

# **EXECUTIVE SUMMARY**

## **Scope of the study**

Over the last decade in South Africa there has been a government drive to provide basic services to all residents. This resulted in considerable development in certain areas of the country and particularly in providing new sewer systems.

South African sewer systems and storm drainage systems are designed as separate systems, while the sewer system (SS) is commonly waterborne. Waterborne sewer systems, also called conventional sewer systems, use water as the mode of transport for excrement and other waste. This research project focuses exclusively on separate sewer systems (SSS) and specifically on the planning of waterborne sewer systems. In this context a SS refers to a system of sewer pipes and other infrastructure such as pumps that are needed to transport the sewage from the point of entry to the point of outfall; wastewater treatment is thus excluded by definition.

## **Key objectives**

The terms of reference for this research project described the need for simple tools to assist staff at all levels of local and regional authorities to complete a basic assessment of their sewer systems through compilation of basic inputs and generation of useful outputs. This research also gives structure to the SS planning process (often termed "master planning") and provides a methodology for compilation of a sewer system plan.

The fundamental aim of the project was to develop a product that would be simple with immediate benefits to the local authority, yet would be based on the vast and advanced pool of knowledge available to researchers and specialist consultants. The intention was thus to provide fundamental principles relating to sewer planning and to provide usable tools to the sewer manager and engineer, rather than to structure a comprehensive specification for implementation of proprietary software. In contrast to the advanced software suites available nowadays this study recognised the need for low-technology tools and guidelines to aid relatively small local authorities in moving towards a sewer system plan (SSP), which would ultimately assist in the improvement of planning functions and service delivery.

It is evident from the definitions provided and the knowledge review that sewer planning is inherently complex and that the related planning process is not geared to a low-technology approach. Recognising this complexity while striving towards a low-technology, user-friendly output was the main challenge of this research. The aim of the project was to present a simplified approach to sewer system planning with accompanying tools that could be used directly as a lowtechnology (non-computer based) method for sewer system planning and to better understand sewer systems and the related planning process. An extensive knowledge review was included in this project.

At this point it should be clear to the reader that the intended use of these tools would be at the level of relatively small (or perhaps poor) local authorities that are hampered by a lack of resources. In many smaller towns computers, and staff with adequate computer knowledge to apply advanced tools, may not always be available at local authority level.

## **Knowledge review**

The knowledge review was extended to also include so-called "grey literature" and key international sources. Consultant's reports were found to provide a large volume of reading

matter and data in this regard, in contrast to limited academic publications. A wide search revealed that very few consultants operate specifically in the field of SS planning. In South Africa sewer systems are designed to convey wastewater flow exclusively. Various design guidelines are available (Little, 2004; City of Tshwane, 2007; CSIR, 2003). Separate stormwater drainage systems exist in parallel for drainage of storm flows, but some groundwater as well as stormwater will ingress the sewer system (Stephenson and Barta, 2005a; Stephenson and Barta, 2005b) and are allowed for partially in SS design criteria. The most recent and arguably the most comprehensive document was produced as an output of WRC project K5-1744 (Van Dijk et al., 2008).

Two pertinent literature references could be traced during the review process addressing SS planning per se in South Africa. The first by Sinske and Zietsman (2001) described the concept of using GIS as a basis for SS planning, while the other by Fair et al. (2008) presents a detailed account of the dynamic planning process. The latter was initiated in view of this research project and aims to describe the comprehensive process in place in large metros.

