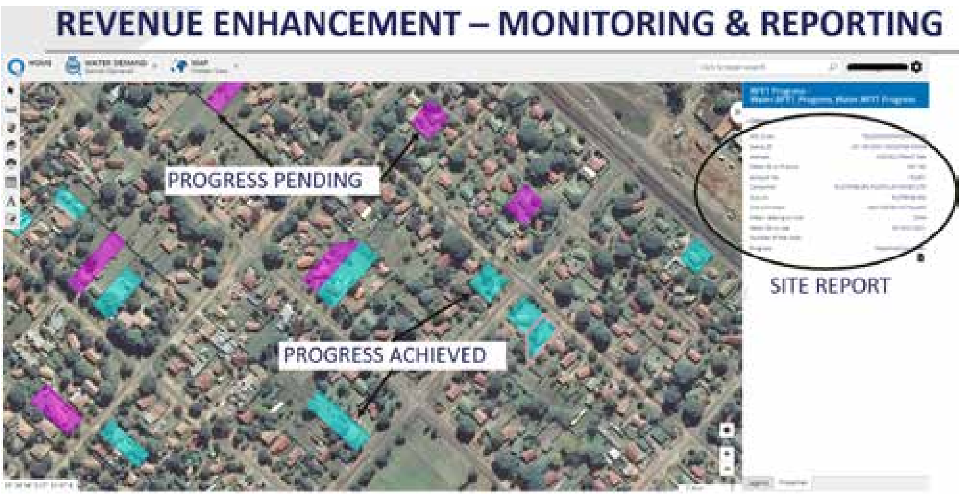

FIGURE 3: Map on the web platform indicating site visits and progress

4. WATER AND SEWER HYDRAULIC MODELS

4.1 Water Hydraulic Model

After incorporation of all available data the model consisted of the following:

- 36 200 pipes with a total length of approximately 2 900 km,
- 43 pump stations,
- 94 reservoirs or tanks of which only 10 has an unknown volume. The remaining 84 reservoirs have a combined volume of 610 Ml,
- 13 towers of which 3 have an unknown volume. The remaining 10 towers have a combined volume of 2.5 Ml.

The current system has significant integration between the bulk service providers, RLM, Royal Bafokeng Nation and the various mines and private systems. Therefore the model and figures above include the Rand Water system downstream of the Barnardsvlei reservoir, the Magalies Water system from the Vaalkop plant to all RLM connection points, the available Royal Bafokeng networks, certain private networks as well as all RLM infrastructure. It also includes areas where no plans were available, but where operational staff indicated availability of water supply. Schematic pipelines and related infrastructure were captured in these instances based on operational knowledge and are included in the figures stated above. The water system layout as captured in the model is shown in Figure 4.

