A First Order National Audit of Sewerage Reticulation Issues

Report to the

Water Research Commission

by

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Executive Summary

The project falls under the following administrative research structure of the Water Research Commission (WRC):

- Key Strategic Area 3: Water Use and Waste Management
- Thrust 3: Wastewater and Effluent Treatment Technology
- Programme 7: Sewerage Reticulation

Summary of principal objectives

The WRC has solicited this project in order to identify key issues and develop appropriate research responses in the field of reticulated sewer infrastructure in South Africa. The project has been developed according to the following principal objectives:

- To Identify and characterise the sewerage reticulation issues on the background of international and regional research work available from accessible databases.
- Prioritizing the sewerage reticulation issues requiring attention within the context of integrated urban water resource management in South Africa, and
- Developing strategic guidelines for dealing with above highlighted issues.

The findings of this project will form the framework for solicited projects and lead to a roll-out of focused research projects dealing with specific needs in the industry.

Outline of work program

Information was collated through literature surveys and stakeholder feedback workshops to establish:

- The status quo of sewerage reticulation in South Africa;
- International trends and regional needs to facilitate the sewerage reticulation operation and maintenance as well as new developments;
- The direct impact of water demand management and other infrastructure on sewerage reticulation; and
- The research priorities and phasing for the WRC in facilitating the most urgent research projects.

By completing a series of workshops with local councils on the topic of sewer reticulation firstly established the concerns of managers and operators and, secondly, ground-truthed the need and priority of research topics identified during the literature survey process. The findings presented in this report form the consolidation of four project deliverables, namely:

- Local and international literature survey
- Status quo of sewer reticulation issues in SA
- First-order situational and gap analysis
- Final report consolidating the previous three items and developing a framework and guideline document indicating specific shortcomings regarding technical, operational and strategic issues and a prioritised roll-out of focused research needs and associated costs.

Although individual reports were produced for each of the above stages, the final report and electronic dataset has been structured to suite the target audience.

International and local literature surveys

The initial literature search revealed over 5500 references to sewer related topics, of which 2021 pertinent international documents and approximately 113 local references were selected for further evaluation. These were further categorised and sorted into topics and sub-topics for ease of reference and reporting.

Although basic reticulated sewer systems have been in existence throughout the millennia, it is only since the mid 19th century that significant advances in terms of a holistic understanding of health, social, planning, design and operation of an effective sewer system have been researched, documented and implemented.

The literature survey, particularly international references, indicated noticeable trends in available research. More than fifty percent of all literature falls within the “Technical” category which deals with planning, design, construction, operation and maintenance of the sewer reticulation.

It must be noted that much of the international research is conducted on combined sewer systems and not separate sewer and stormwater systems which are prevalent in South Africa. However, many issues identified within the combined sewer systems resembling in principle the topics in the research which may be applicable to South African conditions.

All pertinent literature references have been compiled in a searchable spreadsheet format appended in CD-format to this report. Many listed documents in the spreadsheet could not be located or are out of print, precluding a detailed review.

Status Quo of Reticulation Issues

A series of workshops were held at eight main centres throughout South Africa. The workshops were held in parallel with SRK Consulting who was completing similar needs analyses focusing on stormwater infrastructure issues. The intention to hold combined workshops was to determine interfaces between sewer and stormwater departments and establish a way forward by discussing and addressing common issues. A total of 21 metropolitan, local and district councils were represented at the sanitation working sessions.

The workshops accentuated the main constraint facing the management and operation of sewer reticulation systems in South Africa as being a lack of resources and to a lesser extent a lack of funding. The South African Institution of Civil Engineering reported in a recent study that 79 of the 231 municipalities did not have any civil engineers, technologist or technicians, and in general the country only has one engineer per 3200 people, a capacity that is far below internationally accepted norms.

The restructuring of local government structures during the municipal demarcation process and the posting of personnel to other departments has resulted in a loss of knowledge and operational background of how the original sewer systems were constructed and operated. Unfortunately such information has not been captured in suitable database or electronic systems and in many instances there is little as-built (or as recorded) information for much of the systems.

The serious loss in capacity and experience has resulted in the need for increased information dissemination and production of guidelines to assist managers in understanding the full

requirements of planning, designing, operating, and particularly maintaining and rehabilitating/upgrading of sewer infrastructure. With a host of available products, materials, software and methods employed in the various aspects of sewer management, the standardisation and setting of minimum requirements and guidelines will assist in ensuring that minimum levels of service are maintained, specifically in the smaller local authorities.

The research team has identified needs in the industry and established areas where new research is required, where completed research needs to be revisited and where there is a need to disseminate existing research to relevant professionals and administrators.

In terms of research needs, the greatest requirement from local authorities is to investigate and provide guidance in the fields of:

- Operations and maintenance;
- Environmental issues;
- Benchmarking; and
- Analysis of existing systems;

The following fields were considered least important for immediate research requirements:

- Further legislative requirements;
- Guidance on quality systems;
- New system construction;
- New technologies; and
- Safety

Date of research publication

The date of publication of existing research papers has been considered in evaluating the relevance of a research publication in the survey of international and national literature. The earliest references considered for the literature study dated in the late 1960's. The bulk of the research publications available for evaluation have been grouped and presented in two fifteen year periods up to the year 2000. Very few international research publications were sourced for the post 2000 period. However, most of the relevant national research publications available are dated after the year 2000.

Gap-analysis priorities and actions

A gap-analysis was completed as part of the project to categorise and prioritise research needs which had been identified during the previous phases of the project. The gap-analysis was also extended to document elements of sewer infrastructure research and management that were not specifically identified or dealt with during the literature survey and national workshops.

The gap-analysis identified 53 potential research topics for the Water Research Commission to consider further. These topics were consolidated into 31 projects and prioritised based on the needs identified during the national workshops. An additional 6 topics were identified, but it is felt that these

topics have been covered sufficiently under previous research projects and that dissemination of this research is required.

A comparison of coastal and inland local authority priority issues revealed that benchmarking and education were of greatest importance to coastal areas, whilst operational and maintenance and environmental issues concerned more professionals and administrators from the inland areas.

A comparison of smaller local and regional council, and larger metropolitan council issues revealed that operational and maintenance, and system analysis were of greatest importance, whilst the metropolitan council require additional research conducted on benchmarking, social and educational issues.

In general the metropolitan structures are well established with comprehensive systems, resource structures and functional bylaws and procedures. The smaller councils do not have the financial benefit of implementing enterprise-wide information systems or the personnel capacity to manage water service systems. The majority of time is typically spent on keeping the existing sewer system operational with little planned routine maintenance or master planning.

Project outcomes

- A list of 31 prioritised research projects have been identified under this study for further consideration by the WRC. Durations and budgets have been allocated for each of the projects, however the scope of the projects, budgets and durations should be assessed further by the WRC to ensure that they adhere to their overall research and funding strategy at time of implementation.

- The project established the terms of reference for two solicited research projects to be implemented immediately in the field of fundamental research (*Improving Sewerage for South Africa*) and applied research (*Sewer Master Planning Tools and Guidelines*)

- Along with these projects there is a need to develop national standards in the field of buried flexible pipes, jointing systems and trenchless technologies along with national standards bodies.

- There is currently limited funding allocated for research and development on sewer networks, which should be reviewed and addressed by the WRC in conjunction with national and local government, standards bodies and organisations associated with the sewerage industry.

- There is also a need to address the dissemination programme of available information to the industry for valuable research that has been conducted by the WRC and other organisations.

Acknowledgements

The project team wishes to express its appreciation to the Water Research Commission for its financial support and to the following organisations and individuals for their valued input and comment.