### **Three-tiered design philosophy**

A three tier philosophy for SS planning in South Africa was proposed as part of this study (Jacobs and Van Dijk, 2009). With due recognition of the complexity of SS planning, both with regards to the system per se and the flow and load transported by it, but also in view of the need for simple procedures which can be used routinely in areas with low service levels, provision is made for the following three-tiered approach:

- The first tier is termed Level 1 and comprises the application of the most basic design rules presented in hard copy format. The Level 1 approach is intended for use in cases where limited technical skill is available, or the scope of work is relatively small with negligible risk. This approach is sufficient only in smaller municipalities and small towns with limited sewer infrastructure. Quite often Level 1 is dominated by minimum requirements for some parameters rather than hydraulic considerations (e.g. the minimum pipe diameter is driven by the required size needed for rodding and to prevent clogging).
- Level 2 entails a more sophisticated approach incorporating design theories that take into account the hydraulics of system elements, requiring a basic analysis of the system or parts thereof. The analysis of a single main sewer, or pump station and rising main are examples of the Level 2 approach. This would typically be the level needed by a medium sized town.
- Level 3 is essential for cities and large metros. Level 3 is the most advanced and requires advanced skill and software tools to conduct planning of extensive sewer systems.

The definition and application of these three tiers could also in future act as a basis for municipalities to describe the level of complexity of work when appointing a consultant to conduct SS planning.

### **Methodology**

The progress of the research moved from assessing existing knowledge to the compilation of draft sewer system planning tools, which were subsequently workshopped in order to gain feedback and improve the concepts to derive tools suitable for practical application. Finally a set of tools were compiled as a project outcome that could be provided to local authorities at ground level. This text provided a detailed account of the process and its outcomes to mainly academic readership. However, feedback obtained during the stakeholder workshops underlined the importance of also making the result available as a wall-mounted poster. A poster-output was subsequently produced as the key application at local authority level. The poster is available separately from the WRC (SP 1/10). The individual tools, components of which have been incorporated on the poster, are included as Appendixes to this report for those requiring more

information on any one particular tool.

## **Workshops**

With reference to the initial project proposal for K5-1828 the project team set out to hold workshops with various stakeholders. The idea was to complete workshops with stakeholders in order to establish their needs and interventions and to evaluate the experiences of local authorities in using particular types of tools and planning guidelines. Workshops were hosted by the project team. In order to maximise the impact the workshops intended for this research were combined with other practical training sessions organised for local authorities at different venues in the country, where possible.

The idea was to use these workshops with stakeholders to establish the needs with regards to low-technology tools and guidelines for SS planning. The focus would be on local authorities and other stakeholders involved with SS planning where resources limit the application of expensive high-technology interventions (e.g. specialist consultants or advanced software applications).

Four workshops were held during October and November 2009 at the following locations:

- Cape Town (3 days): collaboration with Institute for Municipal Engineers of South Africa (IMESA) conference, Cape Town International Convention Centre, 28-30 October 2009; all conference break periods were available for workshopping with delegates
- Beaufort West (1 day): site visits to three towns in two Municipalities around Beaufort West on 16 November 2009
- De Aar (1 day): site visits to four towns in three Municipalities in the Pixley Ka Seme region on 17 November 2009
- Worcester (½ day): collaboration with Municipal Infrastructure Grant (MIG) workshop held on 20 November 2009, targeting technical staff of all Municipalities in the Western Cape province.

In addition to the four workshops noted above, a post-project workshop was held at the WISA2010 conference in Durban, 18-22 April 2010, in collaboration with another WRC project team (University of Pretoria; Project K5-1744).

## **Tools**

The eventual tools comprised relatively simple check-lists, tables, graphs and diagrams to aid in the critical steps of the planning process. Despite the availability and application of various propriety software suits for system modelling in South Africa the aim in this research was instead to produce a set of basic hard copy tools. The final toolkit comprised the following components:

- Hydraulic design tool – an aid to understanding the relationships between critical parameters used in basic hydraulics of sewer pipes and a useful way of obtaining a feeling for the required pipe size by means of crude assumptions
- Infrastructure costing tool – a mechanism to estimate the fixed capital cost of sewer infrastructure
- Sewer system planning checklist tool – a method to record progress and guide towards an eventually comprehensive SSP
- Master planning process tool – a schematic description of the SS planning process
- Sewer terms tool – this could be viewed as a sewer terms glossary or mini-sewer-dictionary
- WSDP tool – aimed at simplifying the transfer of information from the SSP to the water services development plan (WSDP).