After incorporating all available information to build the water hydraulic model

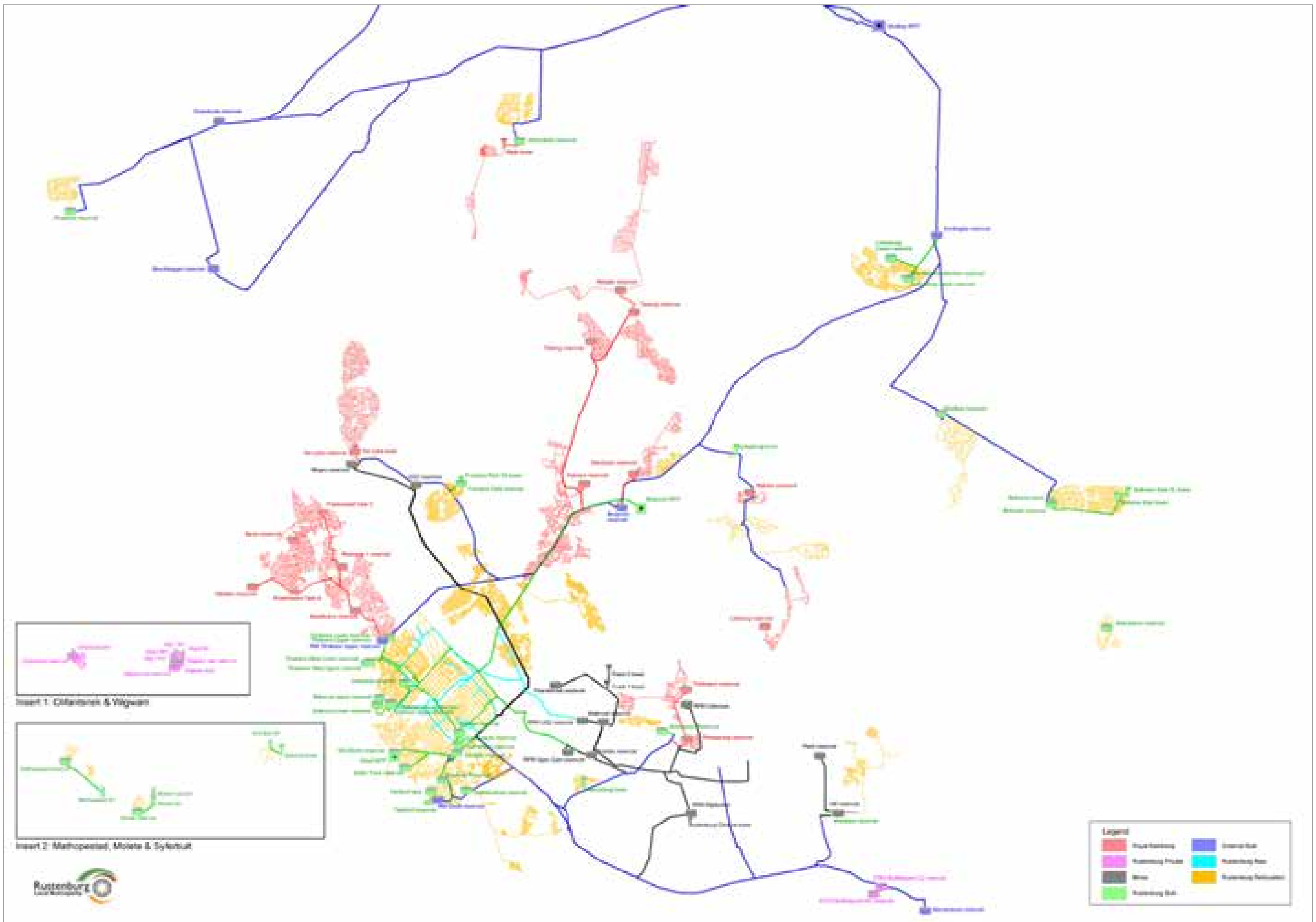

FIGURE 4: **Layout of the water network as captured in the model**

and loading the model with demands resulting from the billing analysis it was ready to be used for analysis. The system was analysed according to certain parameters agreed upon with the municipality to identify areas with deficiencies or conversely with significant spare capacity that would need to be optimally utilised within the broader planning.

Two concerns that were highlighted after the analysis is a recurring theme experienced in other municipalities; difficulty in maintaining zone boundaries as well as reliance on bulk water providers to provide peak demand to certain networks via direct connections. Both are a result of addressing supply problems through short term measures e.g. opening valves to connecting zones or drawing an increased flow from a bulk pipeline until such a time that the origin of the supply issue can be addressed. When the next step is never taken, possibly due to a lack of planning indicating how to address the origin of the problem, the short term measure becomes the permanent state of the system. Projects were identified in the master plan to address such existing problems and can hereafter be used to avoid long term inter zonal and bulk supply dependencies. If the situation arises again the master plan indicates the most appropriate action to address the supply problem while also aiming to improve the system for possible future development.

4.2 Sewer Hydraulic Model

After incorporation of all available data the model consisted of the following:

- 15 600 gravity pipes with a total length of approximately 900 km,
- 12 rising mains with a total length of approximately 23 km,
- 15 300 manholes,
- 8 WWTW with a combined treatment capacity of approximately 54 Ml/d (the capacity of 2 plants are unknown).

This includes certain mine infrastructure that could be obtained from the available plans, certain private networks as well as all RLM infrastructure. It also includes areas where no plans were available, but where operational staff indicated availability of sewer services. Schematic pipelines and related infrastructure were captured in these instances and are included in the figures stated above. A section of the sewer model is shown in Figure 5.