Table 1: Project Team

Name	Company/Organisation	Role
Brian de Swardt	IUI	Project Manager/Sewer Facilitator
Bo Barta	IUI	Senior Researcher/Reviewer
Nicola Avian	IUI	Research Assistant
Jay Stathakis	IUI	Technician/Data Management
Brett Mansfield	IUI	Student/Data Capture
Edson Rhumhizha	IUI	Student/Review
Jean de Swardt	IUI	Secretary
Matt Braune	SRK	Stormwater Facilitator
Xanthe Mayer	SRK	Workshop Co-ordination
Jackie Burke	SRK	Project Liaison

Table 2: Reference Group

Name	Company/Organisation
Dr Heidi Snyman	Water Research Commission (Chairperson)
Prof Neil Armitage	University of Cape Town
Mr Charlie Crawford	Department of Water Affairs and Forestry: Water Services: Technical Innovation Guidance
Mr Anton de Klerk	University of Pretoria
Mr John Harrison	eThekwini Municipality: Planning
Mr Nigel Ireland	City of Cape Town: Water Services: Sanitation
Mr Leon Naude	East Rand Water Care Company (ERWAT/IMESA)
Ms Valitha Roos	Johannesburg Water: Operations Manager

The project team wishes to acknowledge the time and input offered by all attendees at the workshops. A full list of attendees is included in Annexure B: National Audit of Sewer Reticulation Issues. The success of the workshops is attributable to the lively discussion, feedback and interest shown in the project by the attendees, for which the project team wishes to offer their heartfelt thanks.

Structure of Report

The structure of the final report comprises the text report and a data CD compiled as follows:

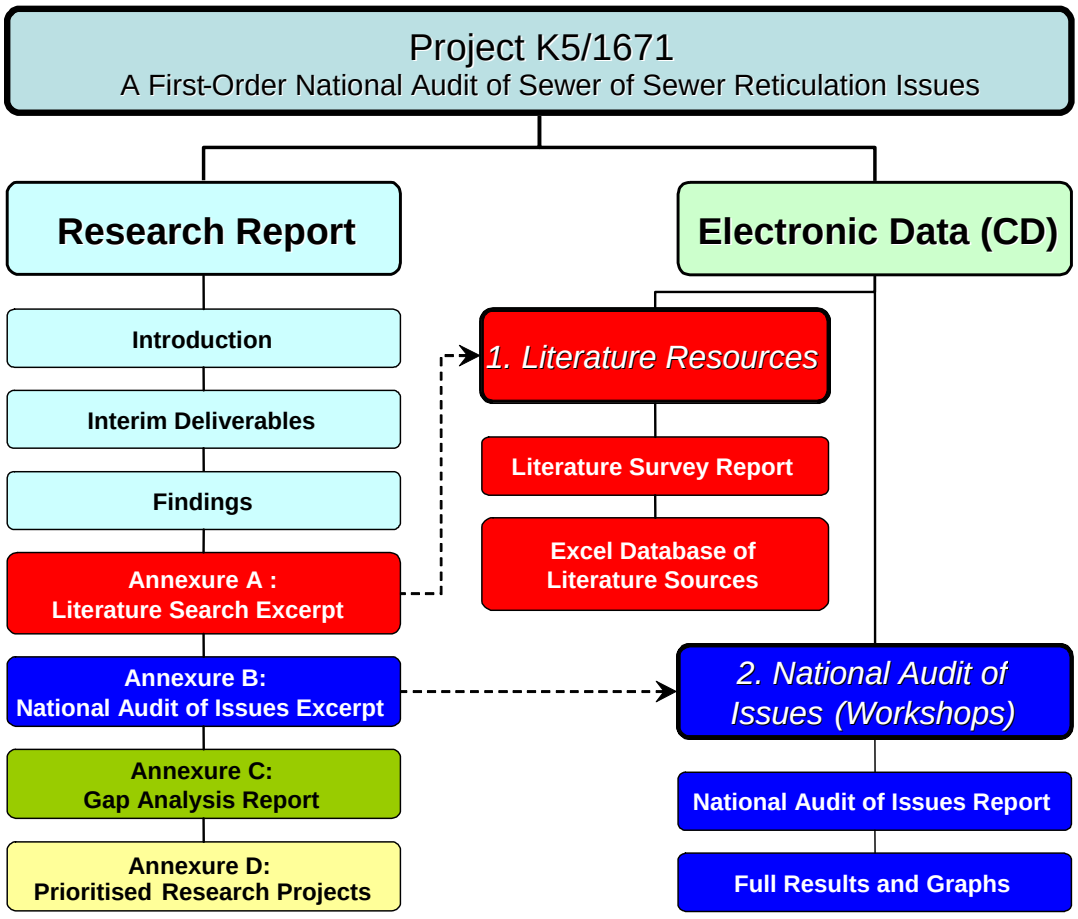

Figure 1: Structure of Research Report

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Annexures (appearing on the enclosed CD)

List of Tables

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List of Abbreviations

DWAF	-	Department of Water Affairs and Forestry
EPA	-	Environmental Protection Agency
FOG	-	Fats, Oils and Greases
IDP	-	Integrated Development Plan
IUWM	-	Integrated Urban Water Management
NISC	-	National Inquiry Service Centre
NSTT	-	National Sanitation Task Team
SAICE	-	South African Institute of Civil Engineering
WRC	-	Water Research Commission
WSDP	-	Water Services Development Plan
WWTW	-	Waste Water Treatment Works

Introduction

1 Introduction

The Water Research Commission (WRC) recognises that sewerage reticulation systems represent a considerable capital investment in the overall provision of waterborne sanitation. Due to various factors such as materials of construction, installation techniques, operating conditions, quality and flow regimes, sewage reticulation systems have a limited life span. In the older metropolitan areas of the South Africa, parts of the sewerage systems have already exceeded their anticipated service life. Owing to the accelerated provision of housing, water and sanitation to previously un-serviced sectors, as well as a rapid rise in new urban commercial and residential developments, there has been a rapid expansion in both the volumes of sewage and also in the extent of new sewerage reticulation installed. This in turn has placed pressure on existing older networks to which such newer developments are often connected.

In the context of integrated urban water management (IUWM), considerable attention has been given to issues, needs and knowledge requirements in domestic water supply, sanitation and sewage treatment. Historically, the sewerage systems responsible for receiving and reticulating the sewage flows have received much less attention (aside from recent research into developing technical alternatives to the conventional gravity sewer such as small bore, solids-free sewers, shallow sewers and vacuum systems). Therefore the sanitation system employed is of obvious relevance.

From interactions over a period of time with a number of key stakeholders, it appears that the state of current, up-to-date knowledge is inadequate around a range of issues regarding sewerage reticulation in South Africa and particularly:

- Technical aspects;
- Operational issues; and
- Strategic Issues

1.1 Objectives

The objective of the study is defined as a first-order audit of technical and infrastructural concerns regarding sewer reticulation on a national basis in order to identify, characterize and prioritize research needs in this area, within the context of integrated urban water resource management. The purpose of the study is to:

- Identify issues of concern, current and future challenges, and research needs in the area of sewerage reticulation in the RSA, including technical, social, environmental, regulation and policy aspects, supported by appropriate case studies and/or prevalence of incidents;
- Determine current, new and future international trends and developments;
- Understand the current and potential future impacts of low water consumption, demand management and related issues and needs;
- Carry out a stakeholder consultation process that confirms and prioritizes such issues/needs in the RSA with regard to sewerage reticulation;
- Provide guidelines for the approach to be adopted by the WRC and others (as appropriate) to address the issues/needs identified.

1.2 Scope of the Study

The study deals directly with sewer infrastructure between the municipal connection and the treatment works, and does not cover on-site sanitation or waste water treatment options.

The project focus is that of a technical nature. It is appreciated that various fields of study such as social sciences, environmental and legal aspects interface directly with the selection of disposal systems, management, financing and operation of sewer reticulation, but these do not form the core focus of this study.