## **Hydraulic Tool**

The application of the average flow velocity in hydraulics is now accepted to be out-dated and

advanced methods are available for determining scouring and sediment transport in sewer pipes (Saatçi, 1990). For the limited application of a simplified tool it was considered necessary to use the average velocity as a means to illustrate some essential relationships, often not understood at the level for which this tool is intended. The hydraulic tool provides graphs to visually illustrate critical relationships between the most notable parameters in sewer flow hydraulics.

### **Infrastructure Costing Tool**

The knowledge review uncovered four types of cost incurred in the installation and operation of a sewer system, namely:

- capital cost (e.g. the cost of constructing new infrastructure)
- operational cost (e.g. electricity for operating pumps, human resources)
- maintenance cost (e.g. repair and refurbishment of ageing infrastructure)
- carbon cost (e.g. the indirect impact on the environment).

Some of these cost types were considered to be set at a technical level higher than what was deemed appropriate for this project. The idea with developing the tool was to start with the most basic cost type (capital) and advance to higher levels of complexity if the need were identified during the workshops. Cost functions would have to be compiled annually by assessing actual costs for various components of sewer construction projects, as per SABS 1200 requirements. These individual costs were integrated to obtain an estimate of what 1 m length of sewer would cost, depending on diameter (in the case of pipes). A similar procedure was followed for pumps, etc. These relatively "fixed" unit values are amenable to amendment at any intermediate stage in the year by increasing the annual base value with a percentage based on the consumer price index (CPI).

Through the workshop-inputs gathered during this study it was found that municipal staff often made their own ad hoc estimates of cost in the absence of better information. In all cases these were based exclusively on capital cost. A clear need for a low-technology tool such as the one presented in this project was noted. The project outcome provides a handy method for estimating sewer infrastructure capital cost.

The infrastructure costing tool was linked to a calendar-format to keep track of the aging information. The poster-calendar would form part of the outcome and would be printed annually, with distribution to stakeholders whose contact details would be maintained by the project team (Stellenbosch University) for the trial period. The project team committed to conduct the administration, poster design, printing and distribution for three years.

### **Sewer System Planning Checklist Tool**

Consultants use in-house checklists to assess the data required during the compilation of a SSP. Two such lists could be obtained as part of this project (from engineering consultants GLS and Aurecon), but in both cases the checklists were not amenable for application at Municipal level. The use of a checklist to describe the particular SSP inputs, and more basically the progression of information from raw data to a final SSP, was considered a convenient tool.

The final checklist was based on a checklist used by GLS Consulting for estimating the workload and cost required to compile a SSP. The checklist was applied in many Municipalities of the Western Cape (as part of non-project related work by GLS Consulting) and the checklist included a few years of development prior to this project.

## **Master Planning Process Tool**

It was considered imperative to include a process description tool in the SSP toolkit. The concept of process description in terms of sewer systems is not new. The knowledge review conducted as part of this study underlined the fact that various authors in the past have presented descriptions of sewer systems and the sewer planning process. None of these specifically attempted to simplify the process in any way, which is the specific focus of this project. It became apparent with progression of the project that a well designed and presented SSP checklist and poster would supersede a mere description of the SS planning process as an independent tool. However, the process description could be used as an aid to understanding the checklist tool.

## **Sewer Terms Tool**

A need was noted to clarify sewer terminology by means of a concise sewer terms list, or sewer terms tool as it was called. The tool would take on the form of a dictionary in mini-booklet form, or at least an extended glossary. The ultimate goal of the terms tool was user education. Understanding the terms often used in this discipline is essential and is considered to be a prerequisite to understanding even the simple low-technology outputs of this project. The idea was also to set the scene for future compilation of an advanced (and technically speaking correct) document that could find application in academic circles and in the field. For the regions evaluated during this research text in English and/or Afrikaans were desired by small local authorities – a future document in these two languages could be the start to a more advanced document later extended to include other official languages. As part of this project a list with terms and definitions was compiled to meet the initial need, but only in English.