Apart from the shortcomings of the sewer system identified during the analysis, the biggest challenge with regards to the sewer model was a lack of as-built information. Large areas were identified to have access to a waterborne sanitation system, but no plans were available. Often the consultant's drawings would indicate a layout but no invert levels. This was managed by assigning a minimum slope to all gravity sewers without slope information, the reasoning being that if the capacity was acceptable at minimum slope, it would not fail at a steeper slope. For areas where a minimum slope would result in gravity pipelines above ground, the natural typography of the area was used to assign a slope.

5. MASTER PLANS

5.1 Future Water Demand and Sewer Flows

The Spatial Development Framework (SDF) of the municipality formed the basis for future planning. The Land Use Management Scheme (LUMS) revision of 2009, Precinct Plans and the Draft Roads Master Plan were also considered in the final refinement of future areas. Furthermore all steep areas, considered to be areas with an incline greater than 1 in 2.5, were

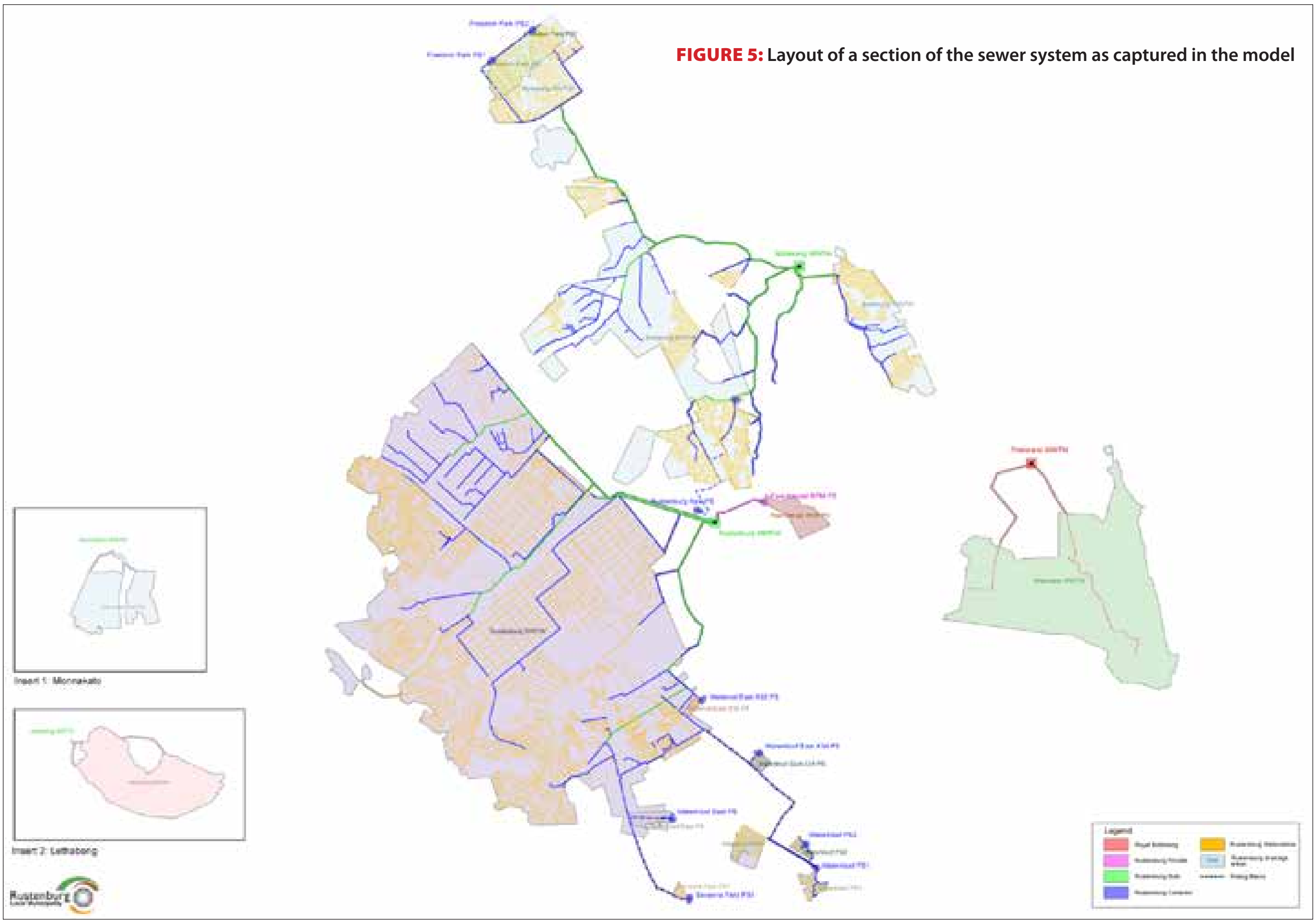

FIGURE 5: Layout of a section of the sewer system as captured in the model

removed from the future areas as undevelopable. This represented the steepest slope on which existing development occurred in Rustenburg and was therefore used as the cut-off.

The resultant potential future land development areas taken into consideration for the study represent a planning horizon of at least 40 to 45 years and could lead to more than a doubling of the current water demand.

Included in the potential future land developments were the in-situ upgrading of developable informal settlements, and the relocation of informal settlements on undevelopable land, as per the Rustenburg housing strategy.

The bulk of the future new land developments is anticipated to occur at the following development nodes:

- Waterval area (east of Rustenburg town, straddling the N4 highway and R24)
- Boitekong
- A new town will be established at Boschhoek
- Each of the following rural areas will also see significant future development:
  - Phatsima
  - Monnakato
  - Lethabong
  - Modikwe and Berseba
  - Bethanie
  - Makolokwe
  - Marikana

A 5% increase in current demand was estimated for mines and a 10% increase in current demand was estimated for all Royal Bafokeng Nation and private residential areas in order to evaluate the effect on the bulk services in future.

5.2 Three phases of planning

The planning process was considered in three phases:

- using the operational model existing problems were identified along with remedial actions that are immediately required,
- using the theoretical current model short and medium term actions were identified to accommodate full development of all existing areas,
- using the theoretical future model medium and long term actions were identified to accommodate all proposed future developments for the ultimate scenario.

The medium and long term projects required to accommodate future development are often times simply the enlargement of an already identified short term project. It is critical to establish this relationship before any projects are implemented. A number of proposed projects have already been amended before implementation to ensure that the infrastructure implemented was in line with the master plan and did not only resolve short term problems but took the broader planning into consideration.

The potential growth and total water requirements as well as a projected timeline were determined as part of the study and can now be used to inform the municipality's bulk water providers in order to align bulk provision planning, ensuring that the bulk providers take the municipality's demand into account and vice versa.

6. CONTINUOUS UPDATING OF INFORMATION

The initial model was based on billing and bulk meter data up to October 2015 which was almost a year old after completion of the study in July 2016. The project is now continued as a bureau appointment, whereby the hydraulic models and master plans are continuously maintained. The billing analysis and revenue enhancement is conducted every month, and the models are continually updated as new projects are completed, surveys are conducted or previously unavailable data becomes available. The master plan and water balances are updated every 4 months to account for all additional information.

Continuous updating of the model and master plan ensures that the master plan is always appropriate to the current state of affairs within the municipality. When a development is proposed within the municipality, it can easily be verified as to whether allowance has been made for such a development in the master plan, what the current water and sanitation situation in the area is, whether the development can be accommodated and if not, which items should be implemented for it to be accommodated. Water consumption can be monitored to determine consumer behaviour and measure the effectiveness of WC/WDM measures. Additional parameters used in the revenue enhancement project can also be monitored and the recommendations adjusted accordingly to ensure that revenue collections remain on an upward trend.