1.3 Project Deliverables

The approach to the research was largely guided by the project's terms of reference and input from the WRC reference group, which required the project team to complete and submit three interim reports prior to the final consolidated report, namely the:

- Literature Survey Report
- National Audit of Sewer Reticulation Issues Report
- Gap-Analysis Report

The interim reports are discussed under section 2, 3, and 4 of this report (**Interim Deliverables**), with both excerpts and full text versions included as follows:

- Review of existing local and international literature (Deliverable 1);

Annexure A : Literature Search Excerpt *Summary of findings from the literature review*

1. Literature Resources **(Data CD)** *Literature Survey Report and Excel Database of Resources*

- Execution of a series of workshops held at major centres in South Africa identifying needs at local government level by means of open discussion and formal question and rating activities, including attendance by the project team at seminars held during the project period which were directly related to sewer infrastructure to establish trends and innovation in the industry and meetings and discussion held with individuals involved in the industry (Deliverable 2);

Annexure B: National Audit of Issues Excerpt *Summary of findings from the National Audit Report*

2. National Audit of Issues (Workshops) **(Data CD)** *National Audit Report including all graphed results from questionnaires (individual local, regional and metropolitan councils)*

- The Gap-Analysis Report (Deliverable 3) consolidated findings from the previous stages of the study and established where research needs existed and where existing research dissemination would be required.

Annexure C: Gap-analysis Report *Gap-Analysis Report*

- The final report (Deliverable 4) constitutes this text report and data CD. The final outcome of the research is a list of prioritised future research initiatives that should be addressed by the WRC.

Annexure D: Prioritised Research Projects *List of prioritised future research projects*

1.4 Composition of Final Report

The structure of the final report provides different stakeholders with access to pertinent portions of the documentation without having to review the entire text document.

The final report is therefore structured into a text report covering the key issues and findings from the study and a data CD which is included with the text report providing additional information, reports and resources that are not published in the text version. This allows for the user to access a greater scope of information, whilst ensuring a concise main report.

Table 3: Structure of Research Report and Final Dataset

Interim Deliverables	Final Deliverables		
	Final Research Report & Annexures	**Literature Resource Document ****	**Pack for Workshop Attendees ****
1: Literature Survey			
Literature Survey Report		X	
Database of literature sources		X	
Summary and excerpt from Draft Literature Survey Report *	X		
2: National Workshops			
National Audit of Sewer Reticulation Issues Report			X
Annexure of full results from questionnaires completed			X
Graphed summary of results *	X		
3: Gap-analysis Report			
Gap-Analysis Report	X		
4: Final Report			
Final Text Report	X		
Proposed research projects	X		

* - Indicates a summary or excerpt from an interim report (full version of the interim report included on data CD)
** - Available on Data CD accompanying text report.

For ease of reference the report has been labelled with the relevant sections and links to more detailed reports and data as indicated below:

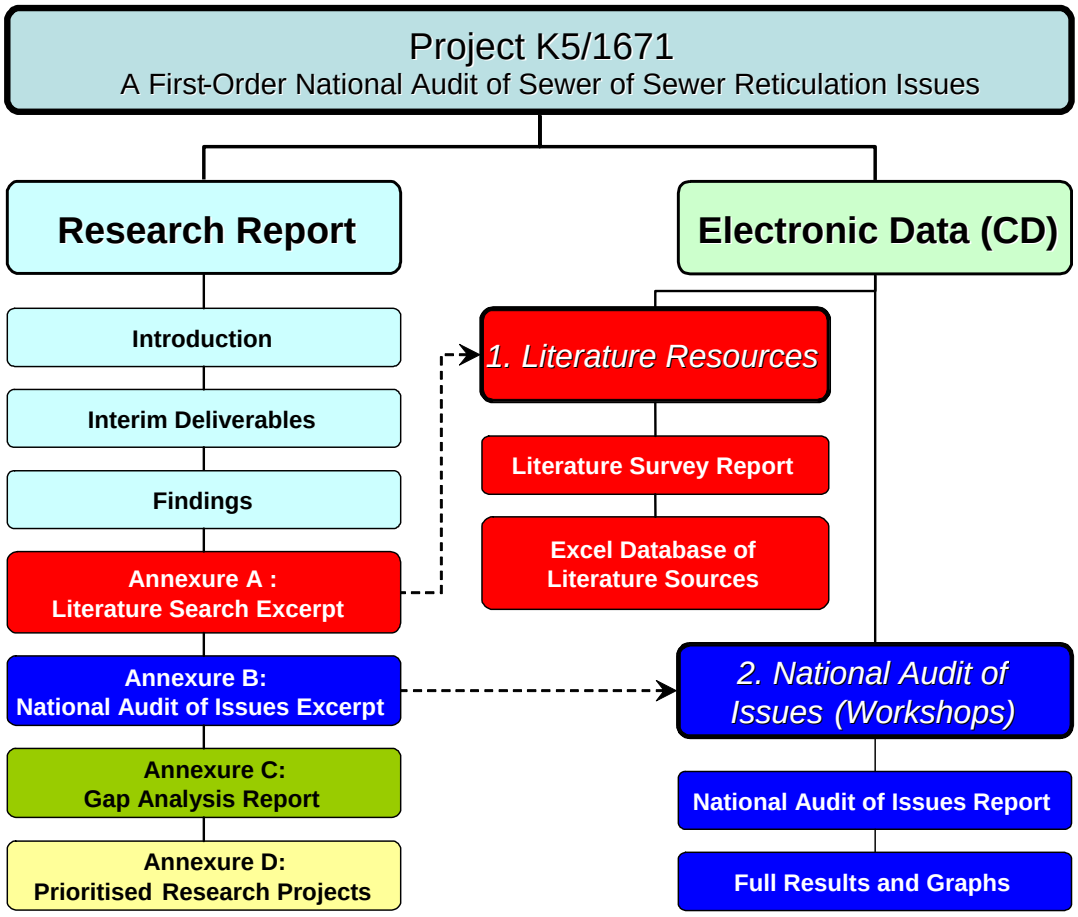


Figure 2: Structure of Research Report

Interim Deliverables

2 Literature Survey (Deliverable 1)

In order to better understand the research needs, it was important to review research papers and studies that have been completed both locally and internationally to determine whether problems experienced currently in South Africa are unique to the way we plan, construct, manage and maintain our systems or whether there are solutions and lessons to be learned from similar experiences elsewhere. It was also important to appreciate the history of reticulated sewer systems and why they have developed into the systems we know today and establish the trend in research over the years. The full Literature Survey report is available on the data CD.

The purpose of the literature survey was therefore to:

Assist the project team in establishing the extent of available research documentation to

- Establish relevance of research in terms of date of publication; and
- Provide an electronic database for interested persons to easily access the categorised research data compiled by the research team.

The following approach and research framework was adopted:

Sourcing of Research Documentation

- Establish the extent of research documentation available internationally and locally;
- Establish documentation that is available free of charge; and
- Establish where remaining documentation can be acquired or purchased.

History

- Track the development of waterborne and reticulated sewer systems;
- Establish the rationale for planning and design considerations;
- Establish the rationale for the implementation of separate and combined sewer systems; and
- Establish the trends in research through the years.

Collation of Documents

- Establish documentation pertinent to this research topic;
- Acquire full abstracts for each document;
- Conduct a physical and internet search to locate text documents; and
- Categorise and sort the research papers into relevant topics and sub-topics.

Literature Survey

- Establish relevance of documentation considering date of publication;
- Review document abstracts, executive summaries and findings;
- Establish from the research whether particular topics require:
    i. New research;
    ii. Further research in adapting existing international research to SA conditions;
    iii. Highlight priorities in research to be conducted;
    iv. Or whether no further research is required.

2.1 Data Acquisition and Compilation

Due to the large number of documents available on the topic, a methodical approach was followed in order to source, categorise and document available research.

2.1.1 Sourcing of Documentation

Documentation was sourced primarily from the National Inquiry Service Centre (NISC SA), the Water Research Commission's Publications List (7 August 2006), internet searches and other publications available and held by members of the project team.