## **Water services development plan (WSDP) Tool**

As part of the project goal to assist local authorities in the improvement of planning functions and service delivery a method was devised to aid with the Water Services Development Planning (WSDP) process. The project team included this tool as a project output although it was not considered to be a key output based on workshop feedback. For this reason it was not incorporated into the poster. The two-page A4 sized WSDP-tool was developed after consultation with KV3 Engineers (Human, 2009), who have been assisting numerous municipalities in the country with developing and updating WSDP's. At the time of investigation KV3 typically made use of specific agenda documentation when initiating a project. The information was kindly provided for perusal to the project team to form the basis for the WSDP-tool.

## **Sanitown sewer system model as benchmark for application**

The development and description of a conceptual, hypothetical hydraulic model for SS analysis was considered useful as part of this project (readers may be au fait with the "Anytown" model used for this purpose for water distribution system analysis). This aspect moves the reader to advance from the focus of this study to more advanced work.

The proposed SS model was called Sanitown, after its brother Anytown. The name is in fact a concatenation of "sanitation" and "town". The Sanitown model was presented at the WISA2010 conference for the first time (De Klerk and Jacobs, 2010). The input parameters and model topology have been carefully selected and refined to include typical yet realistic problems encountered with the hydraulic modelling and planning of sewer systems. The components that were considered notable for inclusion in the model include: the Sanitown model topology, drainage region contours, proposed flow inputs, one future scenario to pose a typical development problem and a few restrictions in terms of system upgrades.

The Sanitown model was also tested as part of this research project by setting up a computer model of Sanitown. With its development the Sanitown sewer model was intended to become a widely used guinea pig for waterborne sewer system analysis, investigation into optimisation techniques and software performance. This type of research is particularly applicable to South Africa with its unique challenges to service delivery demanded by high-level customers at the upper end of the delivery ladder, and those without any service alike.

## **Conclusion**

A key problem in small local authorities – in terms of this research – was that staff at ground level responsible for service delivery were often limited in terms of basic knowledge regarding the sewer system, its operation and planning. The value of the simple tools presented here do not merely lie in their usefulness in sewer system planning, but also in their value as training tools to gain understanding of the sewer system and its planning and to illustrate critical relationships between notable parameters typically used for sewer system planning.

No matter to what extent and how well the simple planning tools provided by this research project are applied in practice, it is imperative that a computer model of the sewer system would ultimately be required. Only by means of an accurate computer model would it be possible to assess the hydraulic capacity of the system. Increasing the level of complexity to a computer model immediately poses a new problem to designers and analysts in that no benchmark model was available to discuss and investigate different approaches to the sewer system design problem.

A hypothetical model for sewer system analysis called Sanitown, a concatenation of "sanitation" and "town", was presented in this text. It included typical yet realistic problems encountered with the hydraulic modelling and planning of sewer systems. The Sanitown model topology, drainage region contours, hypothetical flow inputs, a future scenario and a few restrictions in terms of system upgrades were presented. The Sanitown model was also tested as part of this research project by setting up a computer model of Sanitown, but an example was also provided where the low-technology tools were applied to one of the hypothetical Sanitown developments. With its development the Sanitown sewer model was intended to become a widely used guinea pig for waterborne sewer system analysis, investigation into optimisation techniques and software performance.

The outcomes of this project would aid a Municipality to better understand the working, modelling and planning of a sewer system and its optimisation in terms of hydraulics and cost. The sewer system planning checklist tool in particular would aid staff to record and prepare the required and desired information, ultimately needed to compile a computer model, in a useful format. In doing so an understanding would be gained of both the sewer system and the sewer system planning process.