7. VISUAL DISPLAY OF AND ACCESS TO INFORMATION

All the information that formed part of the initial study and the continuing project is displayed on the web platform. The information is accessible to the municipality through various modules of which the Water Demand, Revenue Enhancement, Water and Sewer modules contain the information as described above. The latest network models and billing information is displayed on a number of interactive maps in a user-friendly environment, facilitating rapid access to and interrogation of municipal infrastructure and billing information at a pipe-by-pipe and stand-by-stand level of detail. Where previously a plan would have to be found in a dusty corner of an office in order to establish the exact particulars of a pipeline, this information can now be accessed in seconds along with the estimated peak flow in the pipeline, whether the capacity of the pipeline is sufficient in the current scenario and whether it will remain so in future and if not, the diameter of the required future parallel pipeline.

Apart from the web based platform, the models were supplied to the municipality in a GIS format together with all captured plans and reports used to compile the models in electronic format. Plan books were generated and electronic and hard copies supplied to the municipality that can serve as a replacement for all as-built drawings. This information is regenerated with each update and supplied to the municipality to ensure access to the latest data irrespective of connectivity.

8. CONCLUSIONS

A master plan of its water services allows the municipality to be proactive rather than reactive to changes in water demand. By establishing a baseline for the current water and sewer situation within the municipality and having a clear vision of where the municipality is heading, allows for appropriate expenditure on water projects and timely interventions ensuring both improved accessibility and reliability of supply.

The municipality has set themselves a very worthy goal of becoming a leader in water management and have started taking steps in achieving this goal through the implementation of technologies that allow them to:

- access their system performance and infrastructure information on a single, easily accessible platform,
- identify critical areas in the water and sewer systems in a timely manner and to address problems taking cognisance of the ultimate scenario,
- incorporate and analyse billing data to ensure that water demand does not remain static but takes changes in consumer behaviour into account,
- incorporate and analyse billing data for related projects such as revenue enhancement.

Through continuous updating the information and planning remain up to date and responsive to a potentially rapidly changing environment.

9. RECOMMENDATIONS

This study has determined the volume of water required to adequately supply the current and future scenario of the municipality and the potential current and future sewer return flows. This information is a critical input into a water resources master plan and therefore the RLM water resources master plan should be updated accordingly.

The current assumption of 10 % growth in residential areas not currently supplied by the municipality and 5 % for industries not supplied by the municipality is a rough estimate based on limited information. These figures should be refined by extending the scope of the investigation to include all water users within the municipal borders to accurately determine the impact on both the bulk and the municipal infrastructure.

Where previous logging results were available, calibration of the system was conducted with good results. This exercise can be extended to calibrate the system on a zone by zone basis, preferably subsequent to any zoning projects to ensure the system responds as intended in planning.

Condition assessment information can be added to the model and can be used to conduct a pipe replacement prioritisation project in order to determine which sections of the aging asbestos cement networks need to be replaced first.

Further refinement of the models by way of implementing the identified surveys should be a continuous exercise. The municipality has started with this process and the models have been adjusted according to the findings.

The most critical point perhaps is that this is still just a tool in the municipality's hands. Buy-in by municipal staff is critical for this system to lead to efficiency within the municipality. Continued training is required to ensure that all relevant municipal staff is proficient in using the system so that their decisions are informed by the master plan to address system deficiencies. Feedback from staff on implemented projects, system changes and inaccuracies picked up during investigations is required to improve the reliability of the system, which again leads to increased trust in the system result, and therefore increased usage, by the staff.

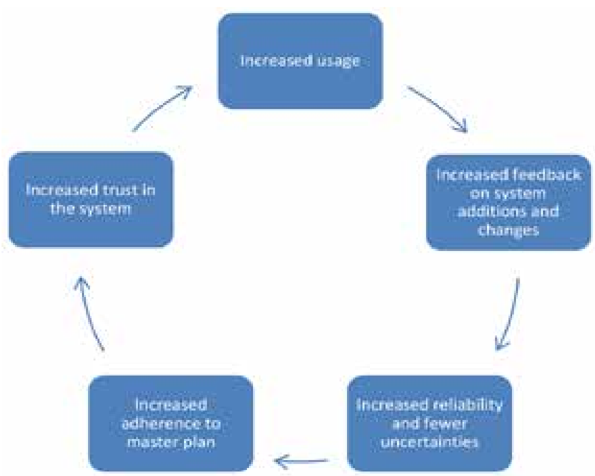

FIGURE 6: User Acceptance, Implementation, Improvement, Trust

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