Of the total 5766 documents found, 2021 international documents and 113 local references were deemed relevant to the topic of reticulated sewer infrastructure.

2.1.2 Categorisation of Documentation

The detailed information retrieved for each reference was sorted in terms of a main category, topic and sub-topic. All information was captured into Excel format for ease of reference and is included on the Data CD. See **Excel Database of Literature Sources**.

The database includes the following fields:

- Author
- Title
- Year of Publication
- Abstract (full text where possible)
- Website address to purchase document
- Website address to download document (if free of charge)
- Other interesting websites referring to this document or documenting a similar topic
- Category (e.g. Technical); Topic (e.g. Design); Sub-Topic (e.g. Sea Outfalls)
- Comments

Where documents have been sourced in electronic format free of charge, these documents have been included on the Data CD.

In many instances the available resources cover more than one specific topic, and it would be advisable for anyone searching this database to search by keyword in the "Title" and the "Abstract" fields.

The research was categorised into the following six categories and sub-topics:

- Financial and Economic Considerations
    - Financial Structuring and Tariffs
    - Financial Considerations for Planning and Constructing New Systems
    - Costs Associated with Sewer Operations and Maintenance
- Social Implications
    - Social Impact of Sanitation System
    - Maintenance of Systems in Small Communities
- Environmental Factors
    - Infiltration and Ingress

    - Exfiltration
    - Spillages (CSO/SSO)
- Regulatory Requirements
    - Legislative Requirements
    - Standards
    - Safety
    - Reporting and Information Dissemination
- Institutional Matters
    - Benchmarking
    - Asset Management
    - Administration
- Technical Issues
    - Non-Conventional Sewers Systems
    - Hydraulic, Structural and Prediction Models
    - Planning of New Combined and Separate Systems
    - Design
    - Discharge and Sewer Quality
    - Products and Specification
    - Operations and Maintenance
    - Inspection and Monitoring
    - System Rehabilitation
    - New System Construction
    - New Technologies
    - Master Planning
    - Information Management
    - Sewer Appurtenances

2.1.3 Combined and Separate Sewer Systems

It should be noted that South Africa has followed a strategy of implementing Separate Sewer Systems (SSS) however, a large proportion of the available literature (particularly international) deals with Combined Sewer Systems (CSS). In order to allow for a holistic approach in assessing the literature, information documented on both strategies has been compiled.

A brief history of sewer reticulation was discussed describing the development of these systems from ancient times through to the present, and particularly identifying the reasons for why combined and single systems were implemented, technological advances and recent developments in sewerage.

2.2 Outcomes from the Literature Survey

The following are the key outcomes from the literature survey:

- Although reticulated sewer systems have been in existence for more than 5000 years, it is only since the mid 19th century that significant advances in terms of a holistic understanding of health, social, planning, design and operation of an effective sewer system have been researched, documented and implemented.

- The initial literature search revealed 5756 references to sewer reticulation, of which 2021 pertinent international documents and approximately 113 local references were selected for further evaluation. These were further categorised and sorted into categories, topics and sub-topics for ease of reference and reporting.

- More than 50% of the research papers fall within the “Technical Issues” category. In the case of the international research, much of the documentation deals with combined sewer systems which convey sewage and a portion of the stormwater runoff. It is imperative that when utilising this research that the fundamentals of the single sewer system employed in South Africa and the international combined systems are understood.

- Much of the international research is conducted on combined sewer systems and not separate sewer and stormwater systems which are prevalent in South Africa. The review briefly addresses the history of these systems, and issues caution under certain topics that the research may not be applicable to South African conditions.

- All pertinent literature references have been compiled in a searchable spreadsheet format. Where literature is freely available Internet links to the actual document have been provided, or else links to a website where the literature can be purchased has been provided. Many documents could not be located or are out of print.

3 Review of Outcomes from the National Workshop Sessions (Deliverable 2)

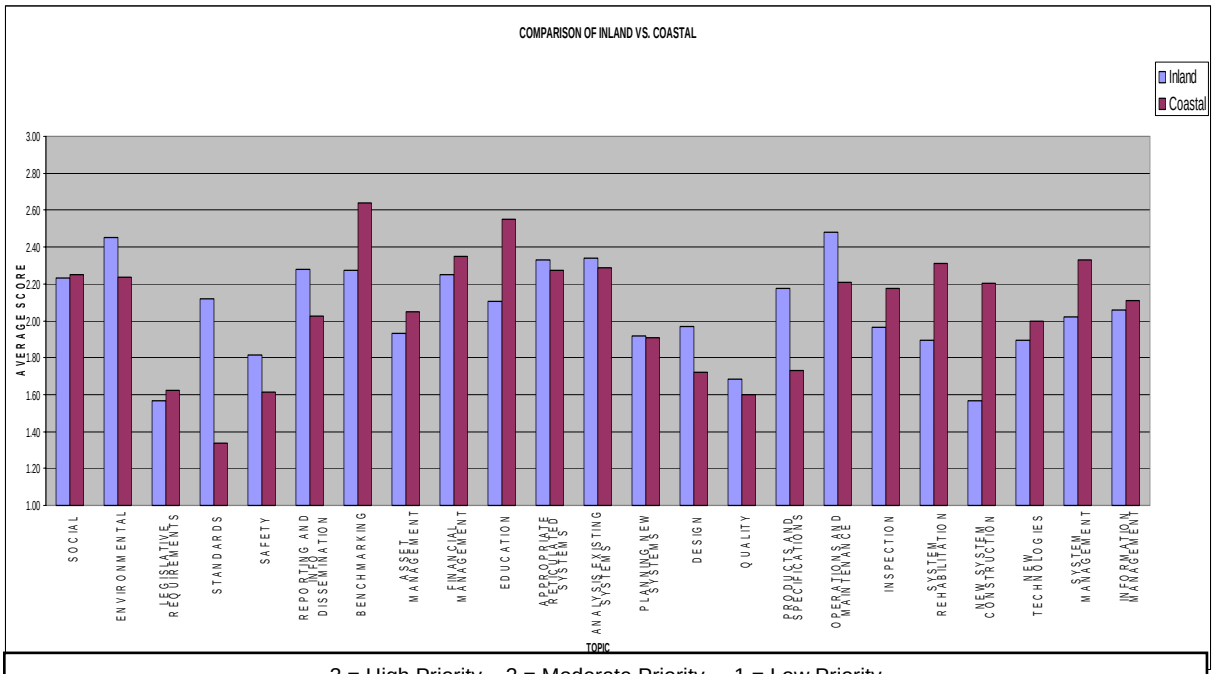
A series of workshops were held during January and February 2007 to establish where problems existed in local authorities and where further research is required in assisting local authorities in better designing, operating and managing all aspects of the sewer infrastructure.

The structure of the workshops included an initial presentation on stormwater and sewer planning and management to stimulate thought and discussion. The workshop then split into separate workgroup session for both stormwater and sewer. The sewer working session comprised an open discussion and completion of formal questionnaires and matrices to assist in rating concerns and needs. The outcomes of the workshop sessions were presented in a report (see Annexure B of the final report) documenting both the formal and informal portions of the workshop.

A comparison of coastal and inland local authority priority issues revealed that benchmarking and education were of greatest importance to coastal areas, whilst operational and maintenance and environmental issues concerned inland areas. There were however no definite issues or research that was urgently required either inland or in the coastal areas that did not affect the other (See Figure 1 below).

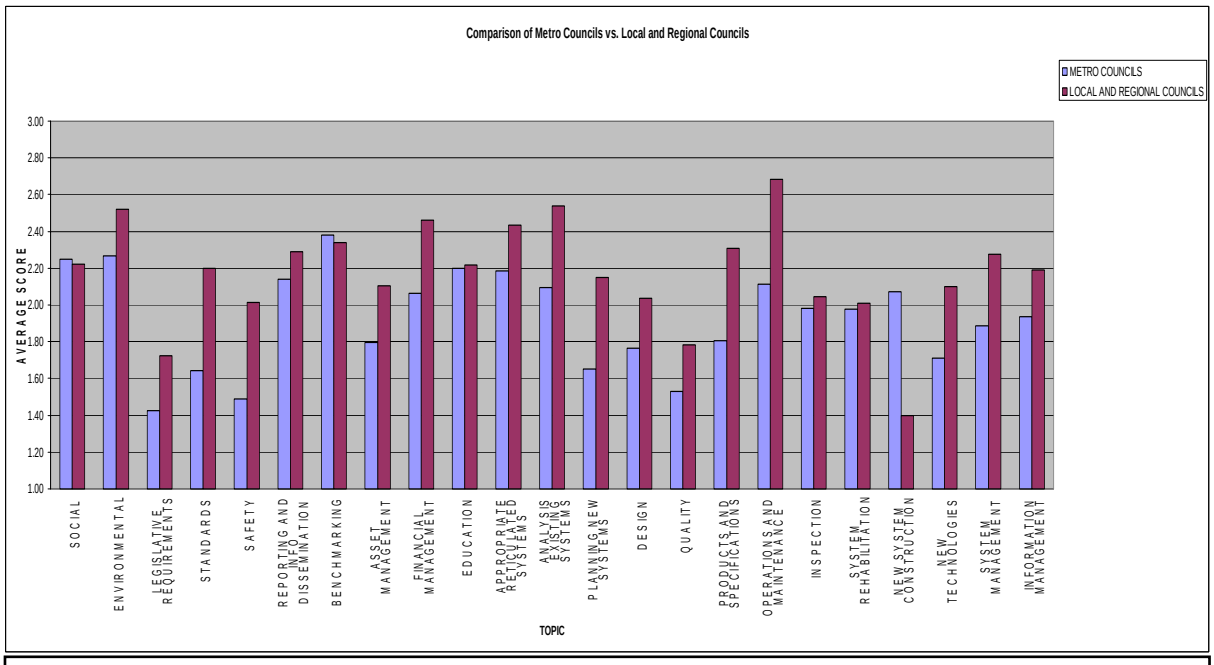
A comparison of smaller local and regional council, and larger metropolitan council issues revealed that operational and maintenance and system analysis were of greatest importance, whilst the metropolitan councils require additional research conducted on benchmarking, social and educational issues. This is a symptom of smaller authorities having thinner corporate and resource structures and therefore being responsible for a greater variety of work and to a larger extent having to be more “hand-on”. The metropolitan council operate in a more corporate environment with well defined structures. To a large extent the research focus for larger authorities is on the enhancing and improving their business, rather than needing guidance on

fundamental issues surrounding the planning, design, operations and management of the systems (See Figure 3 below).



3 = High Priority 2 = Moderate Priority 1 = Low Priority

Figure 3: Comparison of Inland versus Coastal Authority Issues



3 = High Priority 2 = Moderate Priority 1 = Low Priority

Figure 4: Comparison of Metropolitan versus Local and Regional Authorities

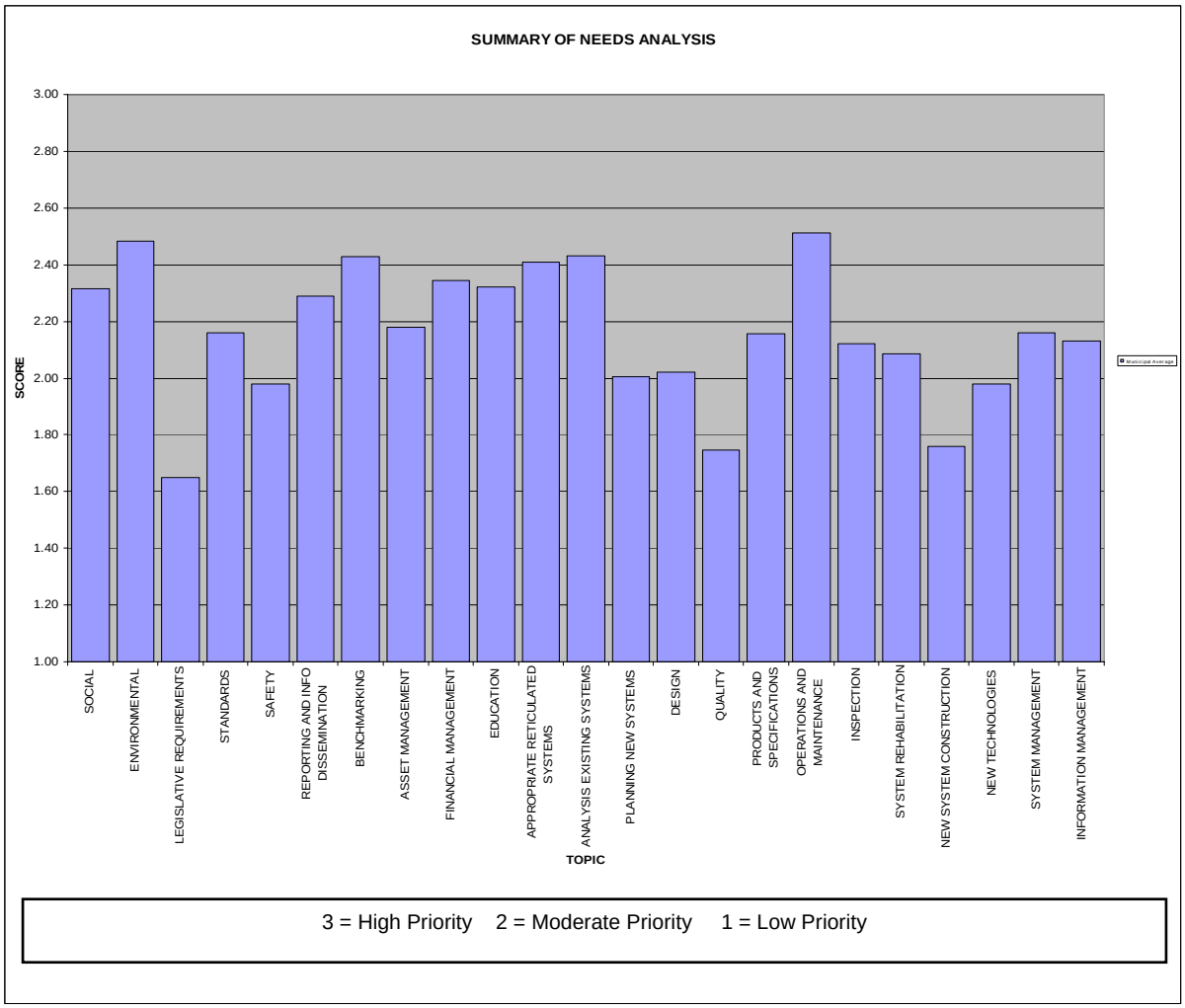


Figure 5: Summary of Research Needs

The figure above indicates the need for further research in specific fields presented to the attendees at the workshops. In terms of research needs, the greatest requirement from local authorities is to investigate and provide guidance in the fields listed in the table below.

Table 4: Ranking of Sewer Reticulation Issues

Higher Priority Issues	Medium Priority Issues	Lower Priority Issues
• Operations and Maintenance • Environmental Issues • Benchmarking • Analysis of Existing Systems • Appropriate Reticulated Systems • Financial Management • Social Issues • Education	• Reporting and Information Dissemination • Asset Management. • Standards • Products and Specifications • Systems Management • Information Management • Inspection	• System Rehabilitation • Design • Planning New Systems • Safety • New Technologies • New System Construction • Guidance on Quality Systems • Further Legislative Requirements

The attendees were asked to rate their institutional arrangements and their available resources to suitably operate in defined fields. The graph below detailed the summary of all local authorities' results. The detailed results for individual authorities are included on the Data CD included with this report. See **Full Results and Graphs** .

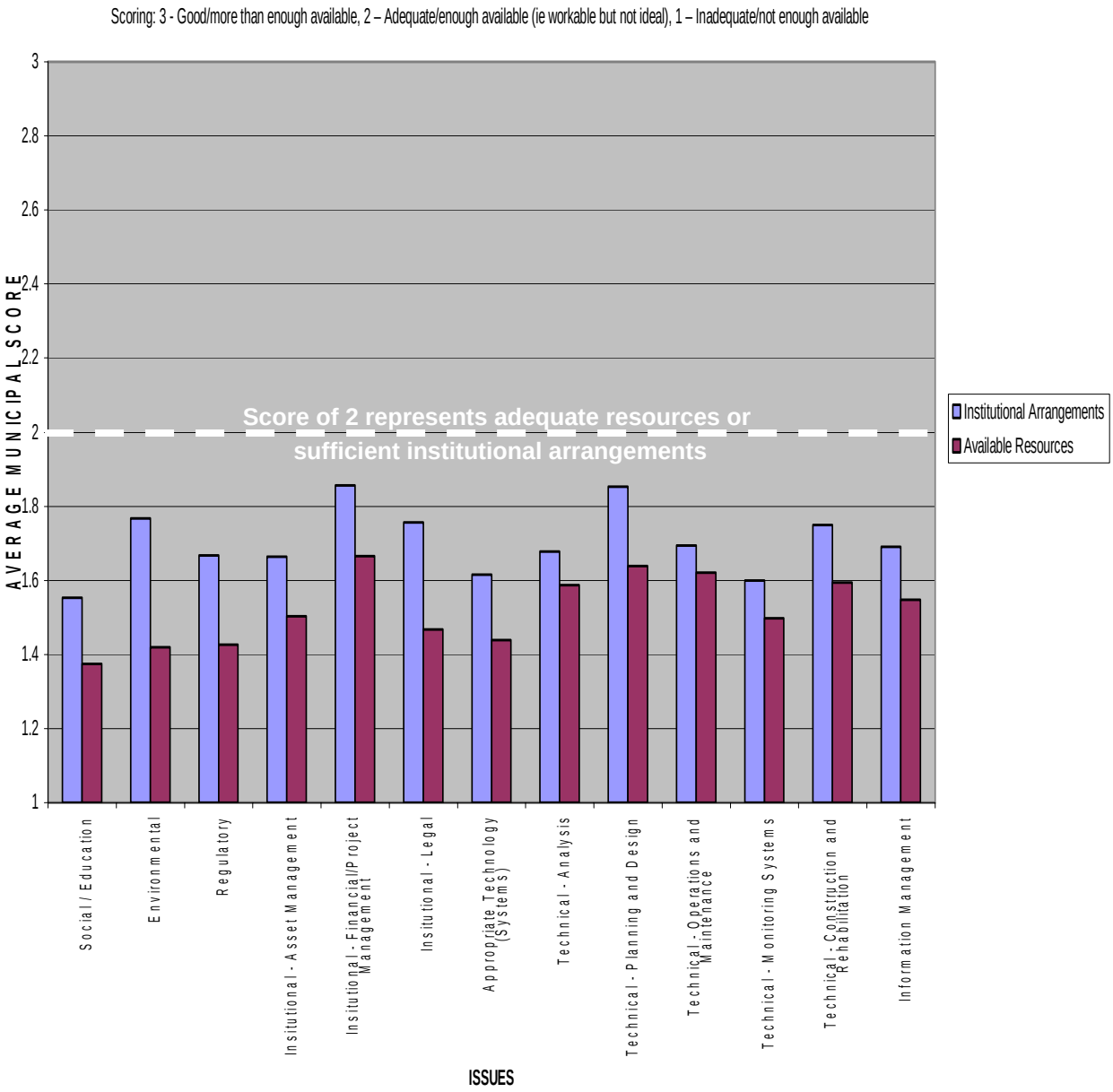


Figure 6: Summary of Available Resources and Institutional Arrangements

On average, local authorities are perceived to be under resourced and feel that they have insufficient tools to assist them in operating optimally. The detailed graphs for individual authorities do differ significantly from the average; however the average results do support the general sentiment in the industry that these factors are curtailing service delivery.

The following fields were deemed to have the lowest rating in terms of institutional arrangements:

- Ability of the authority to deal with social aspects and education of users and operators;

- Structure and methodology for implementing suitable monitoring systems;
- Methodology to evaluate and implement new or appropriate reticulation technologies.

The following fields were deemed to have a lack of resources to drive activities:

- Social aspects and education of users and operators;
- Environmental, regulatory and legal aspects;
- Experienced personnel to evaluate and implement new or appropriate technologies.

4 Review of the Gap-Analysis (Deliverable 3)

The gap-analysis was undertaken to document, establish and prioritise research needs which had been identified during the previous phases of the project. The gap-analysis was also extended to document elements of sewer infrastructure research and management that were not specifically identified or dealt with during the literature survey or national workshops.

4.1 Methodology for Compilation and Prioritisation of Research Needs

4.1.1 General Methodology

A list of topics was initially drafted from the following sources:

- Issues raised by the WRC reference group at the inaugural project meeting;
- Incomplete or additional research requirements identified during the literature survey;
- Issues raised during the series of workshops with local authority participants;
- Issues raised during seminars, courses and discussions;
- Final recommendations from the WRC reference group.

The gap-analysis identified 53 potential research topics for the Water Research Commission to consider further.

The reference group recommended that these potential topics be categorised in terms of the core research fields of the WRC, comprising:

- Fundamental Research
- Applied Research
- Dissemination of Research

The list of 53 specific needs was then consolidated further into 37 potential research projects. These topics were further consolidated into 31 projects which were prioritised based on the needs identified during the national workshops and input from the project team and reference group. The remaining 6 topics were identified as a need during the due process, but it is felt that these topics have been covered sufficiently under previous research projects and that dissemination of this research is required.

4.1.2 Measure of the Need for Particular Research

The prioritisation of the research topics was based on the following framework executed by the project team, with later verification through the reference group participants.

The projects were prioritised in terms of the priority assigned by the respondents and attendees of the national workshops, and a rating applied by the project team. The overall score was applied and calculated as the product of the two ratings. The prioritised list of projects was then further assessed by the WRC reference group and final ratings and priorities were completed.

Each of the proposed projects was further assessed to establish reasonable project durations and project budgets to complete the research.

The reference group raised concern during the project that the funding cycle of the WRC did not suit the funding and resourcing cycle for universities. Although this concern is noted, this project does not attempt to resolve this issue.

The scope of the projects and their proposed durations and costs should be further assessed by the WRC prior to commencing with the bidding process to ensure that correct project scope is defined and sufficient time and budget is available to complete the research adequately.

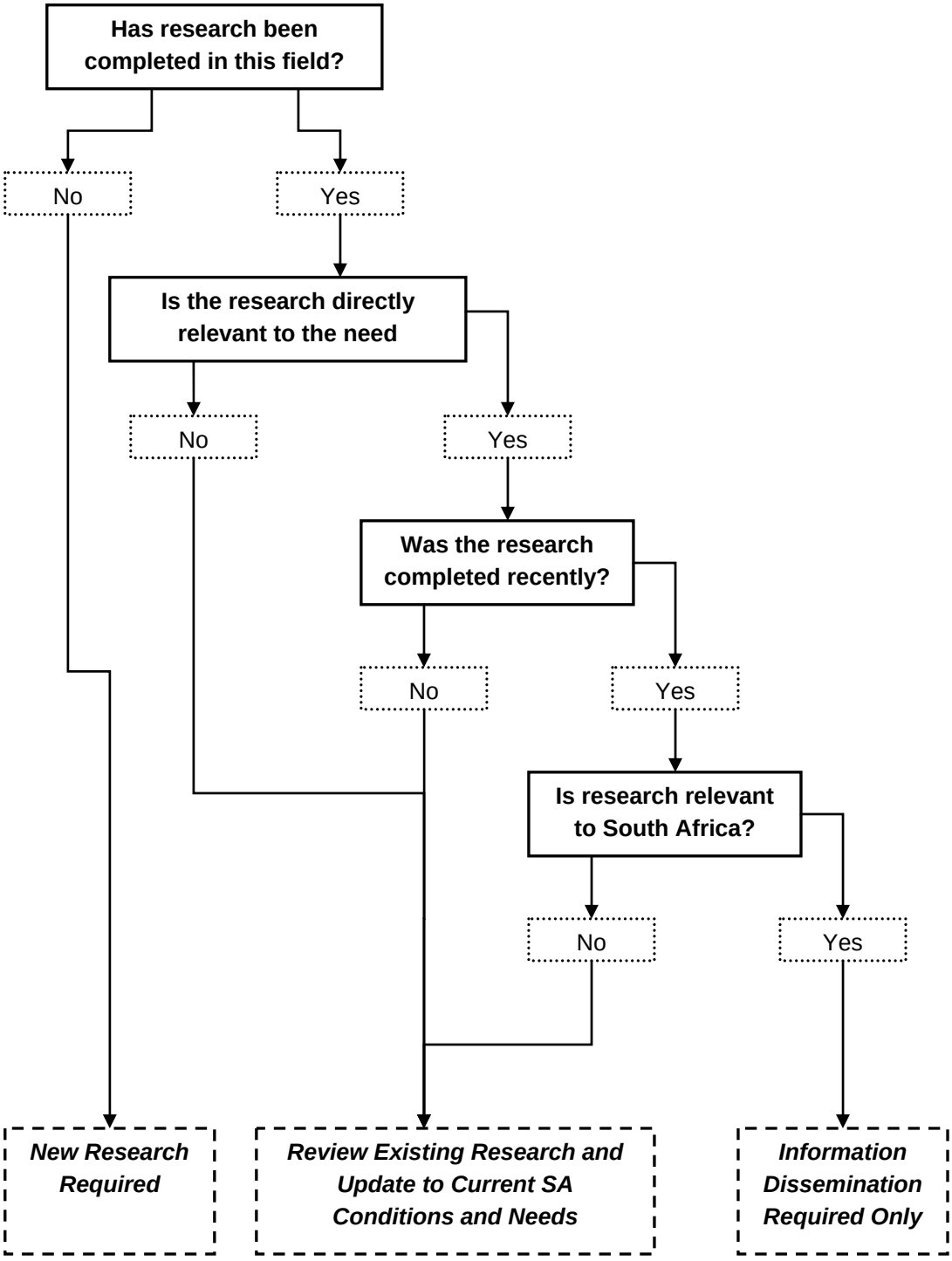


Figure 7: Flow Diagram to Establish Type of Research Required

The final list of prioritised research projects, the proposed budgets and project durations are included in Annexure D.

Findings

5 Published Trends in Research

5.1 Documented International Research Needs

In 2002 the US Environmental Protection Agency commissioned a project to establish the research needs in the field of wastewater collection systems in the USA for the estimated 1 - 1,2 million kilometres of sewer pipes. The findings identified needs primarily in the field of pipeline assessment, operations and maintenance, materials and pipeline construction and rehabilitation with the overall purpose to establish a sustainable sewer system in terms of investment and functionality. (EPA; 2002)

Currently the WRC PLC in the United Kingdom is addressing research in the following fields:

- Proactive Low Cost Monitoring for Sewer Cleaning
- How to Solve the Pitch Fibre Pipe Problem
- Joint Sealing Technologies – a Long Term Solution?
- Infiltration Control Via 'Top-Hat' and Grouting Repair Systems
- Fats, oils and greases (FOG)
- Updating the Sewerage Rehabilitation Manual

The University of New South Wales is currently researching options for limiting odour and corrosion in sewer systems. Sydney Water is promoting sewer mining, which is the process of extracting and utilising raw sewage from the sewer reticulation as a source for recycled water use particularly in semi arid climates. Many other Australian organisations are researching topics where sewerage overflows have caused environmental pollution and associated challenges; however the core topics do not deal directly with the sewer reticulation but rather the effects of the spillages.

The international research trends seem to be similar to the priorities in South Africa, however more stringent environmental legislation in Australia seems to allow motivation towards projects with an environmental slant.

5.2 Local Needs

The SAICE Infrastructure Report Card for South Africa: 2006 compiled by the South African Institute of Civil Engineering rated the state of sanitation infrastructure in South Africa based on a as fair to poor (C- rating) for major urban areas and "very poor" (E rating) for all other areas. The major constraints are identified as skills shortages in the sector and inadequate operation and maintenance of the systems.

Sanitation (including wastewater)	**C-** for major urban areas **E** for all other areas	Serious problems with management of many wastewater (sewage) treatment works. Wastewater leakage and spillage much too high, and frequent problems with on-site sanitation. Inadequate operation and maintenance capacity, and shortage of skilled personnel. Major urban areas grade is pulled down by Cape Town and Sebokeng.
Overall Grade	**D+**	Although South Africa's built environment infrastructure is very good, even world class in parts, the relatively poor overall grade reflects extensive maintenance and refurbishment backlogs. These backlogs are caused primarily by funding and skills shortages.

Figure 8: Excerpt from SAICE Infrastructure Scorecard

(SAICE, 2006)

The Department of Water Affairs and Forestry (DWAF) stated that the major challenges facing South Africa was promoting sustainable, affordable and efficient service delivery. (The Development of a Sanitation Policy and Practice in South Africa, DWAF; 2002).

Table 5: Challenges Tasked to the DWAF

No.	Tasks
1.	Promoting the Water Service Development Planning Process, within the framework of the Integrated Development Plan, as the key instrument for planning, monitoring and regulating water services, with full community involvement. Service provision should be demand-responsive rather than supply driven to ensure appropriate choices of technology, lower costs, better uses of resources and more sustainable services. The Water Service Development Plan should guide strategies related the choice of service levels and technology implemented.
2.	Developing an appropriate regulatory framework that ensures the effective, efficient, equitable and sustainable provision of at least basic sanitation services to all people living in South Africa, and cost-effective, reliable services to businesses and institutions.
3.	Finalisation of the institutional framework. Currently the local government structures must deal with a range of approaches to service provision that span both urban and rural areas. The allocation of powers and functions between district municipalities and local municipalities needs to be resolved.
4.	Rationalising the financial framework in order to support sustainable service provision, specifically with regard to the provision of free basic services and implementing appropriate pricing for services.
5.	Managing the transition to local government as the service provider and DWAF to become the supporter and regulator.
6.	Furthermore, South Africa wishes to share its experience with its neighbours and all African countries, as well as learning from their experiences in order to realise its vision to clear the backlog in sanitation by 2010 in a sustainable manner.

Source: “The Development of a Sanitation Policy and Practice in South Africa” (DWAF; 2002)

The Consolidated Water Sector Report (DWAF; 2006) states that “Sanitation is still not adequately covered in the Water Services Development Plan (WSDP) process and not prioritised by municipalities.” There are still a number of challenges in implementing the legislation, specifically in the compilation of accurate infrastructure plans and conveying of accurate information through to the Water Services Development Plans to the Integrated Development Plans.

5.3 Current WRC Focus on Sewer Reticulation

The topic of sewer reticulation research is dealt with under Key Strategic Area 3: Water Use and Waste Management under Thrust 7: Sewer Reticulation.

The Water Research Commission’s 2005/6 Knowledge Review documents the initiatives that the WRC has undertaken to progress research in various fields. In the 2005/6 financial year R88,3 million was invested in research by the WRC and R27,3 million (or 31% of the total budget) spent specifically on KSA 3: Water Use and Waste Management, however no funding was approved for expenditure on projects under Thrust 7: Sewer Reticulation.

In 2006/7 total investment into research was increased to R112 million with the only expenditure targeted on sewer reticulation being this current project “*A first-order national audit of sewerage reticulation issues*”.

There is a trend towards research on strategic issues and research both upstream and downstream of the reticulated sewer networks, but limited research conducted specifically on the reticulated sewerage systems. During the 2005/6 and 2006/7 financial years the WRC’s investment of sewer reticulation research has amounted to approximately 0,22% of the total budget.

It is important to note that two WRC projects are being completed to assess and ensure that information is being successfully disseminated at a local government level. Failure to disseminate information was identified as being a concern during the workshop sessions.

A project undertaken by the University of Cape Town (K8/606) (Armitage and Hendricks; 2005) entitled “Research needs in Urban Stormwater and Sanitation” revealed many similar issues identified during this study. Key similarities in the two studies include the understanding of the different needs of small local authorities and larger metropolitan authorities, and the need for management assistance through development of guidelines and the need to evaluate and understand alternative systems.

6 Topics Identified by the Research Team

The structuring of the scope of the proposed research projects allows for a holistic approach to identify needs, rather than scoping smaller specific studies where the findings may not be appreciated by a larger audience. The projects have been separated into the three core research categories, namely fundamental research, applied research and research dissemination.

The reference group included an additional field termed “”Management and Other Research”. These topics are also listed separately below, although most would fall in the “Applied Research” category.

The following prioritised projects are proposed by the project team in order of perceived importance:

6.1 Fundamental Research Projects

- Compilation of a National Disaster Management Framework for Sanitation Services
- Guidelines for the Implementation of Non-Conventional Sewer Systems
- Practical Guide for the Monitoring of Sewer Exfiltration and Impacts on Groundwater Resources
- Management of Root Growth in South African Sewers
- Environmental Costing for the Planning, Design, Operation and Maintenance of Conventional and Non-Conventional Sewer Reticulation
- Modelling of Solids Deposition and Mineralization of Organic Matters in Municipal Waterborne Sewers
- Rehabilitation Methods/ Techniques for the Reduction of Extraneous Flows in Reticulated Sewer Infrastructure Systems
- Revision of Design Criteria for the Development and Enhancement of Reticulated Sewer Infrastructure in accordance with Changing Reticulation Patterns
- Identify the Need for the Control of Volatile Organic Compound Emissions from Municipal Sewers
- Planning, Design and Management of Urban Core Waterborne Sewer Systems to the Satellite Sub-Systems
- Impacts of Stormwater Pollution and the Reduction in Dry Weather Flows on the Efficiency of Separate Sewer Systems
- Evaluation of Pollution Damage which Disrupts the Integrity of Reticulated Sewer Infrastructure
- Evaluate Useful Technologies for Increasing Capacity of Reticulated Sewer Infrastructure Systems
- Influences of the Compulsory National Standards and Norms on Operation and Maintenance and the Administration of Reticulated Sewer Infrastructure

6.2 Applied Research Projects

- National Specifications for the Monitoring and Inspection of Reticulated Sewer Infrastructure, Employing In-Situ and Remote Sensing Systems
- Life Cycle Behaviour of Pipe Materials Applicable in Reticulated Sewer Infrastructure
- Rehabilitation Manual for Reticulated Sewer Infrastructure Systems
- Guide on Universal Protection of Reticulated Sewer Infrastructure against Vandalism and Theft
- National Specifications for Appropriate Methods to be employed in Cleaning, Grit Flushing, Dragging and Rodding of Sewer Pipes
- Evaluate the Trade-Offs between Rehabilitation and Replacement of Reticulated Sewer Infrastructure
- Guidelines for the Operations and Maintenance of Sewer Stations

- Revision of Established Standards for Gravity Sewers, Sewer Rising Mains, Pump Stations and Specific Sewer Structures

6.3 Management and Other Research

- National Guideline for Reticulated Sewer Infrastructure Master Planning
- Guide for the Life-Cycle Costing of Reticulated Sewer Infrastructure Components Based on Preventative Maintenance
- Administering of Reticulated Sewer Infrastructure by Amalgamated Local Government Structures
- Alignment of WSDP Information on Reticulated Sewer Infrastructure with the Requirements of the Integrated Development Plan (IDP)
- Guide for the Establishment of Regional Reticulated Sewer Infrastructure Bulk Services
- Modelling of Social and Environmental Costs Incurred in Upgrading/ Rehabilitation of a Reticulated Sewer Infrastructure System
- Guidelines for Special Structures Situated in Reticulated Sewer Infrastructure Systems
- Capacity Building through Educational Means for Planning, Operation, Maintenance and Management of Reticulated Sewer Infrastructure Assets
- Application of the Internet and Other Databases in Water Services with Emphasis on Sanitation

6.4 Projects Identified Where Dissemination is Necessary

The following projects were identified during the workshop sessions, but it is felt that the research topic has been largely covered by existing literature and therefore should not be pursued further. The intention will therefore be to promote dissemination of this information.

- Research and establish impacts of inflow/infiltration (I/I) on pumping installations and waste water treatment works (WWTW) treatment capacity.
- Research and evaluate planning approaches for development of reticulated sewer infrastructure.
- Tariff Structures for the Retail of Services Provided by the Reticulated Sewer Infrastructure Systems.
- Research and update contemporary knowledge on the quality/nature of raw sewerage flows.
- Research and evaluate the sentiments and a true potential for implementing of benchmarking methods.
- Research and compile an Infrastructure Asset Management Manual.

6.5 Project Prioritisation and Funding

All projects are listed above in order of importance and need. Higher priority projects should be considered for implementation immediately by the WRC to assist in addressing the prioritised needs of the industry.

Medium Priority projects should be considered for implementation within the next 3-5 years. These topics should also be considered for alternate funding or to be driven by other institutions that would be capable of implementing the projects at an earlier stage.

The Lower Priority projects should not be commissioned in the short term. The projects may be specific to a limited audience and it may be in their best interest to fund or implement these projects internally (at local council level) to their specific requirements. These research projects may also be of a general nature and are seen as “interesting” rather than as a necessity.

7 Conclusions

There is a need to increase the funding for research and development on reticulated sewer infrastructure in order to assist the industry and local authorities in meeting present challenges.

The WRC is tasked as a member of the National Sanitation Task Team to assist in providing such research opportunities and a greater funding focus should specifically be allocated to under the WRC’s Key Strategic Area 3: Water Use and Waste Management - Thrust 7: Sewer Reticulation.

Reduction of water used for flushing and water reuse increases the concentration of the sewage and increases operational failures. Ingress and infiltration from stormwater systems reduces available capacity in sewers systems and also has a detrimental effect on treatment works. Management of water supply, sanitation systems and stormwater are integral to the way sewer systems will continue to function. It is important to acknowledge trends in the water use industry with a view of assessing the impacts that may affect the reticulated sewer systems in future.

There is a need for guideline documentation, improvement of specifications and development of new standards to raise the level of service and build financially sustainable sewerage business units. There is however a lesser need to conduct research in the fields of innovation and product development.

There is little need for development of further legislation or additional national structures to deal with reticulated sewer infrastructure. The existing frameworks that are in place seem to cover all aspects of strategic and technical fields, however there is a need for improved dialogue between governmental, local authorities, non-governmental and professional associations to ensure the correct issues are addressed to ensure sustainability and guarantee appropriate levels of service.

Further measures are needed to ensure that dissemination of existing and future research is communicated to the correct participants in the industry.

8 Recommendations

The successful management and operation of the existing sewer reticulation asset base and the construction and provision of future infrastructure is largely dependant on suitable legislation, regulations, guidelines and resources. Implementing appropriate collection, conveyance and disposal systems and the ability of the industry to provide infrastructure of an acceptable quality will ensure a prolonged service life, increased real asset value and guaranteed levels of service.

By increasing the funding allocation of potential research projects such as those listed in Annexure D of this report, the WRC will be able to direct the focus in the field of reticulated sewer infrastructure to provide insight and guidance where required by the industry.

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